

CalWin User's Guide

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Contents

About Cal-Scan	1
Programming Reference	1
Introduction to Calwin	3
About Calwin	3
USB & Serial Cable Interface Box	3
Multimedia Card Options for Hawk 9000	4
Setting Up MMC Passwords	4
Clearing an MMC.....	5
Installing Calwin	6
Troubleshooting Installation	7
File Location, Extensions, and Folders	7
Getting Started With Calwin	9
Calwin Menus	10
File Menu.....	10
Program Menu.....	10
Dump Menu	11
Recompensate Menu	11
Presentation Menu	11
Tool Options Menu	12
Software Options Menu.....	13
Connecting Tools to Calwin	15
Connecting the Downhole Gauge	15
Connecting a Hawk 9000 Surface Box	16
Programming Gauges	19
Programming Downhole Tools: Fixed Rate	19
Programming Downhole Tools: Multirate	22
Saving a Program to Disk.....	27
Viewing the Program	28
Programming the Hawk 9000 Surface Box	31
Setting up Hawk 9000	31
Updating Configuration with the MMC	34
Setting up Turbines.....	38
Programming Hawk 9000: Fixed Rate	44
Programming Hawk 9000: Multirate	45

Saving a Program to Disk.....	47
Restarting the Hawk 9000 Surface Box	48
Downloading Data	51
Downloading Data from Hawk 9000	53
Recompensating Data	57
Presenting and Viewing Data	61
Headers	61
Importing Header Information	63
Graphing Data	63
Graph Viewing Options	64
Differential Plot.....	67
Viewing Data in Table View	68
Merging Data	69
Printing Data.....	70
Exporting Data	75
Exporting to Filtered ASCII	77
Exporting to FAS	82
Tool Options and Diagnostics	83
Recorder Tool Settings	83
Setting Recorder Serial Number	84
Inserting Recorder Calibration	84
Getting Hours On Tool	85
Sampling to Terminal	86
Downloading Recorder Calibration	87
Download Tools	87
Manually Dumping Data.....	88
Find End Of Memory and Download	89
AGA Flow Settings for Hawk 9000	90
File Tools	91
Setting Start Time	91
Getting Tool Data From a File	92
Viewing the Configuration Screen	92
Setting Up Com Ports	94
Operation Guide	95
Introduction to Gauge Operation	97
About Badger and Mole Silicon Strain Gauges	97

Badger and Mole Specifications	98
About Badger Tri Tool Silicon Gauge	99
Badger Tri Tool Specifications	100
About Wolverine Quartz Gauge	101
Wolverine Tool Specifications.....	102
About Hawk 9000 Surface Box	103
Hawk 9000 Features	103
Hawk 9000 Safety Approvals	104
Hawk 9000 Specifications	105
Downhole Gauge Setup	107
Guidelines for a Successful Downhole Test	107
Testing the Gauge Before Downhole Tests	108
Downhole Extended Test	108
Programming for an Extended Test	110
Downhole Gradient	115
Programming for a Downhole Gradient.....	115
Testing the Downhole Tool Battery	120
Plugging the Battery into the Downhole Tool	122
Setting Up Surface Read Out	123
Programming Fixed Rate for SRO	123
Downloading and Viewing Data	125
Creating Simple Graphs	127
Viewing Data in Table View	128
Downhole Gauge Maintenance	129
Replacing Downhole Tool O-Rings	129
Downhole Gauge Operational Precautions	132
Preventing Mechanical Shock.....	132
Protecting the Transducer	132
Standard Hawk 9000 Setup	135
Extended Buildup Test	136
Hydrostatic Test	138
Flow Proving	142
Production Testing	147
Starting the Hawk 9000 Surface Box	152
Remote Communication	152
Real Time Monitoring Hawk 9000 with Raven.....	153
Viewing Real Time Hawk 9000 Data.....	154
Working with Multiple Hawk 9000 Boxes	156
Downloading Hawk 9000 Data	158
Downloading with the Interface Box	159

Downloading with Raven	161
Downloading with a Multimedia Card (MMC)	161
Maintaining Hawk 9000	162
Hawk 9000 Operational Precautions	164
Permanent Hawk 9000 Setup	165
Connecting to a Half-Duplex RS-485 Network	167
The Modbus Protocol	169
Modbus Register List (04) (SB v3.16+)	173
Modbus Holding Register List (03 & 16)	178
CSA Intrinsically Safe Installation.....	179
UL Intrinsically Safe Installation.....	180
Internal Wire Hookups of Hawk 9000.....	182
Field Wiring Specifications for Hawk 9000	184
Basic Gas Measurement Theory and Practice	187
Standard Units & Gas Laws	187
Standard Pressure	187
Standard Temperature	188
Supercompressibility	189
Measuring Static Pressure	189
Paper Chart Recorders	190
Meter Runs	190
Turndown Ratio	190
Measuring Gas Flow with Orifice Plates	190
Measuring Gas Flow with Turbines	192
Optical Flow Meters	193
Installing USB Drivers	195
USB Troubleshooting	198
Glossary Of Terms	201

About Cal-Scan

Cal-Scan Services Ltd. is an oil field service company that manufactures and services surface and sub-surface pressure recorders, such as electronic gauges. Located in Edmonton, Alberta, Cal-Scan designs, manufactures, and calibrates downhole and surface oil field recorders. Cal-Scan can also customize any of its tools to suit your needs, and provides custom reporting services for oil field sensors.

Founders Lloyd Carefoot, Bill Chandler, and Jack Hurford began providing custom reporting and calibration of oil field downhole sensors in 1995. With over 60 years combined experience in the oil and gas industry, they soon developed a reputation for quick dependable service, and calibrations that outperformed the original manufacturers.

In 1998, Cal-Scan started developing their own tools to provide better accuracy, lower power consumption, and improved dependability.

Cal-Scan Services Ltd. sells globally. Their tools are used in many of the major oil fields of the world: Saudi Arabia, Texas, Gulf of Mexico, Malaysia, Australia, Venezuela, China, and, of course, at home in Northern Alberta.

Programming Reference

Chapter 1

Introduction to Calwin

This part of the guide describes Cal-Scan's Calwin software and its use with downhole gauges, surface gauges, and surface readout tools to download and display data.

About Calwin

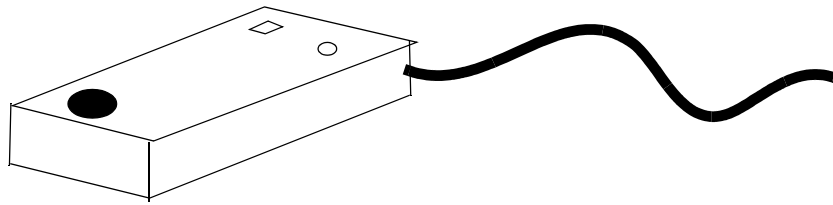
The Calwin program works with Cal-Scan's USB & Serial Interface Box to communicate with downhole gauges and surface boxes. Calwin allows you to program gauges, download information from any of Cal-Scan's recorders, and view the information in graph and tabular form.

You must download Calwin to your computer in order for you use it. You can install the program from Cal-Scan's web site, or from a CD-ROM.

USB & Serial Cable Interface Box

Once you have installed Calwin on your laptop, you will connect the USB & Serial Interface Box to the gauge and your laptop. This enables Calwin to communicate with the recorder so you can program the sampling rate and download information.

The USB & Serial box is also called the Dump Box or the Interface Box. Instructions for connecting gauges to your computer through the Interface Box appear in "Connecting the Downhole Gauge" on page 15 and "Connecting a Hawk 9000 Surface Box" on page 16.



USB & Serial Interface Box

Multimedia Card Options for Hawk 9000

Cal-Scan's Hawk 9000 surface boxes are equipped with a multimedia feature so you can download the box quickly in hazardous conditions. The SD/multimedia card (MMC) is a miniature floppy disk that you insert into the Hawk 9000. You can download your data to the card at over 120 kbps without losing samples. After the data has been downloaded onto the multimedia card, you insert the MMC card into a PCMCIA or USB MMC reader connected to your computer in a safe location.

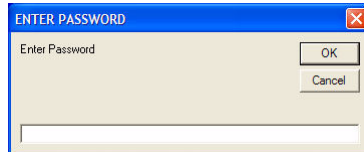
You can clear the MMC data, load settings to update, or change password preferences through Calvin.

Setting Up MMC Passwords

You can set up a 4-digit numerical password to restrict viewing or downloading the Hawk 9000 data.

To set up the MMC password

1. On the **Program** menu, point to **Program SD/MMC**, and click **Password Setup for Viewing** or **Password Setup for Download**.



Enter Password

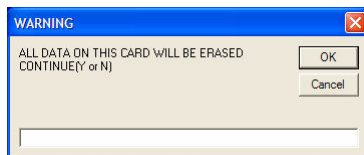
2. In the **Enter Password** dialog box, type the 4-digit password that you created when you programmed the Hawk 9000. Click **OK**. The Hawk 9000 is now set up to permit viewing only after the password has been entered.

Clearing an MMC

This feature erases all of the data on the multimedia card.

To clear an MMC

1. On the **Program** menu, point to **Program SD/MMC** and click **Clear Card**.



Clear Card

2. Type **Y**. Click **OK**.

Installing Calwin

You can install Calwin from the Cal-Scan web site or from CD.

Note

You must be logged on as a user with Administrator privileges in order to install programs in Windows 2000 or XP. Refer to your Windows documentation or contact your system administrator for information about user privileges.

To install Calwin from the Cal-Scan web site

1. On your computer, go to the Cal-Scan Services Ltd. web site, which is located at www.welltestsolutions.com www.calscan.net
2. Click **Downloads, Software** and click the Calwin download link to download the file.
3. After the Calwin has finished downloading, exit the Cal-Scan web site and confirm that a Calwin shortcut has been created on your desktop.
4. Test that the software has been successfully installed by clicking the Calwin icon. The Calwin screen should appear on your computer.

To install Calwin from CD-ROM

1. Insert the CD into the CD-ROM drive (usually D) and follow the prompts.
2. If installation does not start automatically, do the following:
 - a. From the Windows Task Bar, click **Start**, and select **Run**
 - b. In the box, type `D : SETUP>EXE`, and click **OK**. If your CD-ROM drive is not D, substitute that letter.
 - c. Follow the prompts on the screen to complete the installation.

Troubleshooting Installation

If you have trouble installing Calvin, check these possible causes. Problems can result when installing Calvin due to the following:

- The computer battery is weak. Recharge the battery and try again.
- Internet connection was interrupted during download. Check your internet connection.
- Other programs running. Close all other programs before installing.
- There is a gauge attached to your computer. Remove attached gauges.
- If you have installed Calvin, but other users cannot use it, you may not have installed Calvin while logged on to your computer as an administrator. Ensure that you have administrator permissions, or contact your system administrator.

File Location, Extensions, and Folders

Calvin is designed to work with the Windows Operating System on your computer. The Calvin operating files are usually stored in your Windows Directory,

`C:\PROGRAM FILES\Cal-Scan SERVICES LTD\Calwin`

It can be helpful to create folders in your Windows Directory to store the files you create. For example, you may want to create a folder for each oil well, company, or project to organize your data and reports.

When you download recorded data from Cal-Scan's gauges, the computer stores the information in a file in your Windows Directory. Each file has a file extension, such as `.prg`, at the end of the file name. The extension tells you what type of file it is. In this case, the `.prg` tells you that this particular file is a program file.

`C:\PROGRAM FILES\Cal-Scan SERVICES LTD\Calwin Contains Calvin2002.exe`. This is the executable file that runs the Calvin Software Program

C:\PRESSURE Contains the configuration file.

C:\PRESSURE\DATA Contains dump files with .bin and .cmp extensions. These files are created when data is downloaded from a recorder.

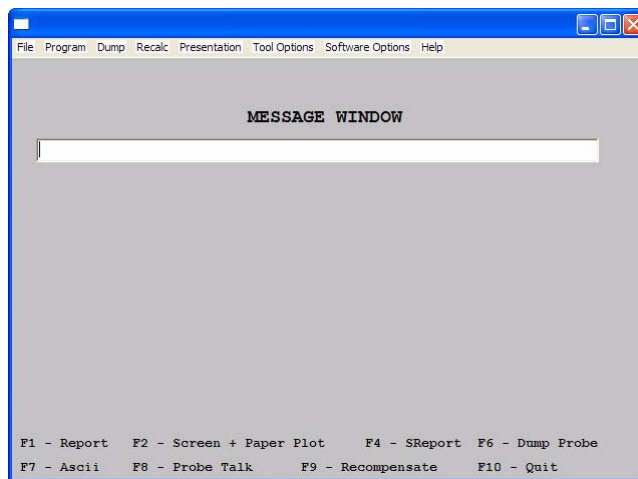
C:\PRESSURE\CALB Contains calibration files for the gauges and turbines. Calibration files have a .cal extension for gauges, and .trb for turbines.

C:\PRESSURE\PROGRAM Contains the program files you saved. Program files have a .prg extension.

Chapter 2

Getting Started With Calwin

You can use the menus at the top of the screen or the F Keys listed at the bottom of the window to execute any task.



Calwin main screen

Calwin Menus

There are several menus and commands that you can access from the menu bar along the top of the Calvin main screen.

File Menu

This menu contains options for importing, exporting, and merging data. It also contains the **Exit** option, for closing Calvin. Pressing F10 also takes you out of Calvin.

- **Export.** See “Exporting Data” on page 75.
- **Import.** See “Importing Header Information” on page 63.
- **Merge CMP Data.** See “Merging Data” on page 69.
- **Exit.** Closes Calvin.

Program Menu

These options give you different gauge programming options to program the gauge to record the specific information you want. Calvin prompts you at each step of the process, to make programming the gauge easy.

- **Program Tools.** See “Programming Gauges” on page 19.
- **Program SD/MMC.** See “Multimedia Card Options for Hawk 9000” on page 4.
- **View Program on Tool.** See “Viewing the Program” on page 28.
- **Calculate Battery Usage.**

F8 opens a window that asks if you want program a fixed or multirate, or view the gauge program.

Dump Menu

The **Dump** command is used to download raw data from gauges. You will need to dump the gauge to collect the data that the gauge has recorded. See “Downloading Data” on page 51.

F6 opens your data folder containing your .cmp files so you can select a file to view in both calendar time and delta time.

Recompensate Menu

The **Recompensate** options are used to compensate raw data that has already been dumped. Since raw data is essentially a series of 1's and 0's, it must be recalculated or reformatted from machine language so it can be understood by humans. See “Recompensating Data” on page 57.

Calwin automatically compensates your raw data when it is saved. However, you may need to manually recompensate raw data. You might send or receive a binary file that needs to be manually recalculated. You will also need to manually recompensate raw data if the gauge was damaged in the field, since the serial number on the gauge may have become corrupted, or the calibration could have been scrambled or corrupted.

Recompensated files have a .cmp file extension. These files are stored in your data folder.

- **Recompensate from Disk**
- **Recompensate from SD/MMC**

F9 opens your data folder so you can select a binary file to recompensate.

Presentation Menu

Presentation options are used to view, graph, or print data once the raw data (bin file) has been recompensated. You cannot do any of these tasks until the bin file has been recompensated.

- **View Graph.** See “Graphing Data” on page 63.
- **Print Table.** See “Printing Data” on page 70.
- **View Table.** See “Viewing Data in Table View” on page 68.
- **View Differential Graph.** See “Differential Plot” on page 67.
- **Test Information.** See “Headers” on page 61.
- **Real-time.** See “Viewing Real Time Hawk 9000 Data” on page 154.

F1 opens your data folder, from which you can choose a .cmp file to create and print reports.

Tool Options Menu

These options are used to set or change the initial settings of surface gauge tools.

- **Tool Settings.** See “To view recorder parameters” on page 83.
- **Recorder Tools.** See “Recorder Tool Settings” on page 83.
- **Download Tools.** See “Download Tools” on page 87.
- **Change Real Time Settings.** See “AGA Flow Settings for Hawk 9000” on page 90.
- **Permanent Surface Box**
- **E-Line SRO**

Software Options Menu

This menu contains software setup items. These options are used to set or change the initial settings of the gauges.

- **Configuration.** See “Viewing the Configuration Screen” on page 92.
- **E-mail Setup**
- **File Tools.** See “File Tools” on page 91.
- **Turbine Tools.** See “Setting up Turbines” on page 38.

Chapter 3

Connecting Tools to Calvin

To access the data collected by downhole gauges or surface boxes, you must connect to the USB & Serial Interface Box and your computer. Before you connect, you should test the battery in the gauge to ensure that it is functioning correctly.

Connecting the Downhole Gauge

To connect the downhole gauge, you will need the following:

- Badger, Mole, or Wolverine gauge.
- USB & Serial Interface Box (Interface Box); also called the Dump Box.
- A USB cable or a serial cable.
- Computer.

Note

Insert a 9-volt battery into the back of the Interface Box when using a serial cable

To connect a downhole gauge to your computer and Interface Box

1. Attach one end of a USB or serial cable to the Interface Box, and the other end of the cable to the USB or serial port on your computer. Remember to insert a 9-volt battery into back of the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box cable to the top of the gauge.

3. Ensure that the red LED (light emitting diode) on the face of the Interface Box flashes 4 short signals to indicate that it is active.
4. If the LED flashes 4 short signals, you are now ready to communicate with the recorder using Calvin.
5. If the Interface Box LED does not flash 4 short signals, do not run the recorder. Disconnect the cables and try again until you see the 4 LED flashes.

Connecting a Hawk 9000 Surface Box

To connect a Hawk 9000 surface box to your laptop, you will need the following:

- Hawk 9000 surface gauge box. Note that the flat toggle button on the face of the surface box performs the same function as the black button on the right side of the unit. This is so you can use the protruding toggle button when the protective cover is on the surface box in the field.
- USB & Serial Interface Box with its 6-pin Lemo connector cable, or Raven interface box and RS-485 cable.
- Computer with Calvin software installed.
- A USB or serial cable.

Note

Insert a 9-volt battery into the back of the Interface Box when using a serial cable

Warning

Do not use the serial port of the surface box in hazardous locations. Program the surface box in a safe location before installing, or use the Raven interface box to program safely.

To connect the Hawk 9000 surface box

1. Attach one end of a USB or serial cable to of the Interface Box, and the other end of the cable to the appropriate port on your computer. Remember to insert a 9-volt battery into the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box 6-pin Lemo connector to the face of Hawk 9000 surface box.

You will need to set up and program the Hawk 9000 before you can actually turn the unit on. Refer to “Programming the Hawk 9000 Surface Box” on page 31.

Chapter 4

Programming Gauges

You can program gauges to collect data at a fixed rate, or create a schedule of specific time periods with multirates. Multiple sample rates are generally not needed, since Cal-Scan's tools can record well over 600 000 sample points. You can filter the data later if you do not need to view all of the data.

Programming Downhole Tools: Fixed Rate

Fixed Rate is used to program the recorder to run at one sample rate until the memory is full. You can enter the sample rate in seconds, minutes, or hours.

You will need to provide the following information:

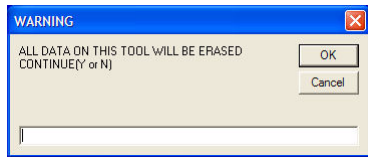
- *Sample Rate.* This is typically 30 seconds, but the rate you choose will depend on the type of test that you want to run. Usually, the reservoir engineer will specify the rate.
- *Expected downhole temperature.* This allows Calvin to calculate the expected current draw on the battery over the duration of the test. If you do not know the temperature, then enter the 150° C, the maximum temperature at which the gauge will run. Calvin will calculate the worst possible current draw.
- *Test duration.* This is used with the temperature to determine the number of amp hours of battery capacity that will be needed for the test.

Note

Calvin always programs the first 13 readings at a 5 second rate, even if you program the gauge for 30 seconds or some other rate. This enables you to see the last 4 LED flashes on the Interface Box immediately after you plug in the battery, rather than waiting for the specified interval to pass.

To program a gauge using fixed rate sampling

1. On the **Program** menu, click **Program Tools**. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the gauge data.

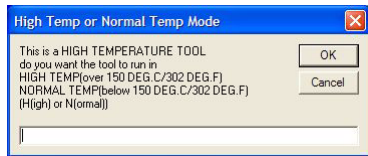


Erase Data Warning

2. If your gauge is a high-temperature gauge, choose the temperature mode. To run the gauge in high-temperature mode, type **H**, otherwise type **N**. Click **OK**.

Note

When you choose high-temperature mode, a warning appears, because battery consumption is higher in this mode. Type **Y** to confirm your choice, and click **OK**.



Temperature mode

3. Type the expected temperature. Click **OK**.



EXPECTED TEMPERATURE

Enter expected downhole temperature(DEG. C).

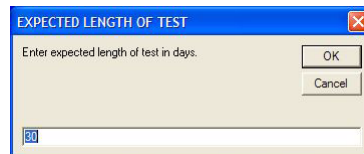
OK

Cancel

150

Expected Temperature

4. Type the test duration. Click **OK**.



EXPECTED LENGTH OF TEST

Enter expected length of test in days.


OK

Cancel

30

Test Duration

5. Type the sample rate and then click **Program Tool**. The Erase Data warning appears again. Type **Y** and click **OK** to proceed with programming.



Fixed Rate Programming

☒ FIXED RATE ☐ MULTI RATE ☐ SURFACE READ OUT

FIXED RATE

HOURS: 0 MINUTES: 0 SECONDS: 0

PROGRAM TOOL

EXIT

Fixed Rate Programming

6. Do not unplug the gauge or shut off the Interface Box while the gauge is being programmed. The new program settings appear. Once you see this message, it is safe to disconnect the Interface Box.

```

                                PROGRAM RATES
Recorder#: 9725
Date and Time Programmed: 12/08/2004 13:18:29

Sample Rate      Duration      # of Samples
HH:MM:SS        DDD:HH:MM:SS
00:00:05        000:00:01:00        12
00:00:05        040:09:57:20       698368

OVERRUN RATE
00:00:30        000:00:00:00

Programmed Duration      040:09:58:20
Total Duration Including Overrun      040:09:58:20
Number of samples used on recorder: 0
Tool has been programmed in NORMAL TEMPERATURE mode
AMP HOURS required for expected duration of 30 Days 0.544 AH
AMP HOURS required for Total duration including overrun 0.733 AH

```

Fixed Rate: Finish

Programming Downhole Tools: Multirate

Use the **Multirate** option to program the gauge to run up to 15 different sample rates during the test. You will need to specify the **Sample Rate** and the **Duration** for each rate.

The following example shows a sample rate of 10 seconds for 1 hour, and a second sample rate of 1 minute for 30 days. The columns show the sample rate number, sample rate, duration, and total accumulated samples. The length of test, samples remaining to be programmed, and the battery usage appear under the sample rate rows.

Program Sample Rates

☐ FIXED RATE
 ☒ MULTI RATE
 ☐ SURFACE READ OUT

MULTI RATE

	SAMPLE RATE			DURATION			SAMPLES USED
	HOURS	MINUTES	SECONDS	DAYS	HOURS	MINUTES	
<input checked="" type="checkbox"/> Select 1	0	0	10	0	1	0	360
<input checked="" type="checkbox"/> Select 2	0	1	0	30	0	0	43200
<input type="checkbox"/> Select 3							
<input type="checkbox"/> Select 4							
<input type="checkbox"/> Select 5							
<input type="checkbox"/> Select 6							
<input type="checkbox"/> Select 7							
<input type="checkbox"/> Select 8							
<input type="checkbox"/> Select 9							
<input type="checkbox"/> Select 10							
<input type="checkbox"/> Select 11							
<input type="checkbox"/> Select 12							
<input type="checkbox"/> Select 13							
<input type="checkbox"/> Select 14							
<input type="checkbox"/> Select 15							

LENGTH OF TEST: 30 Days 1 Hours 0 Minutes 0 Seconds
 SAMPLES LEFT: 273634
 BATTERY USAGE: 0.145

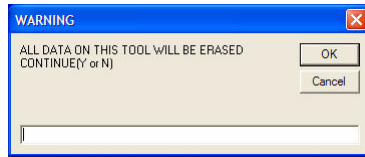
Multirate Example

Note

Calwin always programs the first 13 readings at a 5 second rate, even if you program the gauge for 30 seconds or some other rate. This way, you do not need to wait to see the 8 LED flashes on the Interface Box after you plug in the downhole gauge battery.

To program gauges using multrate

1. On the **Program** menu, click **Program Tools**. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the gauge data.

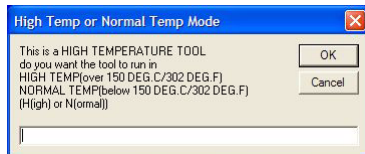


Erase Data Warning

2. If your gauge is a high-temperature gauge, choose the temperature mode. To run the gauge in high temperature mode, type **H**, otherwise type **N**. Click **OK**.

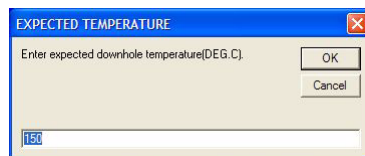
Note

When you choose high-temperature mode, a warning appears, because battery consumption is higher in this mode. Type **Y** to confirm your choice, and click **OK**.



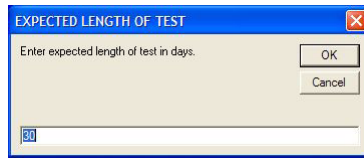
Temperature mode

3. Type the expected temperature. Click **OK**.



Expected Temperature

4. Type the test duration. Click **OK**.



Test Duration

5. The **Program Rates** dialog box appears. Click **Multirate**.



Program Rates

6. To begin selecting the sample rates, select the checkbox beside a row, for example, **Select 1**.

Program Sample Rates

☐ FIXED RATE ☒ MULTI RATE ☐ SURFACE READ OUT

MULTI RATE

	SAMPLE RATE			DURATION			SAMPLES USED
	HOURS	MINUTES	SECONDS	DAYS	HOURS	MINUTES	
<input checked="" type="checkbox"/> Select 1	0	0	10	0	1	0	360
<input checked="" type="checkbox"/> Select 2	0	1	0	30	0	0	43200
<input type="checkbox"/> Select 3							
<input type="checkbox"/> Select 4							
<input type="checkbox"/> Select 5							
<input type="checkbox"/> Select 6							
<input type="checkbox"/> Select 7							
<input type="checkbox"/> Select 8							
<input type="checkbox"/> Select 9							
<input type="checkbox"/> Select 10							
<input type="checkbox"/> Select 11							
<input type="checkbox"/> Select 12							
<input type="checkbox"/> Select 13							
<input type="checkbox"/> Select 14							
<input type="checkbox"/> Select 15							

LENGTH OF TEST: 30 Days 1 Hours 0 Minutes 0 Seconds SAMPLES LEFT: 273634 BATTERY USAGE: 0.145

SAVE PROGRAM TO HARD DRIVE RETRIEVE PROGRAM FROM HARD DRIVE

PROGRAM TOOL EXIT

Multirate

7. In the **Sample Rates** boxes that appear, type or select a sample rate.
8. In the **Duration** boxes, type or select the length of time that you want to sample. Ensure that the duration is longer than the sample rate.
9. To set another sample rate, repeat steps 6 to 8. Continue until you have entered all of your sample rates. If there is time left over in the test duration after entering the program, the rate will default to a 30 second sample rate for the remainder of the test duration.
10. To remove a sample rate, clear the check box.
11. After you are satisfied with the program you have set up, click **Program Tool**. The Erase Data warning appears again. Type **Y** and click **OK** to proceed with programming. The program details appear. To exit this screen and return to the Calvin Main Screen without programming the gauge, click **Exit**.

```

                                PROGRAM RATES
Recorder#: 9725
Date and Time Programmed: 12/08/2004 13:33:45

```

Sample Rate HH:MM:SS	Duration DDD:HH:MM:SS	# of Samples
00:00:05	000:00:01:00	12
00:00:10	000:01:00:00	360
00:01:00	030:00:00:00	43200

```

OVERRUN RATE
00:00:30          227:08:44:00          654808
Programmed Duration 030:01:01:00
Total Duration Including Overrun 257:09:45:00
Number of samples used on recorder: 0
Tool has been programmed in NORMAL TEMPERATURE mode
AMP HOURS required for programmed duration 0.145 AH
AMP HOURS required for Total duration including overrun 1.516 AH

```

Multirate Finish

Saving a Program to Disk

If you run the same test regularly, you can re-use a previously saved program that contains your selected sample rates and durations. You can also open a saved program and modify it before applying the program to the gauge.

To save a program to disk

1. Create a program as described in “To program gauges using multirate” on page 23.
2. Click **Save Program to Hard Drive**. A **Save File** dialog box appears. Type a name for the file and click **OK**. The program will be saved in C:\pressure\program.
3. Click **Program Tool** to apply the program settings.

To open a saved program

1. Open the **Program Sample Rates** dialog box as described in “To program gauges using multrate” on page 23.
2. On the **Program Sample Rates** dialog box, click **Retrieve Program from Hard Drive**. An **Open File** dialog box appears.
3. Choose the program file that you want to open and click **Open**. The program information appears in the **Program Sample Rates** dialog box. You can use the program as-is, or modify the settings.
4. Click **Program Tool** to apply the program settings.

Viewing the Program

You can view the sample rate details for a gauge after it has been programmed.

The information displayed will vary, depending on the gauge and its configuration. Typical information includes:

- **Recorder #**, the gauge serial number.
- **Date and Time Programmed**
- **Sample Rate, Duration** and **# Samples**, for each test phase, including the automatically-programmed 13 samples at the beginning of the test.
- **Overrun rate**, which defaults to 30 seconds. This is the rate that the gauge will collect samples if it continues to run beyond the programmed duration.
- **Programmed duration**, the length of time that you have programmed the gauge to collect samples.
- **Number of samples used on recorder**
- **Amp Hours** required for the test duration and for total duration, including overrun

To view a gauge's program

1. On the **Program** menu, click **View Program on Tool**. The program that is currently stored on the gauge appears on the computer screen.
2. You then have the option to print a copy of the program by clicking **Print to Printer** or **Print to PDF**. Most operators find it helpful to print a hard copy of the gauge program for future reference.

Chapter 5

Programming the Hawk 9000 Surface Box

The Hawk 9000 surface box can be programmed using fixed rate or multirate sampling.

Setting up Hawk 9000

Before programming the sample rate of a surface box, you will need to enter settings specific to the box, such as the surface box time, display options, password protection, temperature display units, and input selections.

It is helpful to set the Hawk 9000 time to your the time on computer if you want to overlay the data from more than one surface box. All of the boxes will then be running from the same clock.

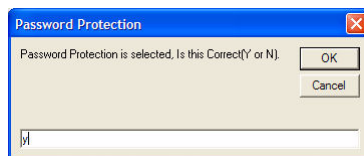
To set up the Hawk 9000 surface box

1. On the **Program** menu, click **Program Tools**. The **Surface Box Setup** dialog box appears.

Hawk 9000 Surface Box Setup

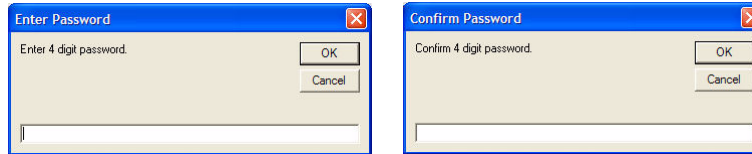
2. Choose one of the following in the **Display Options** box:
 - **Always On:** Display remains on all of the time.
 - **Always Off:** Display shows no pressures or temperatures.
 - **User Turn On:** Display turns on when the button is pushed, and stays on for length of time that you specify.
3. If you want to enable passwords, in the **Password Protection** box, click **Password On**. This option sets password protection for downloading and reprogramming the Hawk 9000. Ensure that everyone who needs to know the password knows it so they can program or download the Hawk 9000. To disable password protection, select **Password off**.
4. Choose the **Pressure Display Units**. This sets the pressure units that the Hawk 9000 will display. These units cannot be changed until the box is reprogrammed.

5. Choose the **Temperature Display Units**. This sets the temperature units that the Hawk 9000 will display. These units cannot be changed until the box is reprogrammed.
6. Choose data inputs from the gauge. The available inputs will depend on the hardware setup. You can enable data download by selecting the corresponding check box, and then assign a label for use in reporting. Select or type the name of the inputs the Hawk 9000 will use for the test:
 - **Pressure1**, pressure and internal temperature.
 - **Pressure2**, pressure and internal temperature.
 - **External RTD**, external temperature.
 - **Channel 4**, flow. The **4 to 20 ma (milliamps) Differential** box appears. Calvin automatically presents a formula for the calculation. You can choose this formula, or enter a new formula.
7. To set up flow calculations, in the **Flow Calculation** box, click **On**. In the **Orifice Meter** box, specify the orifice plate and meter tube diameters, and the specific gravity parameters. Click **OK**.
8. **Battery Voltage** displays the battery voltage of the Hawk 9000 to determine the battery charge level. If the batteries are low, the LCD display on the face of the Hawk 9000 will also show a battery warning.
9. Click **Done**.
10. If you have chosen to enable password protection, do the following:
 - a. Confirm that you want password protection by typing **Y** and clicking **OK**.



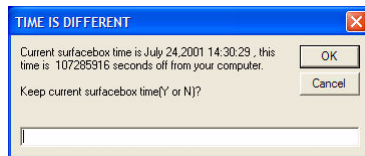
Confirm Password

- b. In the appropriate boxes, type and confirm a 4-digit password.



Confirm Password

11. The difference between the clock on the Hawk 9000 and your computer clock appears. To keep the Hawk 9000 time, type **Y**. To reset the Hawk 9000 time to match your computer, type **N**. Click **OK**.



Surface Box Time

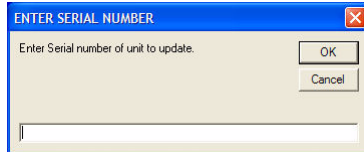
Updating Configuration with the MMC

Updating using the multimedia card enables you to change Hawk 9000 settings safely, without using the serial connection.

To use an MMC to update Hawk 9000 settings

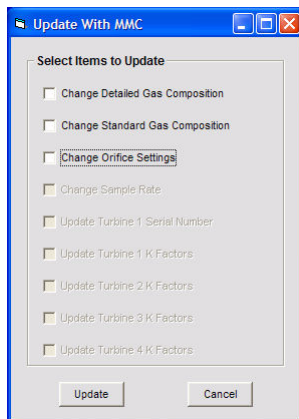
1. Download data from the Hawk 9000, as described in “To download data with a multimedia card” on page 53.
2. Set up your multimedia card reader as directed. Insert the MMC into the card reader.
3. Open Calvin, and on the **Program** menu, point to **Program SD/MMC** and click **Update settings**.

4. Type the serial number of the Hawk 9000 that you will update, and click **OK**.



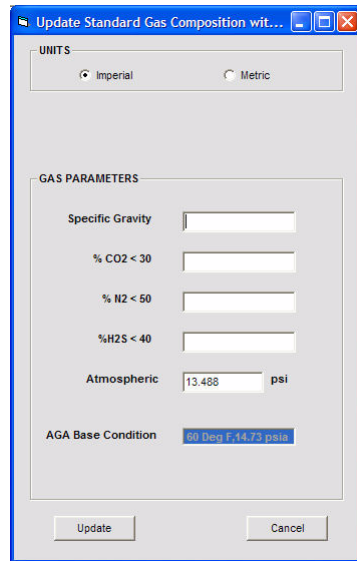
Enter Serial Number

5. In the **Update with MMC** dialog box, select the items that you want to update. Click **Update**.



Select Items to Update

- To update gas composition, define the units of measurement and gas parameters. Click **Update**.



The screenshot shows a software dialog box titled "Update Standard Gas Composition wit...". It contains two main sections: "UNITS" and "GAS PARAMETERS".

UNITS: This section has two radio buttons: "Imperial" (which is selected) and "Metric".

GAS PARAMETERS: This section contains several input fields and labels:

- "Specific Gravity" with an empty text input field.
- "% CO2 < 30" with an empty text input field.
- "% N2 < 50" with an empty text input field.
- "% H2S < 40" with an empty text input field.
- "Atmospheric" with a text input field containing "13.488" and a label "psi".
- "AGA Base Condition" with a text input field containing "60 Deg F, 14.73 psia".

At the bottom of the dialog box are two buttons: "Update" and "Cancel".

Update Standard Gas Composition

7. To update gas composition details, define the gas mix and click **Update**.

Update Detailed Gas Composition with...

Gas Mix Analysis

Mole Fractions(%)

Methane > 0.5 or < 1.0 (C1)	
Nitrogen < 0.5 or = 1.0 (N2)	
CO2 < 0.3 or = 1.0 (CO2)	
Ethane < 0.2 (C2)	
Propane < 0.05 (C3)	
Water < 0.00015 (H2O)	
Hydrogen sulfide < 0.0002 (H2S)	
Hydrogen < 0.10 (H2)	
Carbon monoxide < 0.03 (CO)	
Oxygen < 0.0002 (O2)	
iso-Butane (iC4)	
n-Butane (nC4)	
iso-Pentane (iC5)	
n-Pentane (nC5)	
n-Hexane < 0.001 (nC6)	
n-Heptane < 0.0005 (nC7)	
n-Octane (nC8)	
n-Nonane (nC9)	
n-Decane (nC10)	
Helium < 0.005 (He)	
Argon < 0.0002 (Ar)	

Sum of Fractions(%)

Atmospheric

13.488

Update Cancel

Update Detailed Gas Composition

8. To update orifice settings, define the units, gas parameters, and orifice plate settings. Click **Update**.

Update Orifice with MMC

UNITS

☒ Imperial ☐ Metric

GAS PARAMETERS

AGA Base Condition 60 Deg F, 14.73 psia

ORFICE PLATE SETTINGS

Orifice Plate Diameter Inches

Meter Tube Diameter Inches

Specific Gravity

LOCATION

☒ Upstream ☐ Downstream

TYPE

☒ Flange Tapped Orifice Plate ☐ ?

Update Cancel

Update Orifice

9. The new settings are saved to the MMC. You can now insert the card into the slot in the Hawk 9000 to update its settings. The settings are updated automatically.

Setting up Turbines

If your Hawk 9000 is set up with turbines, you will need to load a configuration file appropriate for the turbine type.

Depending on the type of turbine you are setting up, you can choose from two options:

- *Bi-directional*. For turbines equipped with two pickups, this option allows you to measure fluid flow in either direction. The Hawk 9000 can collect data from up to two bi-directional turbines (maximum four turbine inputs).
- *Filtering*. Each turbine input can measure the frequency of the turbine signal, and allows measurement of two gas densities. It can also separate two different densities, for example, if you are measuring liquids that occasionally has a burp of gas. The gas causes the turbine to spin faster than normal, causing the accumulation to be off. By choosing the maximum expected flow rate, Hawk 9000 can discard any flow rates that exceed this value. This leads to a very accurate rate. This filter rate can be used to separately accumulate each fluid, liquid, and gas rate.

To configure turbine settings

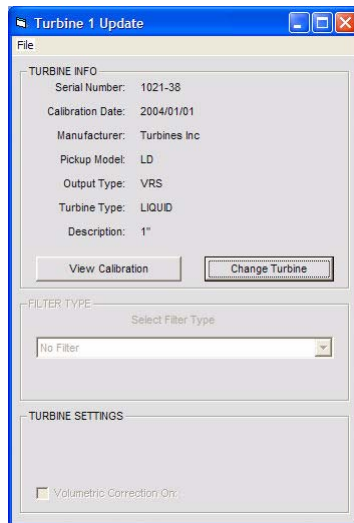
1. On the **Program** menu, click **Program Tools**. The **Surface Box Setup** dialog box appears.

The screenshot shows the 'Surface Box Setup' dialog box with the following details:

- Display Options:** ALWAYS ON
- Display Units:** Pressure: KPAG, Temperature: CELSIUS, Gas Flow: 10³ m³
- Password Protection:** ☐ PASSWORD ON, ☒ PASSWORD OFF
- Communication:** (Empty)
- Optional Well Information:** Company Name: Joes Farm, UWI or LSD: 123-456
- Channel Selections:** STATIC, TUBING 1, METER, CHANNEL 4. Checkboxes: Pressure 1, Pressure 2, External RTD 1, 4 to 20 mA Range 0 to 72.18238 psi.
- PULSED INPUT:** ACTUAL GAS FLOW, SN: 1021-38 1", Turbine 2 Off.
- Fluid Media:** UNKNOWN, Update button.
- Flow Calculations:** ☐ Off, ☒ On. Select Gas Channel Name: GAS FLOW. Flow Method: ☐ Flow Prover, ☐ Orifice Diff, ☒ Turbine. Supercompressibility: Standard.
- Sampling Information:** Minimum Sample Rate: 3 Seconds, Available Samples on: 398677.
- Battery Voltage:** 3.531
- Buttons:** DONE

Hawk 9000 Surface Box Setup

2. Select the check box that corresponds to the turbine that you are configuring, and do the following:
 - a. From the **Fluid Media** list, choose the type of fluid, such as **OIL**.
 - b. Click **Update**.
3. The **Turbine Update** dialog box opens. Do the following:
 - a. On the **File** menu, click **Open**. Choose the calibration file for the turbine and click **OK**.
 - b. On the **File** menu, click **Save**.
 - c. On the **File** menu, click **Exit**.



Turbine Update

4. Finish configuring the rest of the Hawk 9000 settings, as described in “To set up the Hawk 9000 surface box” on page 31.

Creating and Editing Turbine Calibrations

In order to configure turbine settings for the Hawk 9000, you will need to create and save an appropriate calibration file for the turbine type that you will be using.

There are some specific settings that you must enter when configuring the Hawk 9000 equipped with a turbine:

- *Serial number.* This is marked on the outside of every turbine. The serial number is used as the file name of the calibration file.
- *Calibration date.* This is an easy way to keep track of the last date of calibration, to determine when the calibration should be checked next.

- *Uni- or Bi-directional.* Turbines can be designed to either measure flow in only one direction, or to measure flow in both directions. This is usually indicated on the outside of the turbine, by an arrow. Hawk 9000 can be used to measure flow separately in both directions with bidirectional turbines.
- *Turbine type.* Each turbine is calibrated to measure one or both of liquid or gas. Check your calibration sheet to determine the type of turbine.
- *Output type.* Turbines pickups can have either two or three pins. For two-pin pickups, choose **URS**; for three-pin pickups, use **Open Collector**.

To create a turbine calibration

1. On the **Software Options** menu, point to **Turbine Tools**, and click **Edit Turbine Calibration**.

The screenshot shows the 'Turbine Calibration Info' window. It contains the following sections:

- Turbine Info:**
 - Serial Number: [Text Field]
 - Calibration Date (YYYY/MM/DD): [Text Field] / /
 - Manufacturer: [Text Field]
 - Pickup Model: [Dropdown Menu]
 - Uni/Bi Directional: [Dropdown Menu]
 - Output Type: [Dropdown Menu]
 - Turbine Type: [Dropdown Menu]
 - Turbine Description: [Text Field]
- Forward Gas Calibration:**

	FREQUENCY (Hz)	K FACTOR Pulses/USGAL
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

☐ 1 Factor
☐ 10 Factors ☒ 16 Factors

[CLEAR ALL]
- Forward Liquid Calibration:**

	FREQUENCY (Hz)	K FACTOR Pulses/USGAL
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

☐ 1 Factor
☐ 10 Factors ☒ 16 Factors

[CLEAR ALL]
- Reverse Gas Calibration:**

	FREQUENCY (Hz)	K FACTOR Pulses/USGAL
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

☐ 1 Factor
☐ 10 Factors ☒ 16 Factors

[CLEAR ALL]
- Reverse Liquid Calibration:**

	FREQUENCY (Hz)	K FACTOR Pulses/USGAL
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

☐ 1 Factor
☐ 10 Factors ☒ 16 Factors

[CLEAR ALL]

Turbine Calibration

2. In the **Turbine Calibration Info** dialog box, do the following:
 - a. In the **Serial Number** box, type the serial number of the turbine.
 - b. In the **Calibration Date** box, type the date.
 - c. In the **Manufacturer** box, type the maker of the turbine.
 - d. In the **Pickup Model** list, choose **LD** (low drag), **RF** (radio frequency), or **Std** (standard)
 - e. Choose **Uni-** or **Bi-** directional.
 - f. In the **Description** box, type a description.
 - g. In the **Turbine Type** list, choose **Gas**, **Liquid**, or **GasLiquid**.
 - h. In the **Output Type** list, choose **VRS** or **Open-collector**
 - i. Depending on the turbine type and direction you selected, up to four sets of calibration factors may be available for you to configure. For each, choose the number of factors, and then enter the **Frequency** and **K Factor** for each.
3. On the **File** menu, click **Save**.
4. On the **File** menu, click **Exit**.

To edit an existing turbine calibration file

1. On the **Software Options** menu, point to **Turbine Tools**, and click **Edit Turbine Calibration**.
2. On the **File** menu, click **Load**. From the dialog box that appears, choose the file to edit and click **Open**.
3. The saved settings appear in the **Turbine Calibration** dialog box. Edit these settings as required.
4. On the **File** menu, click **Save**.
5. On the **File** menu, click **Exit**.

Programming Hawk 9000: Fixed Rate

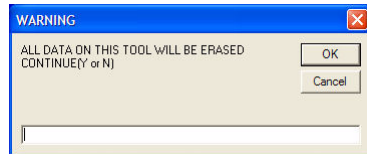
Fixed Rate is used to program the recorder to run at one sample rate until the memory is full. You can enter the sample rate in seconds, minutes, or hours.

Note

Calwin always programs the first 13 readings at a 5 second rate, even if you program the gauge for 30 seconds or some other rate. This means that you will see pressure samples immediately after the Hawk 9000 has been started.

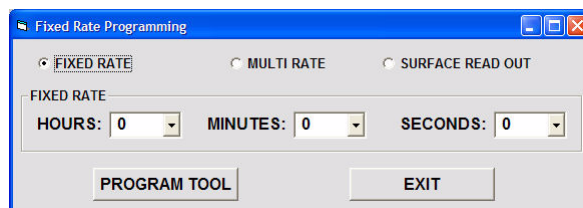
To program a surface box using fixed rate sampling

1. From the **Program** menu, click **Program Tools**. Set up the surface box as described in “Setting up Hawk 9000” on page 31. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the gauge data.



Erase Data Warning

2. Type the sample rate, and then click **Program Tool**.



Program Rates

3. Do not unplug the gauge or shut off the Interface Box while the gauge is being programmed. A message that shows the new program settings appears. Once you see this message, it is safe to disconnect the Interface Box.

```

                                PROGRAM RATES
Recorder#: 9725
Date and Time Programmed: 12/08/2004 13:18:29

Sample Rate      Duration      # of Samples
HH:MM:SS        DD:HH:MM:SS
00:00:05        000:00:01:00        12
00:00:05        040:09:57:20        698368

OVERRUN RATE
00:00:30        000:00:00:00

Programmed Duration      040:09:58:20
Total Duration Including Overrun      040:09:58:20
Number of samples used on recorder: 0
Tool has been programmed in NORMAL TEMPERATURE mode
AMP HOURS required for expected duration of 30 Days 0.544 AH
AMP HOURS required for Total duration including overrun 0.733 AH

```

Fixed Rate: Finish

Programming Hawk 9000: Multirate

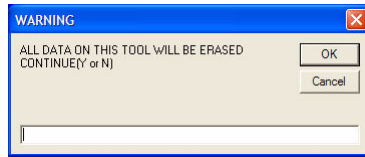
Use the **Multirate** option to program the gauge to run up to 15 different sample rates during the test. In the **Sample Rate Page**, you will need to specify the **Sample Rate** and the **Duration** for each rate.

Note

Calwin always programs the first 13 readings at a 5 second rate, even if you program the gauge for 30 seconds or some other rate. This way, you will see pressure samples immediately after the Hawk 9000 has been started.

To program Hawk 9000 with multrate

1. From the **Program** menu, click **Program Tools**. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the gauge data.



Erase Data Warning

- To begin selecting the sample rates, select the checkbox beside a row, for example, **Select 1**.

	SAMPLE RATE			DURATION			SAMPLES USED
	HOURS	MINUTES	SECONDS	DAYS	HOURS	MINUTES	
<input checked="" type="checkbox"/> Select 1	0	0	10	0	1	0	360
<input checked="" type="checkbox"/> Select 2	0	1	0	30	0	0	43200
<input type="checkbox"/> Select 3							
<input type="checkbox"/> Select 4							
<input type="checkbox"/> Select 5							
<input type="checkbox"/> Select 6							
<input type="checkbox"/> Select 7							
<input type="checkbox"/> Select 8							
<input type="checkbox"/> Select 9							
<input type="checkbox"/> Select 10							
<input type="checkbox"/> Select 11							
<input type="checkbox"/> Select 12							
<input type="checkbox"/> Select 13							
<input type="checkbox"/> Select 14							
<input type="checkbox"/> Select 15							

LENGTH OF TEST: 30 Days 1 Hours 0 Minutes 0 Seconds SAMPLES LEFT: 273634 BATTERY USAGE: 0.145

SAVE PROGRAM TO HARD DRIVE RETRIEVE PROGRAM FROM HARD DRIVE

PROGRAM TOOL EXIT

Multirate

- In the **Sample Rates** boxes that appear, type or select a sample rate.
- In the **Duration** boxes, type or select the length of time that you want to sample. Ensure that the duration is longer than the sample rate.

5. To set another sample rate, repeat steps 2 to 4. Continue until you have entered all of your sample rates. If there is time left over in the test duration after entering the program, the rate will default to a 30 second sample rate for the remainder of the test duration.
6. To remove a sample rate, clear the check box.
7. After you are satisfied with the program you have set up, click **Program Tool**. The program details appear. To exit this screen and return to the Calvin Main Screen without programming the gauge, click **Exit**.

```

                                PROGRAM RATES
Recorder#: 9725
Date and Time Programmed: 12/08/2004 13:33:45

Sample Rate      Duration      # of Samples
HH:MM:SS        DDD:HH:MM:SS
00:00:05        000:00:01:00        12
00:00:10        000:01:00:00        360
00:01:00        030:00:00:00        43200

OVERRUN RATE
00:00:30        227:08:44:00        654808

Programmed Duration  030:01:01:00
Total Duration Including Overrun  257:09:45:00
Number of samples used on recorder:  0
Tool has been programmed in NORMAL TEMPERATURE mode
AMP HOURS required for programmed duration 0.145 AH
AMP HOURS required for Total duration including overrun 1.516 AH

```

Multirate Finish

Saving a Program to Disk

If you run the same test regularly, you can re-use a previously saved program that contains your selected sample rates and durations. You can also open a saved program and modify it before applying the program to the gauge.

To save a program to disk

1. Create a program as described in “To program Hawk 9000 with multirate” on page 45.

2. Click **Save Program to Hard Drive**. A **Save File** dialog box appears. Type a name for the file and click **OK**. The program will be saved in C:\pressure\program.
3. Click **Program Tool** to apply the program settings.

To open a saved program

1. Open the **Program Sample Rates** dialog box as described in “To program Hawk 9000 with multrate” on page 45.
2. On the **Program Sample Rates** dialog box, click **Retrieve Program from Hard Drive**. An **Open File** dialog box appears.
3. Choose the program file that you want to open and click **Open**. The program information appears in the **Program Sample Rates** dialog box. You can use the program as-is, or modify the settings.
4. Click **Program Tool** to apply the program settings.

Restarting the Hawk 9000 Surface Box

After you have programmed the Hawk 9000, the clock on the unit will display the number 5.00. This indicates that the Hawk 9000 is in low power mode. You will need to restart the box to resume sampling.

To restart the Hawk 9000 after programming

1. Quickly press the toggle button at least 5 times within 3 seconds until pressures or temperatures appear in the display. If the number 5.00 reappears, you were not successful in starting the Hawk 9000, and it is not running.
2. The Hawk 9000 will not start sampling until the internal clock reaches an even minute. This makes synchronizing time easier when you are running more than one gauge.
3. Remove the Interface Box cable. The Hawk 9000 will not start sampling if the 6-pin Lemo connector is connected to the unit.

4. To toggle between sensors or channels on the Hawk 9000 display, press the toggle button.

Chapter 6

Downloading Data

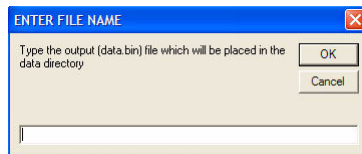
Once you have connected the gauge to your computer as described in “Connecting Tools to Calvin” on page 15, you can retrieve the data collected by the tool and save it to your computer. The **Dump** command pulls data from the gauge to your computer.

When you dump the gauge, the raw data is stored in a binary file format. Binary files (bin files) have a .bin extension at the end of the file name. Binary files will be stored in your data folder.

After the data is saved, it is compensated with the calibration data to produce real data. Compensated files have a .cmp file extension.

To download data from downhole gauges

1. Connect the gauge to your computer as described in “Connecting Tools to Calvin” on page 15. Click **Dump**. In the **Enter File Name** dialog box, type a name for the file and click **OK**. If a file with that name already exists, you can choose to overwrite the existing file or choose a new file name.



File Name

2. In the **Enter Start Date** dialog box, type the start date and start time for the recorder. This is the time that the battery was plugged into the gauge.

ENTER START DATE(MM/DD/YYYY HH:MM:SS)

Done

Start Time

3. The recorder will start uploading the binary (raw) data to the computer. You will see the samples counting down in the message window. After all of the samples have downloaded, you will see the samples counting down in the message window as they are compensating.
4. In the **Select Data for Output** dialog box, choose the data to plot on the left and right axes. Select the axis to plot from the **Available** list, and click the arrow buttons to move the selected data to the appropriate axis.

Select Data For Output

Exit

PLOT ON LEFT AXIS

9725 - Pressure - KPAG

AVAILABLE TO PLOT

PLOT ON RIGHT AXIS

9725 - Int Temperature - °C

PLOT DATA

Select Output Data

Downloading Data from Hawk 9000

Note

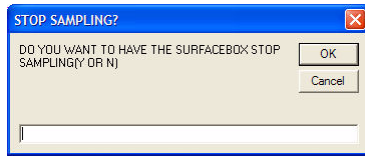
Do not use the serial port on the Hawk 9000 in hazardous locations. Download the data from the Hawk 9000 with a multimedia card or the Raven interface box instead. You may also do a sniff check, and then download the Hawk 9000 data with the serial port, but this is not recommended.

To download data with a multimedia card

1. Insert the multimedia card into the memory card slot on the face of the Hawk 9000. The conductors on the card should face the right side of the slot, in order to make contact with the prongs.
2. Press the toggle button on the Hawk 9000 to begin dumping the data onto the multimedia card. The LCD displays a **Card Busy** message, indicating that the dump is taking place.
3. When the data has been downloaded, the LCD displays a **Card Done** message. You can now remove the multimedia card.
4. Press the toggle button to reactivate the Hawk 9000 and return it to the normal display. You now have the binary (raw) data on the multimedia card, which you can manually compensate on your computer at a safe location. Insert the MMC card into a PCMCIA or USB MMC reader connected to your computer to copy the data file to your hard drive.

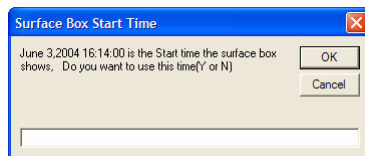
To download data with an Interface Box

1. Connect the Hawk 9000 to the USB & Serial Interface Box and laptop as described in “To connect the Hawk 9000 surface box” on page 17.
2. Click **Dump**. In the dialog box that appears, type **Y** to stop the Hawk 9000 sampling. The **Reprogram** light appears on the face of the box, and the Hawk 9000 goes to sleep to conserve power. If you type **N**, then the Hawk 9000 will resume sampling after the interface box is disconnected, and you will lose the data collected while the Interface Box is plugged in.



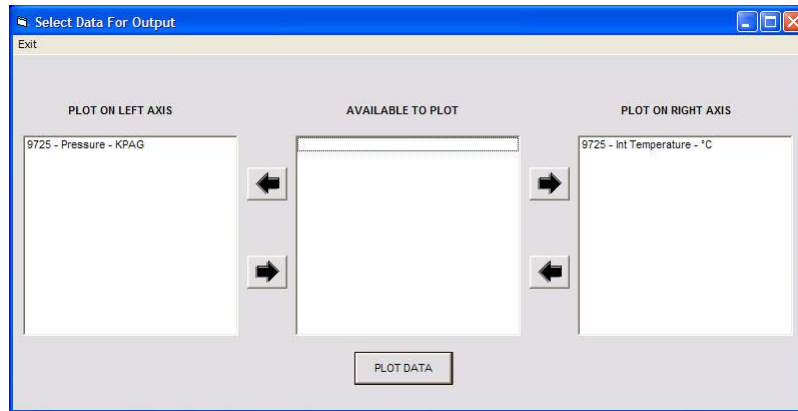
Hawk 9000 Sampling

3. In the **Save** dialog box, type the file name you want to use. If a file with that name already exists, you can choose to overwrite the existing file, or choose a new file name.
4. The time the Hawk 9000 was started appears. You can use this time by choosing **Y**, or you can enter your own time, by selecting **N**. This will be used by the software as the time that the Hawk 9000 was started.



Hawk 9000 Start Time

5. The recorder will start uploading the binary (raw) data to the computer. You will see the samples counting down in the message window. After all of the samples have downloaded, the program will begin to compensate the binary data.
6. In the **Select Data for Output** dialog box, choose the data to plot on the left and right axes. Select the axis to plot from the **Available** list and click the arrow buttons to move the selected data to the appropriate axis.



Select Output Data

7. Click **Plot Data**. The program will plot the channel you select.

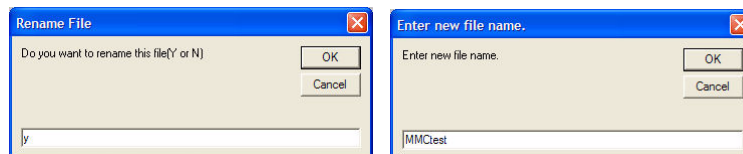
Chapter 7

Recompensating Data

This option allows you to compensate an existing binary file manually. For example, you might want to manually recompensate a binary file that was sent to you by modem or e-mail.

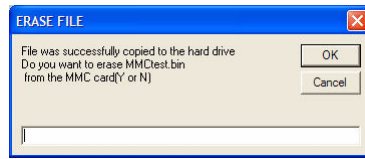
To manually recompensate data

1. On the **Recompensate** menu, click **Recompensate From Disk**, or press F9. If the binary file you want to compensate is on a multimedia card, rather than on the computer, insert the multimedia card (MMC) into the computer, and click **Recompensate From MMC**.
2. A **File Open** dialog appears that shows the binary files in your data folder. If necessary, browse to and select the appropriate location. Choose the file you want to recompensate, and click **Open**.
3. If you are compensating from MMC, do the following.
 - a. The **Rename File** dialog box appears. To rename the file, type **Y** and click **OK**. In the next dialog box, type the new name and click **OK**.



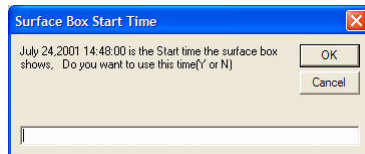
Rename file

- b. The **Erase File** dialog box appears. To clear the MMC, type **Y** and click **OK**.



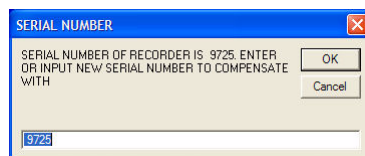
Erase File

- c. The **Surface Box Start Time** dialog box appears. To use the time on the surface box, type **Y**. If you want to manually select a start time, type **N**. Click **OK**.



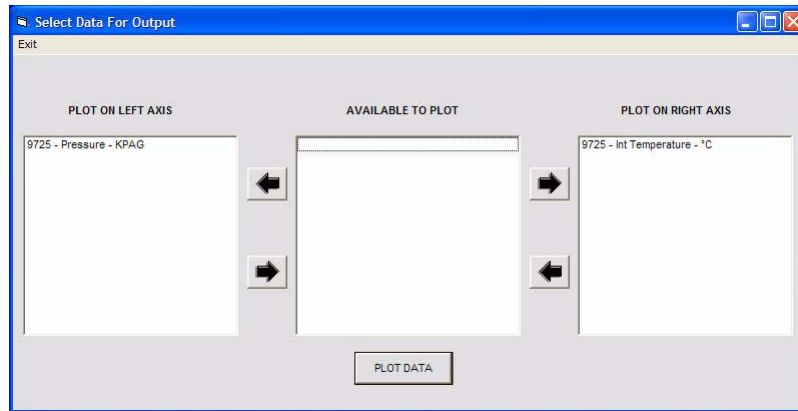
Surface Box Start Time

4. If **Calibration from Tool** was enabled in the **Configuration** dialog box, a window will display the serial number for the tool used in the test. Check the serial number, and type the correct number if necessary. Click **OK**.



Enter Serial Number

5. In the **Select Data for Output** dialog box, choose the data to plot on the left and right axes. Select the axis to plot from the **Available** list and click the arrow buttons to move the selected data to the appropriate axis.



Select Output Data

6. Click **Plot Data**. The recompensated data appears on the plot.

Chapter 8

Presenting and Viewing Data

After you have downloaded the data, you can view it in table or graph format.

Headers

Headers contain information about your company, which can then be inserted into your reports. There are a number of features that you can choose when you enable headers.

You can also import information from a header that is already saved on the computer. For example, to save time, you can complete the header form while the test is running, and save it to your Temp files. Then, after you download data from the gauge, you can import the header file from your Temp files. Note that you can save up to three lines in the address section of the header form.

To set header options

1. Enable headers. On the **Presentation** menu, click **Test Information**.

TEST INFORMATION

File Edit Gradient Stops Print

Oil Company Name:

Oil Company Address:

Well Location:

Well Name:

Field: Pool: Formation:

Type Of Test: Well Licence Number:

Well Fluid Status:

Well Mode Status:

Well Type Status:

Well Type Indicator:

Prod. Int.(KB)Top: Meters Prod. Int.(KB)Bottom: Meters

CF Elev.: Meters GRD. Elev.: Meters KB Elev.: Meters

Pool Datum: Meters Producing Through: O.H. Diameter: mm

Casing Liner Diameter: mm Tubing OD.: mm Tubing ID.: mm

Casing OD.: mm Casing ID.: mm PBTD: Meters

Total Depth: Meters Tubing Depth: Meters

Initial Tubing Pressure: KPAG Initial Casing Pressure: KPAG

Final Tubing Pressure: KPAG Final Casing Pressure: KPAG

Shut In (Must Have MM/DD/YYYY HH:MM:SS):

Run Depth Top (KB): Meters Run Depth Bottom (KB): Meters

Top Gauge On (MM/DD/YYYY HH:MM:SS):

Bottom Gauge On (MM/DD/YYYY HH:MM:SS):

On Bottom (MM/DD/YYYY HH:MM:SS):

Off Bottom (MM/DD/YYYY HH:MM:SS):

Remark #1:

Remark #2:

Remark #3:

Remark #4:

Header

2. In the **Test Information** dialog box, type your company information.
3. Save the header by doing the following:
 - a. On the **File** menu, point to **Save Header to Bin Files**, and click **Temp Bin File**. This option saves a copy of the header in a temp folder.
 - b. Type a name for the file, and click **OK**.
4. To apply the header information to an existing binary file, on the **File** menu, point to **Save Header to bin files**, and click one of the following:

- **Top Bin File.** The header will be imported into the file, and the program will take a half metre off the top gauge gradient depths.
- **Bottom Bin File.** The header will be imported into your file, and the program will retain the bottom gauge depths that you specified.

Importing Header Information

If you have previously saved a header, you can import the information from the saved file. You can also retrieve header information from an existing binary file, if you have applied header information to it.

To import a header

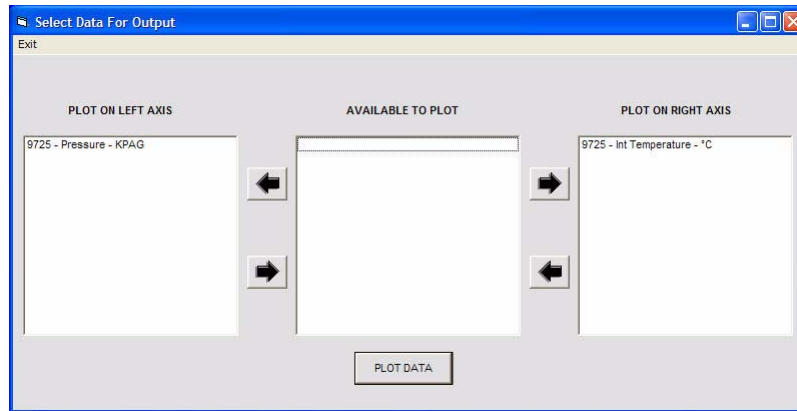
1. From the **Presentation** menu, click **Test Information**.
2. On the **File** menu, point to **Import Header**, and click either **Import from Bin File** or **Import from Temp File**. A list of the files in the bin directory appears.
3. From the **Select Bin File** list, choose the file to import and click **OK**.

Graphing Data

Graphing options allow you to graph pressure and temperature over time.

To create a graph

1. On the **Presentation** menu, click **View Graph**, or press F2.
2. A dialog box opens, showing the compensated files in your data folder. Select the file you want to graph, and click **Open**.
3. In the **Select Data for Output** dialog box, choose the data to plot on the left and right axes. Select the data to plot from the **Available** list and click the arrow buttons to move the selected data to the appropriate axis.



Select Output Data

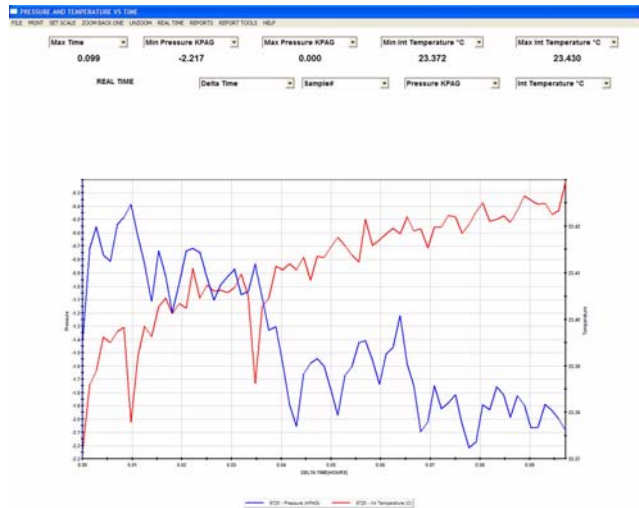
4. Click **Plot Data**. The data appears on the plot.

Graph Viewing Options

After you have created a graph, you can modify the display options to show only specific data, show the values at different points in the graph, print, and zoom.

Headings at the top of the graph show the **Max Time**, **Min Pres (pressure)**, **Max Pres**, **Min Temp** (temperature), and **Max Temp**.

Clicking the graph area displays the values at the selected point, as well as readings before and after the mouse point.



Sample Graph

Printing Graphs

You can print graphs to your default printer or create a PDF file.

To print a graph

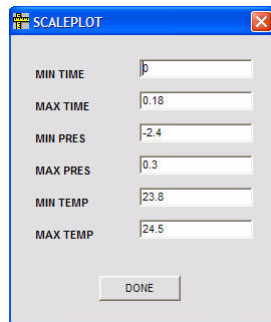
1. Create a graph as described in “To create a graph” on page 63. On the **Print** menu, click **Print to Printer** or **Print to PDF**.
2. In the dialog boxes that appear, type the oil company name, well location, and date of the test. Click **OK**.
3. The graph will print on the Windows default printer or save to PDF.

Setting Graph Scale

The scale of the graph is determined by the data in the test. You also can customize the scale.

To change the graph scale

1. Create a graph as described in “To create a graph” on page 63. Click **Set Scale**.

A screenshot of a software dialog box titled "SCALEPLOT". It contains six input fields for setting graph scales: MIN TIME (0), MAX TIME (0.18), MIN PRES (-2.4), MAX PRES (0.3), MIN TEMP (23.8), and MAX TEMP (24.5). A "DONE" button is located at the bottom.

Set Scale

2. Type the minimum and maximum time, pressure, and temperature in the appropriate boxes.
3. Click **Done** to apply the changes. You can now print or modify the graph as usual.

Zooming Graph Areas

To zoom into an area on the graph

1. Right-click and drag around the area you want to zoom.
2. To revert to the original view, click **Unzoom** on the graph menu bar. If you have zoomed more than once, and you can also use the **Zoom Back One** command to revert to the previous scale.

Viewing Calendar Time Graphs

delta time (time relative to the start time) is the default time format for graphs. You can also change the graph time to show the actual, calendar time.

To change the time format to calendar time in graphs

1. On the graph view tool bar, click **Real Time**. The menu name will change to **Delta Time**.
2. To change back to delta time, click **Delta Time**.

Changing the Start or End Time

You can change the start or end time that appears on the graph. When you export data from the adjusted graph, the exported data reflects the changes you made in the graph.

To change the start or end time

1. On the graph, click the location that you want to designate as the new start or end time.
2. On the **Report Tools** menu, click **Select Start** or **Select End**. The selected time will now appear as the new start or end time.

Differential Plot

The Differential plot displays the difference in pressure between two devices on the same graph so you can compare the data. Note that the start times of both gauges must be entered before the software will permit you to create a differential graph.

To create a differential plot

1. On the **Presentation** menu, click **View Differential Plot**.
2. A dialog box opens, showing the compensated files in your data folder. Select a file, and click **Open**.
3. Select the second file you want to graph, and click **Open**. A graph appears, showing the difference between the two sets of data.

Viewing Data in Table View

The table view displays the data from a recorder in tabular format.

To view data in table view

1. On the **Presentation** menu, click **View Table**, or press F4.
2. In the **Select cmp File** dialog box, select the file you want to view and click **OK**.

REAL TIME	DELTA TIME	SAIPLUB	Pressure	Air Temperature
hours			KPa(a)	°C
01/01/2004 00:00:05	0.001389	1	-1.407	23.372
01/01/2004 00:00:10	0.002778	2	-0.717	23.388
01/01/2004 00:00:15	0.004167	3	-0.683	23.359
01/01/2004 00:00:20	0.005556	4	-0.768	23.386
01/01/2004 00:00:25	0.006944	5	-0.817	23.389
01/01/2004 00:00:30	0.008333	6	-0.833	23.397
01/01/2004 00:00:35	0.009722	7	-0.484	23.386
01/01/2004 00:00:40	0.011111	8	-0.387	23.378
01/01/2004 00:00:45	0.012500	9	-0.629	23.392
01/01/2004 00:00:50	0.013889	10	-0.834	23.399
01/01/2004 00:00:55	0.015278	11	-1.118	23.386
01/01/2004 00:01:00	0.016667	12	-0.738	23.403
01/01/2004 00:01:05	0.018056	13	-0.921	23.408
01/01/2004 00:01:10	0.019444	14	-1.198	23.401
01/01/2004 00:01:15	0.020833	15	-0.974	23.403
01/01/2004 00:01:20	0.022222	16	-0.737	23.403
01/01/2004 00:01:25	0.023611	17	-0.713	23.411
01/01/2004 00:01:30	0.025000	18	-0.747	23.408
01/01/2004 00:01:35	0.026389	19	-0.893	23.407
01/01/2004 00:01:40	0.027778	20	-1.103	23.408
01/01/2004 00:01:45	0.029167	21	-0.983	23.408
01/01/2004 00:01:50	0.030556	22	-0.927	23.408
01/01/2004 00:01:55	0.031944	23	-0.874	23.407
01/01/2004 00:02:00	0.033333	24	-1.062	23.410
01/01/2004 00:02:05	0.034722	25	-1.040	23.408
01/01/2004 00:02:10	0.036111	26	-0.834	23.386
01/01/2004 00:02:15	0.037500	27	-1.087	23.403
01/01/2004 00:02:20	0.038889	28	-1.329	23.408
01/01/2004 00:02:25	0.040278	29	-1.302	23.411

SCROLL SAMPLE TIME: 0.002778 SCROLL SAMPLE# 1

View Data

Merging Data

To use this feature, the files you select must have the start times entered in them. You can merge the data from up to eight different gauges into one file. This feature allows you to:

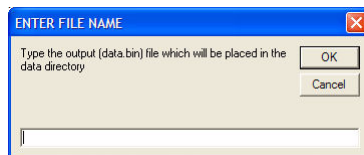
- Add more recent data to an older file, to make a continuous record.
- Compare how different recorders are running in relation to each other.
- Merge downhole data to Hawk 9000 data; for example, adding pressure data to surface flow.

Note

When merging files with different time ranges and multiple gauges, you must merge files to create a continuous record for each gauge separately, before merging data from different gauges.

To merge data

1. On the **File** menu, click **Merge CMP Data**. A dialog box opens, showing the compensated files in your data folder. Select a file, and click **Open**.
2. The dialog box appears again. Select the another file, and click **Open**.
3. In the **Enter File Name** dialog box, type a name for the merged data file and click **OK**. The data from the two files are now combined in one file.

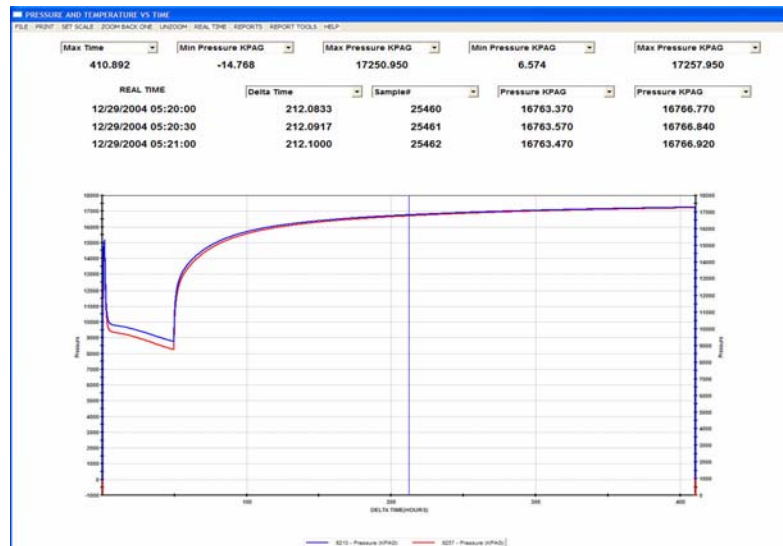


Save Merged File

4. To merge the data from another gauge, repeat steps 1 and 2, selecting the merged file as the first file.

Merging Data: Examples

In the following example, the data from two downhole gauges (top and bottom) are merged and compared. This helps to verify that the gauges are operating correctly. When the gauges are submerged in liquid, there should be about a pound of pressure difference between the two, due to higher hydrostatic pressure on the bottom gauge.



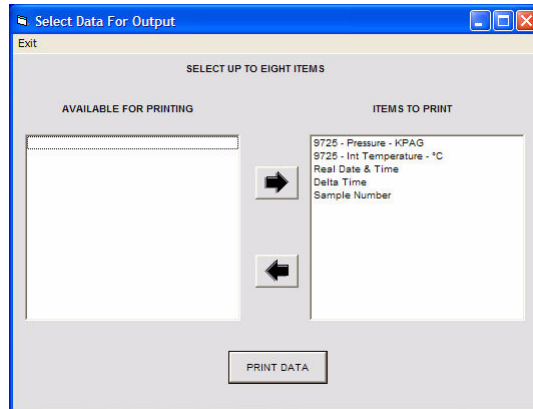
Merging top and bottom gauge data

Printing Data

To print table data

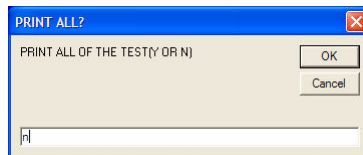
1. On the **Presentation** menu, click **Print Table**. You can also press F1.
2. A dialog box opens, showing the compensated files in your data folder. Select the file that contains the data that you want to print, and click **Open**.

3. In the **Select Data for Output** dialog box, choose the data columns that you want to print by selecting the name of the column in the **Available** column and clicking the arrow buttons. Click **Print Data**.



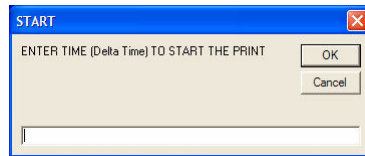
Select Print Output

4. Choose the time range of the data to print:



Choose data time range

- To print the whole report, type **Y**.
- If you want to print a section of the data, type **N**. In the appropriate boxes, type the start hour and the end hour of the data section you want to print. If the test is 100 hours long, and you want to print the data between 10 and 20 hours, 10 hours will be the start hour, and 20 hours will be the end hour.

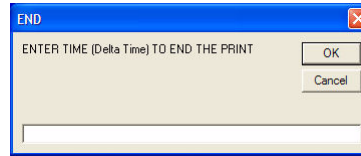


START

ENTER TIME (Delta Time) TO START THE PRINT

OK

Cancel



END

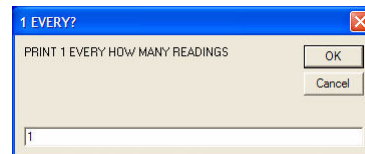
ENTER TIME (Delta Time) TO END THE PRINT

OK

Cancel

Choose data time range

5. In the **Print 1 Every How Many Readings?** box, type the number of samples you want to print. For example, enter 1 to print every reading, or type 10 to print every 10th reading.



1 EVERY?

PRINT 1 EVERY HOW MANY READINGS

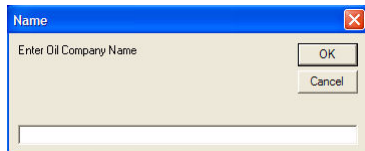
OK

Cancel

1

Print Every?

6. Type the **Oil Company Name**.



Name

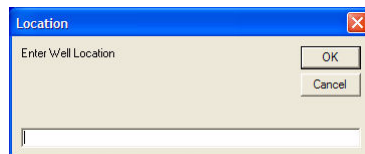
Enter Oil Company Name

OK

Cancel

Oil Company Name

7. Type the **Location**.



Location

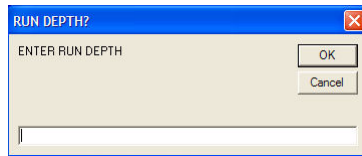
Enter Well Location

OK

Cancel

Well Location

8. Type the **Run Depth**, and then click **OK**.



Run Depth

Chapter 9

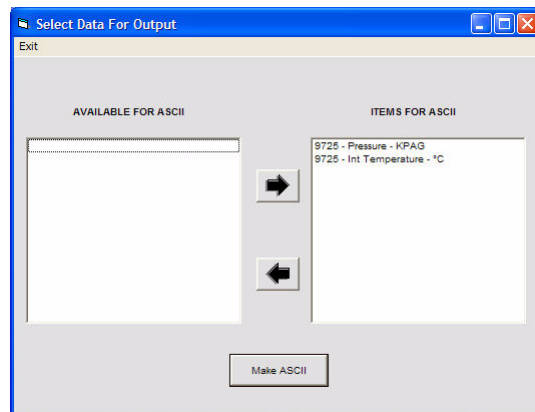
Exporting Data

This option exports data from a compensated file to an ASCII file that can be viewed in a spreadsheet, or in a text editor, such as Microsoft Word or WordPad.

You can choose to export all samples of the selected data with the **Standard ASCII** option, or use the **Advanced ASCII** option to filter the samples.

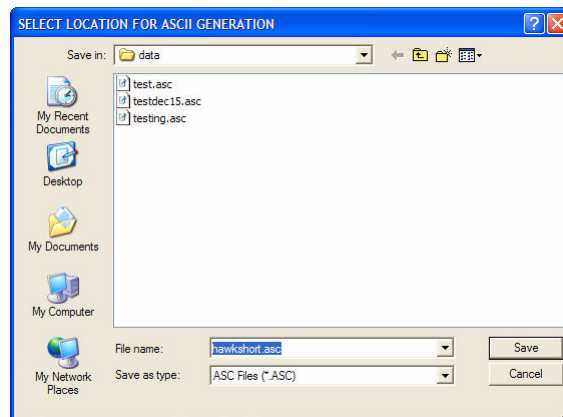
To export compensated data to standard ASCII

1. On the **File** menu, point to **Export, ASCII File**, and click **Standard ASCII**. You can also press F7.
2. A dialog box appears that displays all of the compensated files in the data folder, which is C:\PRESSURE\DATA by default. If necessary, browse to and select the appropriate directory. Choose the file you want to make an ASCII file for and click **Open**.
3. In the **Select Data for Output** dialog box, choose the data that you want to include. Select the data channel from the **Available** column and then click the arrow button to move it to the **Items for ASCII** box.



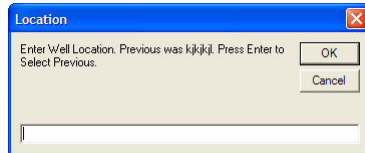
Select Data for Output

4. Choose the file name and the location in which you want to save the ASCII file. The default directory is C : \PRESSURE\DATA.



Save ASCII

5. If you have set the ASCII Header to **ON** in the Configuration Screen, a dialog box opens that asks you if you want to use all test header information in the ASCII file. Type **Y** to use include all header information. If you type **N**, you will be asked to enter a **Well Location** for the test. See “Headers” on page 61. Click **OK**.



Well Location

6. The message **ASCII File Complete** will appear. To view the ASCII File, use Windows Word or WordPad to open the file.

Exporting to Filtered ASCII

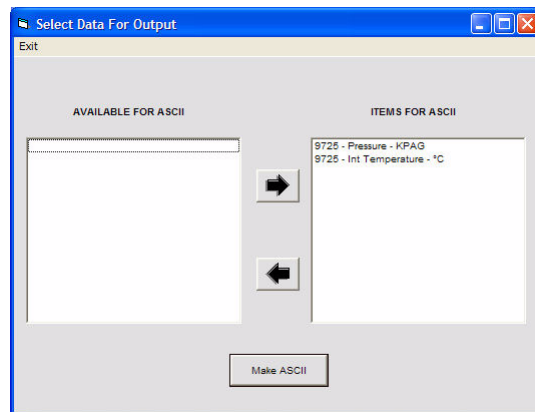
ASCII files are typically 10 times as large as the original compensated file. This makes it difficult to e-mail or load into third-party software. You may want to filter ASCII files to reduce the number of samples that you export to limit the size of the ASCII file.

The **Advanced ASCII** option allows you to filter the samples in two ways:

- Remove data points at specified intervals, for example, remove every second sample.
- Export the data points within a specified time span only.
- Remove data points that have not changed in value significantly over long periods of time. This option ensures that you do not lose important data by keeping data points that show major changes.

To export compensated data to filtered ASCII

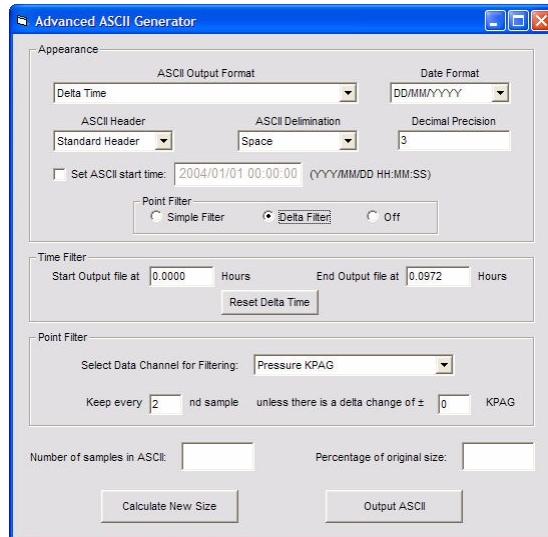
1. On the **File** menu, point to **Export, ASCII File**, and click **Advanced ASCII**.
2. A dialog appears that displays all of the compensated files in your data folder, which is usually C:\PRESSURE\DATA. If necessary, browse to and select the appropriate directory. Choose the file you want to make an ASCII file for and click **Open**.
3. In the **Select Data for Output** dialog box, choose the data that you want to include. Select the data channel from the **Available** column and then click the arrow button to move it to the **Items for ASCII** box.



Select Data for Output

4. In the **Appearance** area, choose the time and date formats and the decimal precision.
 - a. **ASCII Output Format**
 - **Delta Time**, time relative to the specified start time.
 - **Date Real Time**, the date, plus the actual calendar time.

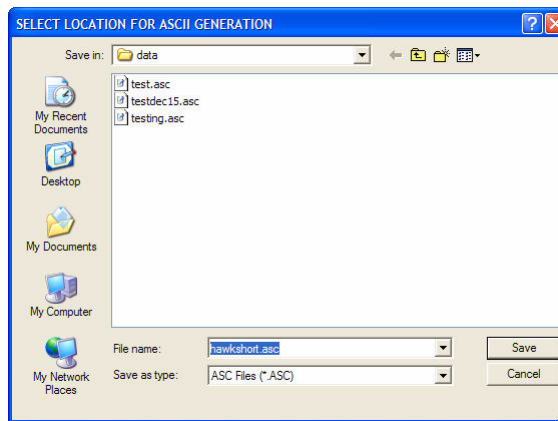
- **Date Real Time Delta Time**, the date, actual time, and relative time.
- b. **Date Format**
 - **DD/MM/YYYY**
 - **MM/DD/YYYY**
 - **YYYY/MM/DD**
- c. **ASCII Header**. If you have configured headers as described in “Headers” on page 61, you can insert this information into the ASCII output.
 - **Standard**
 - **None**
- d. **ASCII Delimiter**, the character used to separate fields in the exported file:
 - **Space**
 - **Comma**
 - **Tab**
- e. **Decimal Precision**, number of decimal places to include.



Advanced ASCII

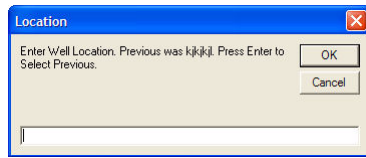
5. If the start time is incorrect, select **Set ASCII start time**, and type the correct start time in the box.
6. To filter data, in the **Filter** box, click one of the following options:
 - **Simple Filter**, to remove samples at fixed intervals.
 - **Delta Filter**, to filter according to the change in value.
7. To define the time period, in the **Start Output File** and **End Output File** boxes, type the delta time (relative to start) of the start and end of the time period. You can also use the graph view to select the start and end times, as described in “Changing the Start or End Time” on page 67.
8. In the **Keep every** box, type the number of samples you want to discard between samples you keep. for example, if you want to ensure that you keep at least every 10th sample, type 10.

9. If you selected **Delta Filter**, from the **Select Channel for filtering** list, choose the data that you want to filter. In the **Unless there is a delta change of** box, type the change in value at which Calvin will consider a sample significant. For example, if you type 5, Calvin will discard all data points unless the value changes by more than 5 units from the previous point. Calvin will then record the point at which the change occurred, as well as the previous point.
10. Click **Calculate New Size** to see the number of samples and the percentage of the original size of the resulting file after filtering.
11. Click **Output ASCII**.
12. Choose the file name and location in which you want to save the ASCII file. The default directory is C : \PRESSURE\DATA.



Save ASCII

13. If you have set the ASCII Header to **ON** in the Configuration Screen, you will be asked to enter a Well Location for the test. See “Headers” on page 61.



Well Location

14. The message **ASCII File Complete** will appear. To view the ASCII File, use Windows Word or WordPad to open the file.

Exporting to FAS

FAS (Fekete ASCII Standard) is a standard file format used by Fekete Associates Inc. petroleum software. You can export CMP files to this format to use it with Fekete applications that require this format.

The procedure for creating FAS files is the same as for ASCII files, except that options for filtering and formatting are disabled.

Chapter 10

Tool Options and Diagnostics

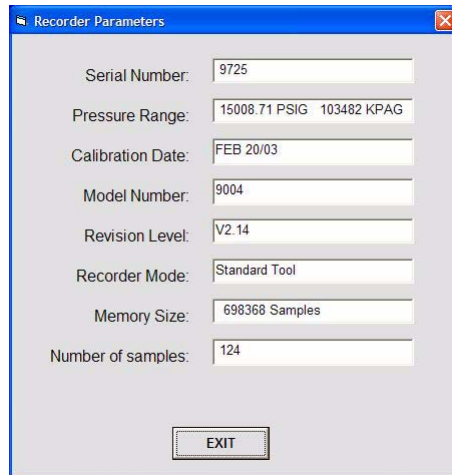
This chapter describes how to change the settings for orifice plate size, calibration, serial number, and start time. It also covers viewing and downloading tool information.

Recorder Tool Settings

The **Recorder Parameters** window displays the parameters of the gauge, as shown in the following example. You can also edit the settings in this dialog box.

To view recorder parameters

1. On the **Tool Options** menu, click **Tool Settings**.
2. The **Recorder Parameters** dialog box opens.



The image shows a Windows-style dialog box titled "Recorder Parameters". It contains several input fields for configuring a recorder. The fields and their values are: Serial Number (9725), Pressure Range (15008.71 PSIG 103482 KPAG), Calibration Date (FEB 20/03), Model Number (9004), Revision Level (V2.14), Recorder Mode (Standard Tool), Memory Size (698368 Samples), and Number of samples (124). An "EXIT" button is located at the bottom center of the dialog.

Parameter	Value
Serial Number:	9725
Pressure Range:	15008.71 PSIG 103482 KPAG
Calibration Date:	FEB 20/03
Model Number:	9004
Revision Level:	V2.14
Recorder Mode:	Standard Tool
Memory Size:	698368 Samples
Number of samples:	124

Recorder Parameters

Setting Recorder Serial Number

A low battery or a damaged gauge can scramble the gauge data and serial number. **Set Serial#** allows you to insert the serial number back into the gauge. When you select this feature, a window will ask you for a password.

Contact Cal-Scan at (780) 944-1377 for consultation and password information.

Inserting Recorder Calibration

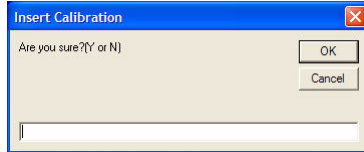
A low battery or a damaged gauge can cause a calibration error to occur when you are recompensating a bin file. When this happens, you will need to use the **Insert Calibration** feature to insert a new calibration from C:\PRESSURE\CALB into the gauge.

Calwin automatically saves the calibration of each new gauge it comes in contact with. The calibration files are saved in C:\PRESSURE\CALB.

On older gauges, you will need to manually save the calibration for each gauge. See "Downloading Recorder Calibration" for more information on this process.

To insert recorder calibration

1. On the **Tool Options** menu, point to **Recorder Tools** and click **Insert Calibration**. In the dialog box that appears, confirm that you want to continue by typing **Y** and clicking **OK**.



Confirm

2. The calibration is updated.

Getting Hours On Tool

Cal-Scan gauges automatically record the number of hours the gauges have been running. The **Get Hours on Tool** feature displays the number of hours that the gauge has been used.

Note

The hours on the gauge can only be reset by a Cal-Scan representative.

To view the hours on a tool

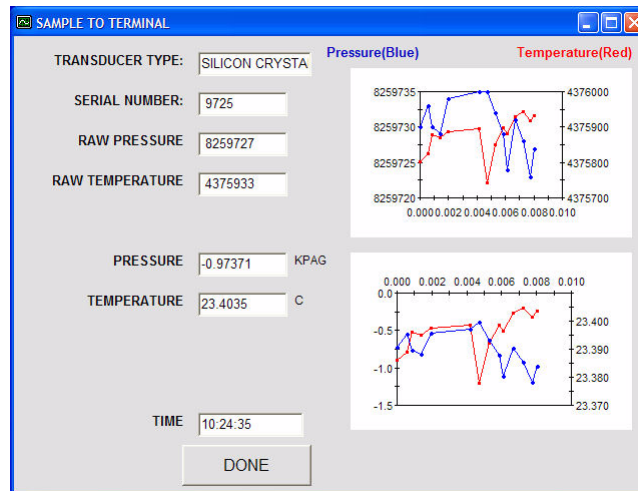
1. On the **Tool Options** menu, point to **Recorder Tools** and click **Get Hours on Tool**.
2. The number of hours appears in the message window.

Sampling to Terminal

This feature allows you to monitor the samples the gauge is collecting. If you suspect that the gauge is not operating correctly, you can view the samples by selecting **Sample to Terminal**. This is particularly useful for downhole gauges, where there is no LCD display.

To view samples on the terminal

1. On the **Tool Options** menu, point to **Recorder Tools** and click **Sample to Terminal**. The pressure and temperature will be displayed as the gauge is sampling.



Sample to Terminal

2. When you are finished observing the samples, click **Done**.

Downloading Recorder Calibration

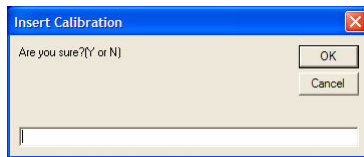
The **Download Calibration** feature is used to download the calibration from the gauge into C : \PRESSURE\CALB. If a calibration error occurs, you can download the calibration back onto the gauge and resume recompensation.

A low battery or a damaged gauge can cause a calibration error when you are recompensating a bin file.

Calwin automatically creates a calibration file for each new gauge it comes in contact with. These files are stored in C : \PRESSURE\CALB. If you see a calibration error, you know you have an older gauge.

To download a recorder calibration file

1. On the **Tool Options** menu, point to **Recorder Tools** and click **Download Calibration**. In the dialog box that appears, confirm that you want to continue by typing **Y** and clicking **OK**.



Confirm

Download Tools

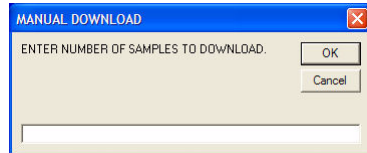
Download tools allow you to specify the data that you want to retrieve from the tool or MMC, such as restricting the time span of the data, or from the end of memory.

Manually Dumping Data

This feature allows you to download a specific number of readings that the gauge has recorded, starting with the first sample. This is useful if the gauge has been damaged, and you suspect it is showing the incorrect number of samples.

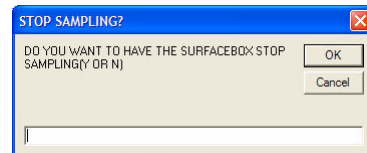
To manually download data

1. From the **Tool Options** menu, point to **Download Tools** and click **Manual Dump**.



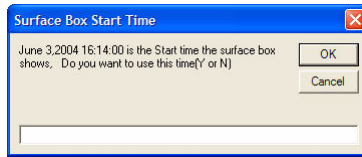
Manual Dump

2. In the **Manual Dump** dialog box, type the number of samples to download and compensate. Click **OK**.
3. If you want the gauge to continue sampling during the dump, type **Y** and click **OK**. Type **N** to stop sampling while you download data.



Stop Sampling

4. Type a name for the file you are creating. Select the start time. If you are using a Hawk 9000, choose the channel you want to plot.



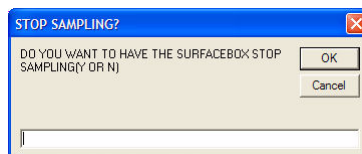
Start Time

Find End Of Memory and Download

A low battery or a damaged gauge can scramble your data or cause the gauge to lose track of the end of memory. If the gauge has been damaged and you suspect that it is showing the incorrect number of samples, use this feature to automatically locate the end of memory.

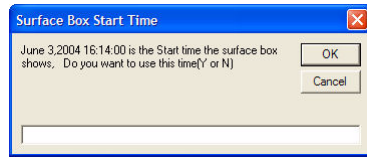
To locate the end of memory

1. On the **Tool Options** menu, point to **Download Tools** and click **Find End of Memory and Download**.
2. If you want the gauge to continue sampling during the dump, type **Y** and click **OK**. Type **N** to stop sampling while you download data.



Stop Sampling

3. Type a name for the file you are creating. Select the start time. If you are using a Hawk 9000, choose the channel you want to plot.



Start Time

AGA Flow Settings for Hawk 9000

This feature is designed for Hawk 9000 boxes that have been programmed for flow calculations. The **Flow Calculation** must be set to **On** in the **Surface Box Setup** dialog box.

Flow calculations are performed using parameters such as pressure differential and orifice size to estimate the flow rate. If flow rate becomes unmeasurable due to incorrect orifice size, you may need to change the orifice diameter. In this case, you will need to change the orifice settings in the gauge as well.

Note

You can change the orifice settings up to 31 times before the gauge will stop recording the changes.

To change orifice settings

1. On the **Tool Options** menu, point to **Change Real-time Settings** and click **Change Orifice Settings**.

Change Orifice Settings

2. In the **Flow Prover Setup** dialog box, type the new size. Click **OK**. The new diameter will automatically be applied.

File Tools

File tools allow you to view and edit gauge and gauge program data stored in a file.

Setting Start Time

If the start time was entered incorrectly during data retrieval, you can use this feature to change the start time in a binary or CMP file.

To set the start time in a binary file

1. On the **Software Options** menu, point to **File Tools** and click **Set Start Time**. From the list that appears, select the binary file to edit and click **OK**.



Set Time

2. In the **Set Start Time** dialog box, type the new start time and click **Done**.

Getting Tool Data From a File

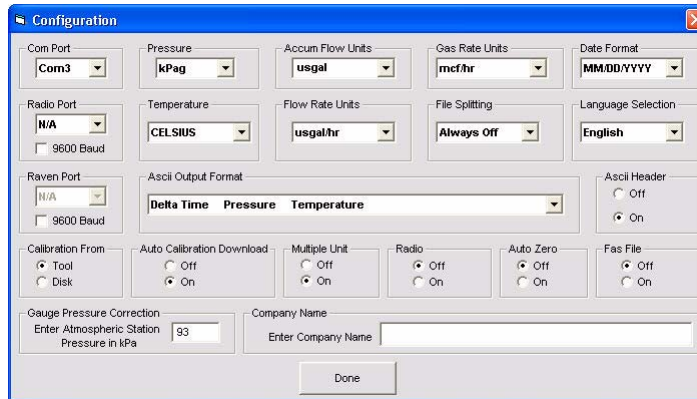
This feature allows you to extract gauge data from a binary file.

To get tool data from a file

1. On the **Software Options** menu, point to **File Tools** and click **Get Tool Data from File**.
2. From the list that appears, select the file to use and click **OK**. The program information opens.

Viewing the Configuration Screen

This feature allows you to view or change the gauge program defaults to meet your needs.



Configuration

You can set the following:

- Units of measurement, including pressure, temperature, flow rate, and gas rate.
- Origin of **Calibration** data, from tool or disk. For information about calibration files, see “Inserting Recorder Calibration” on page 84.
- **Auto Calibration Download** When this is set to **On**, Calwin will automatically create a copy of the device’s calibration file when it is connected.
- **ASCII headers** inserts the header information into ASCII files you generate. For information about headers, see “Headers” on page 61.
- **Radio** enables radio mode.
- **Multiple unit** allows you to view and configure any of the devices on your network, if you have a number of gauges set up.
- **Gauge Pressure Correction.** The value you type into this box will be subtracted from the absolute pressure when viewing pressure in gauge. For example, at an elevation of 2000 feet above sea level, you would enter 93 (kPa).

- **Date format**
- **ASCII output formats**
- **Auto Zero** sets all negative values to 0.
- **File splitting** sets your preferences for splitting files. You can set Calvin to divide the downloaded data whenever the battery was disconnected and reconnected.
- **Language**

Setting Up Com Ports

Com ports are the communication ports on the back of your computer that allow you to connect devices such as your mouse or the Interface Box. Each com port can accommodate only one device.

In most circumstances, your computer should automatically detect the Interface Box, but you may occasionally need to manually set the Com port when using a serial connection.

To set up Com ports

1. On the **Diagnostics** menu, click **Set Up Com Port**. Calvin automatically establishes which port the Interface Box should use, given the other devices you have connected to your computer.
2. To check which Com port the Interface Box is using, on the **Diagnostics** menu, click **Configuration**. If necessary, you can change the port number and click **OK**.

Operation Guide

Chapter 11

Introduction to Gauge Operation

This part of the guide describes downhole tools, their setup, and maintenance.

About Badger and Mole Silicon Strain Gauges

Badger and Mole are downhole silicon strain gauges that measure pressure and temperature. Badger and Mole are dependable, user friendly, and power-efficient. The outside diameter of the Mole is 3/4", and the outside diameter of the Badger is 1.25". All housings are made of 718 INCONEL™ or equivalent material. The Badger and Mole come in a variety of pressure ranges, from 750 psi to 15 000 psi.

The Calvin software package and a USB & Serial Interface Box are used to program and download data from all of our tools.

These tools maintain high accuracy and resolution with low power consumption. Badger and Mole require only one AA lithium battery to power them for up to 1 year, eliminating the need to stack batteries to get the test in. The savings in the battery costs alone make these tools an attractive alternative to the other tools on the market today.

Cal-Scan also carries a fast response temperature tool, in both 1.25" and 3/4". The sample rate on these tools can be set as fast as one sample per second. With a total of 696 000 samples, the tool will run for up to 4 days at this rate. The recorder will still fill the memory with any sample rate on a single AA battery, even if the memory is doubled to 1.3 million samples.



Badger and Mole

Badger and Mole Specifications

Pressure Accuracy	0.024% Full Scale
Pressure Resolution	0.0003% Full Scale
Pressure Drift	< 3 psi/Year
Pressure Ranges	Various up to 15 000 psi
Temperature Accuracy	0.15% Full Scale
Temperature Resolution	0.002% Full Scale
Operating Temperature	up to 150° C
Power Requirements (volts)	3.3 VDC
Power Requirements (battery life)	1 AA Lithium Cell/Year
Number of Data Points	348 000 Sets (Expandable)
Minimum Sample Rate	1 Sample/Second
Housing Material	718 INCONEL™ Standard

Housing Diameter	0.75 and 1.25 Inches
Housing Length 0.75 Inch Recorder	12 and 20 Inches
Housing Length 1.25 Inch Recorder	22 Inches
Transducer Type	Silicon Crystal
Communications	RS-232 via Communication Box
Software	Windows 95/98/2000/XP

About Badger Tri Tool Silicon Gauge

External temperature sensors have been standard on most logging tools for years, but they can be expensive. The Badger Tri Tool is an innovative, cost-effective downhole tool that records fast-response external temperature using an external temperature sensor, in addition to accurate internal pressure and temperature readings at a one second sample rate.

Temperature recorders can give you valuable information about a well. Unfortunately, these sensors are slow, because the temperature sensor is located near the pressure sensor to obtain an accurate pressure calculation. Badger Tri Tool was designed to detect fast-changing temperature transients, so the data can be used effectively.



Badger Tri Tool

Badger Tri Tool Specifications

Pressure Accuracy	0.024% Full Scale
Pressure Resolution	0.0003% Full Scale
Pressure Drift	< 3 psi /Year
Pressure Ranges	Various up to 15 000 psi
Temperature Accuracy	15% Full Scale
Temperature Resolution	002% Full Scale
Temperature Response	17 Seconds (90% of 0° C to 100° C)
Operating Temperature	Up to 150° C
Power Requirements (volts)	3.3 VDC
Power Requirements (battery life)	1 AA Lithium Cell/Year
Number of Data Points	348 000 Sets (Expandable)
Minimum Sample Rate	1 Sample/Second
Housing Material	8 INCONEL™ Standard
Housing Diameter	0.75 and 1.25 Inches
Housing Length 0.75 Inch Recorder	2 and 20 Inches
Housing Length 1.25 Inch Recorder	22 Inches
Transducer Type	Silicon Crystal
Communications	RS-232 Via Communication Box
Software	Windows 95/98/2000/XP

About Wolverine Quartz Gauge

The Wolverine has the same usability of our Badger and Mole tools, but with 10 times better stability and resolution than the typical strain gauge. This improved performance increases the sample rate to 1/10th of a second, yet with the same accuracy as Badger and Mole. This allows you to capture fast pressure pulses (for example in fracing) that other downhole recorders would miss.

The Wolverine works with the industry's standard quartz transducers, and is the first quartz tool to operate using only one 3.6 volt lithium cell (for temperatures under 150° C), or two cells (for temperatures over 150° C).

Wolverine is built for durability and dependability. All housing is made of 718 INCONEL™ or equivalent material to provide a long-lasting housing. We extensively test all of our tools at elevated temperatures to ensure that it will stand up to the rigors of the oil field.

The Wolverine comes in a variety of pressure ranges to 20 000 psi, and two temperature ranges, 150° and 177° C.



Wolverine

Wolverine Tool Specifications

Pressure Accuracy	< $\pm 0.02\%$ Full Scale (0.015 typical)
Pressure Resolution	< 0.0001% Full Scale (1-second sample rate or greater) < 0.00024% Full Scale (0.1 to 0.5 second sample rate)
Pressure Drift	< 1psi/Year
Pressure Ranges	Up to 20 000 psi
Temperature Accuracy	$\pm 0.5^\circ\text{C}$ ($\pm 15^\circ\text{C}$ typical)
Temperature Resolution	0.0002% Full Scale
Operating Temperature	Up to 175°C
Battery Requirements	One or two 3.6 or 3.9 volt Lithium C/CC Cell
Battery Life	Fills memory at least once with a battery pack
Number of Data Points	696 000 or 1.38 million
Minimum Sample Rate	0.1 second
Maximum Sample Rate	18 hours
Housing Material	8 INCONEL™ Standard (other types available)
Housing Diameter	0.75 and 1.25 Inches (other sizes available)
Housing Length 1.25 Inch Recorder	30 inches (standard battery pack) 34 inches (extended battery pack)
Transducer Type	Quartz
Communications	RS-232 via Communication Box
Software	Windows 95/98/2000/XP

About Hawk 9000 Surface Box

Hawk 9000 is a low-powered, dependable surface box that can monitor two pressure inputs, external temperature (through an RTD), and differential pressure (using a 4/20ma) input. The sensors allow you to monitor oil and gas well buildups, perform flow line analysis (with the optional external RTD or differential pressure sensor), as well as monitor general pressure and temperature. The onboard LCD display allows the operator to view the pressure and temperature on both pressure sensors, and the temperature on the external RTD.

The Hawk 9000 performs well even under extreme environmental conditions. Field tests have shown that the data quality on the Hawk 9000 is superior to other surface box units available on the market.

We use our Calwin software package and a USB & Serial Interface Box to program and download data from all of our tools.

Hawk 9000 Features

- Password Protection
- Generic 4/20ma input allows you to use any 4/20ma sensor
- Pressure ranges are from 750 psi to 15 000 psi
- Calibrated temperatures from -40° to 80° C.
- Double the memory available
- SD/multimedia card input for downloading data in an explosive environment

The Hawk 9000 can record data at any sample rate for up to a year using a single 3.6 V Lithium C-Cell. Depending on the box configuration, you can collect up to 348 000 samples per pressure channel, or up to 270 000 with the external RTD. If you need to collect more samples, more memory can be added.

You can set the display to be always on, always off, or to shut itself off after a programmed time interval. If the display is set up to turn itself off, it can be turned back on by pressing the button on the outside of the box. Display units (kPag or pSig) can be set at time of programming. For added security, you can set a password to prevent unauthorized downloading or reprogramming of the unit.

Hawk 9000 is fully CSA and UL approved for use at hazardous sites.

The built-in SD multimedia card (MMC), similar to the ones used in digital cameras, allows you to download data without a laptop. These cards are fully approved to be used in hazardous locations; you do not need to perform a sniff check for explosive gas, as you would with a laptop.

Cal-Scan can also custom design surface gauge boxes to meet your needs. A wireless communication board allows monitoring and downloading without connecting to a communication box.

Hawk 9000 Safety Approvals

Standard Box with Multimedia Card	Div 1 Class 1 Group A,B,C,D CSA/UL
With 4/20mA and/or External RTD	Div 1 Class 1 Group A,B,C,D CSA/UL
With I/O Expansion Card	Div 1 Class 1 Group A,B,C,D CSA/UL
With RS-485/External Power Card	Div 2 Class 1 Group A,B,C,D CSA/UL
With Wireless Link	Div 1 Class 1 Group A,B,C,D CSA/UL

Hawk 9000 Specifications

Pressure Accuracy	0.024% Full Scale
Pressure Resolution	0.0003% Full Scale
Pressure Drift	< 3 psi/Year
Pressure Ranges	Up to 15 000 psi
Pressure Units	psia, psig, kPaa, kPag
Temperature Accuracy	0.15% Full Scale
Temperature Resolution	0.002% Full Scale
Temperature Units	°C or °F
Operating Temperature	40° - 50° Celsius
Power Requirements (volts)	Two 3.6 VDC lithium C-cells
Power Requirements (battery life)	1 Lithium battery pack/Year
Number of Data Points	696 000 or 1 392 000 sets/channels
Minimum Sample Rate	1 Sample/2 Seconds
Transducer Type	Silicon Crystal
Communications	RS-232, USB, RS-485, wireless
Software	Windows 95/98/2000/XP

Chapter 12

Downhole Gauge Setup

Before setting up a downhole tool, you must first decide what you want to do with the data. This chapter describes the gradient and extended tests using downhole tools, and how to configure the tools to collect appropriate data for these tests. Tool programming is accomplished with the Calvin software, which is described in detail in the Calvin Reference Guide.

Setting up the gauge consists of the following steps:

- Programming the sample rate and duration of the test.
- Cleaning the tool or replacing O-rings, if necessary.
- Testing the battery.
- Installing the battery and verifying its operation.
- Running the gauge.

Guidelines for a Successful Downhole Test

To run a downhole test successfully, you must ensure that the gauge is undamaged and runs properly, and that the data collected is valid. Otherwise, you must determine what problems occurred during data collection so you can interpret the data appropriately.

Cal-Scan's gauges, while designed to withstand vertical shock, do not tolerate side impact. Although you may want to save time by lowering gauges down the hole as quickly as possible, line speeds greater than 150 feet per minute can lead to impact with the sides of the pipe, and damage to the tool.

You must test the battery each time you run a test, especially if you are using a new one. High-temperature lithium ion batteries can oxide (passification film), which decreases the voltage. Passification can cause the gauge to stop working.

In sub-room temperature, the battery will need to be warmed for best performance. See “Testing the Downhole Tool Battery” on page 120 for information about testing and verifying battery operation.

Check that O-rings are intact and the correct type before running tests. These prevent well fluids from entering the gauge and damaging the sensitive instruments inside. O-ring failure can lead to data loss and expensive repairs.

The pressure sensor is much less resistant to chemicals than the body of the gauge. During long tests, or when well fluids may be corrosive, you will need to protect the sensor itself. See “Protecting the Transducer” on page 132 for information about protection methods.

Testing the Gauge Before Downhole Tests

Despite your best efforts, sometimes the test will go wrong. Fortunately, you can follow certain procedures to ensure that even in the event of a problem, you can still use the data collected during a test, or at least narrow down the possible causes of the problem.

Before running any test, start an end test by exposing the pressure sensor to atmosphere for at least ten samples. Atmospheric pressure is fairly stable, and so serves as a good reference against which you can test the gauge measurement. A failing gauge sensor will produce a reading well beyond the normal atmospheric pressure. A normal atmospheric reading indicates that the gauge is operating properly, and data collected will be likely to be correct.

Downhole Extended Test

In most well tests, a limited amount of fluid is allowed to flow from the formation being tested. The formation is isolated behind cemented casing and perforated at the formation depth, or the formation is straddled by a pair of packers that isolate the formation, in openhole. The pressure at the formation is monitored over time. The formation is then closed (or shut in), and the pressure

is monitored at the formation while the fluid within the formation equilibrates. Analyzing these pressure changes can provide sufficient information to characterize a well.

The most frequently used pressure transient test is the *pressure buildup* test. The test is conducted by producing a well at constant rate for some time, shutting the well in, allowing the pressure to buildup in the wellbore, and then recording the pressure (usually downhole) in the wellbore over time.

Another common test is the *drawdown* test, conducted at the start of well production or following an extended shut-in period. Rate and pressure are recorded as function of time. Drawdown data are usually noisy, meaning that the pressure fluctuates as fluid flows past the gauges, and small variations in flow rate occur. This is especially true for new wells, where well cleanup can last for days after production has begun. Due to the noise, such data can be difficult to interpret.

Pressure falloff tests, performed on injection wells, are analogous to pressure buildup tests in production wells.

Pressure gradient tests determine the change in wellbore fluid pressure as a function of depth, typically in psi/ft. or kpa/m. These tests imply formation fluid density or fluid contacts to determine the depth of any fluid.

All of these tests involve running the downhole gauge in the well for the entire duration of the test.

Programming for an Extended Test

Fixed Rate is used to program the recorder to run at one sample rate until the memory is full. You can enter the sample rate in seconds, minutes, or hours.

In order to program the gauge for an extended test, you will need to provide the following information:

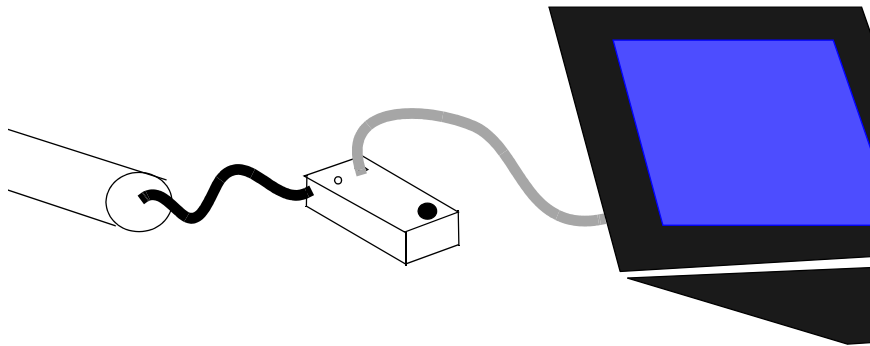
- *Sample Rate.* This is typically 30 seconds, but the rate depends on the type of test that you want to run. Usually, the reservoir engineer will specify the rate. Multiple sample rates are generally not needed, since Cal-Scan's tools can record well over 600 000 sample points. You can filter the data later if you do not need to view all of the data.
- *Expected downhole temperature.* This allows Calvin to calculate the expected current draw on the battery over the duration of the test. If you do not know the temperature, then enter 150° C, the maximum temperature in which the gauge will run. Calvin will calculate the worst possible current draw.
- *Test duration.* This is used with the temperature to determine the number of amp hours of battery capacity that will be needed for the test.

Note

Calvin always programs the first 13 readings at a 5 second rate, even if you program the gauge for 30 seconds or some other rate. This enables you to see the last 4 LED flashes on the Interface Box immediately after you plug in the battery, rather than waiting for the specified interval to pass.

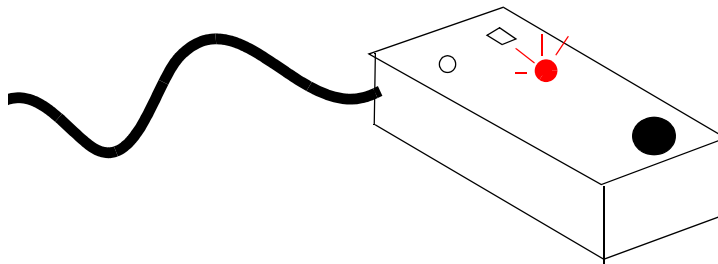
To program a gauge for an extended test

1. Attach one end of a USB or serial cable to the USB & Serial Interface Box, and the other end of the cable to the USB or serial port on your computer. Remember to insert a 9-volt battery into back of the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box cable to the top of the gauge.



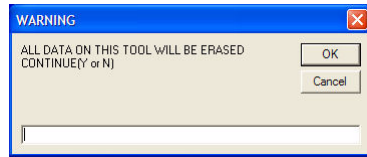
Programming a gauge

3. Ensure that the red LED (light emitting diode) on the face of the Interface Box flashes 4 short signals to indicate that it is active. If the 4 short signals do not appear, do not run the recorder. Disconnect the cables and try again until you see the 4 LED flashes.



Ensure that the Interface Box is active

4. Open the Calvin program. On the **Program** menu, click **Program Tool**. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the gauge data.

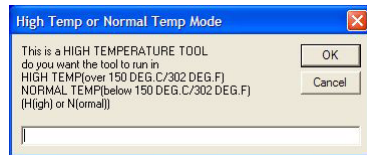


Erase Data Warning

5. If your gauge is a high-temperature gauge, the **Temperature mode** dialog box appears. To run the gauge in high temperature mode, type **H**, otherwise type **N**. Click **OK**.

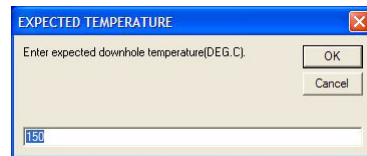
Note

High-temperature mode will deplete the battery more quickly than normal mode. Use this mode only if the temperature will be greater than 150° C.



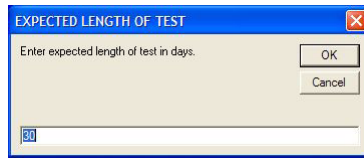
Temperature mode

6. Type the expected downhole temperature. Click **OK**.



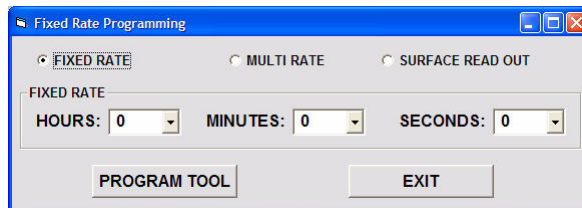
Expected Temperature

7. Type the test duration. Click **OK**.



Test Duration

8. Type the sample rate, for example, 30 seconds, and then click **Program Tool**. Do not unplug the gauge or shut off the Interface Box while the gauge is being programmed. A message that shows the new program settings appears. Once you see this message, it is safe to disconnect the Interface Box.



Fixed Rate Programming

9. After you have finished programming the gauge, the program rates appear. Verify that the settings are correct:
 - **Recorder #**, the gauge serial number.
 - **Date and Time Programmed**.
 - **Sample Rate, Duration, and # Samples**, for each test phase, including the automatically-programmed 13 samples at the beginning of the test.
 - **Overrun rate**, which defaults to 30 seconds. This is the rate at which the gauge will collect samples if it continues to run beyond the programmed duration.

- **Programmed duration**, the length of time that you have programmed the gauge to collect samples.
- **Number of samples used on recorder**.
- **Temperature mode**, either high temperature or normal.
- **Amp Hours** required for the test duration and for total duration, including overrun. Ensure that your battery capacity is enough to power the gauge for the expected test length. Standard cell capacity is 1.5 amp hours.

```

PROGRAM RATES

Recorder#: 9725
Date and Time Programmed: 12/08/2004 13:18:29

Sample Rate      Duration      # of Samples
HH:MM:SS        DDD:HH:MM:SS
00:00:05        000:00:01:00    12
00:00:05        040:09:57:20    698368

OVERRUN RATE
00:00:30        000:00:00:00

Programmed Duration    040:09:58:20
Total Duration Including Overrun    040:09:58:20
Number of samples used on recorder: 0
Tool has been programmed in NORMAL TEMPERATURE mode
AMP HOURS required for expected duration of 30 Days 0.544 AH
AMP HOURS required for Total duration including overrun 0.733 AH

```

Fixed Rate: Finish

10. Inspect the O-Rings and replace if necessary, as described in “To replace O-rings” on page 130.
11. Test and install the battery, as described in “Testing the Downhole Tool Battery” on page 120 and “Plugging the Battery into the Downhole Tool” on page 122.

Downhole Gradient

The downhole gradient test is a common in the oilfield. This test allows you to determine three things about the well:

- Depth of fluid in the well, such as water or oil.
- Bottom hole pressure.
- Density of gas.

To run the test, an operator runs the gauges downhole, stopping them after a certain depth to allow the gauge to settle. After getting a good pressure reading at the first depth, the operator lowers the gauges, and takes a measurement at the new depth. The data at different depths can then be used to create a pressure/depth plot. The plot, along with standard time/pressure plot, can be interpreted to yield the information described previously.

In order to produce accurate results, you must record the actual depth carefully. Otherwise, the gradient will contain errors.

The gradient test involves running the downhole gauge in the well for the entire duration of the test.

Programming for a Downhole Gradient

Fixed Rate is used to program the recorder to run at one sample rate until the memory is full. You can enter the sample rate in seconds, minutes, or hours.

In order to program the gauge for a downhole gradient test, you will need to provide the following information:

- *Sample Rate*. This is typically 30 seconds, but the rate depends on the type of test that you want to run. Usually, the reservoir engineer will specify the rate. Multiple sample rates are generally not needed, since Cal-Scan's tools can record well over 600 000 sample points. You can filter the data later if you do not need to view all of the data.

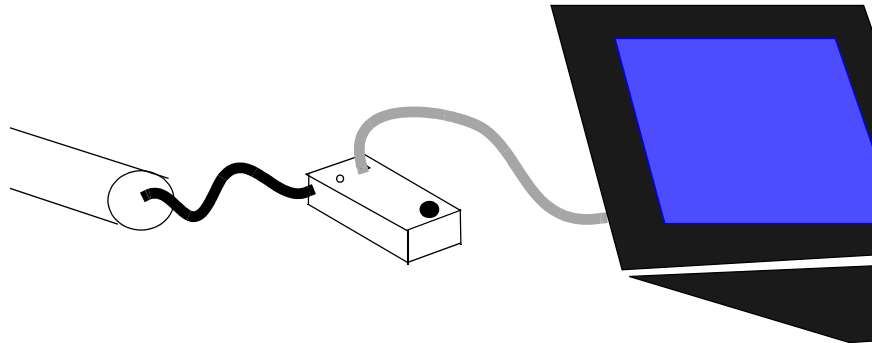
- *Expected downhole temperature.* This allows Calvin to calculate the expected current draw on the battery over the duration of the test. If you do not know the temperature, then enter 150° C, the maximum temperature in which the gauge will run. Calvin will calculate the worst possible current draw.
- *Test duration.* This is used with the temperature to determine the number of amp hours of battery capacity that will be needed for the test.

Note

Calvin always programs the first 13 readings at a 5 second rate, even if you program the gauge for 30 seconds or some other rate. This enables you to see the last 4 LED flashes on the Interface Box immediately after you plug in the battery, rather than waiting for the specified interval to pass.

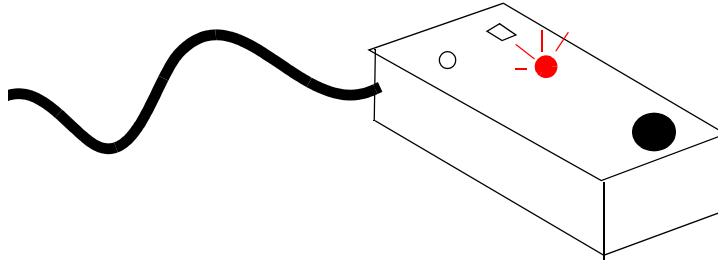
To program a gauge for a downhole gradient

1. Attach one end of a USB or serial cable to the USB & Serial Interface Box, and the other end of the cable to the USB or serial port on your computer. Remember to insert a 9-volt battery into back of the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box cable to the top of the gauge.



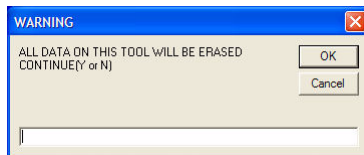
Programming a gauge

3. Ensure that the red LED (light emitting diode) on the face of the Interface Box flashes 4 short signals to indicate that it is active. If the 4 short signals do not appear, do not run the recorder. Disconnect the cables and try again until you see the 4 LED flashes.



Ensure that the Interface Box is active

4. Open the Calwin program. On the **Program** menu, click **Program Tool**. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the gauge data.

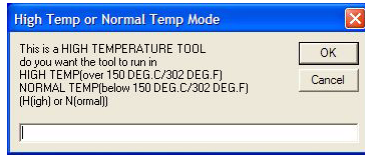


Erase Data Warning

5. If your gauge is a high-temperature gauge, the **Temperature mode** dialog box appears. To run the gauge in high temperature mode, type **H**, otherwise type **N**. Click **OK**.

Note

High-temperature mode will deplete the battery more quickly than normal mode. Use this mode only if the temperature will be greater than 150° C.



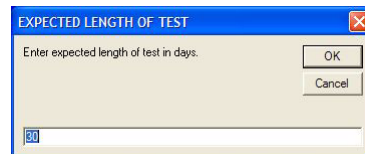
Temperature mode

6. Type the expected downhole temperature. Click **OK**.



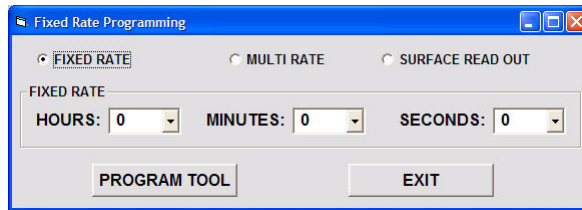
Expected Temperature

7. Type the test duration. Click **OK**.



Test Duration

8. Type the sample rate, for example, 30 seconds, and then click **Program Tool**. Do not unplug the gauge or shut off the Interface Box while the gauge is being programmed. A message that shows the new program settings appears. Once you see this message, it is safe to disconnect the Interface Box.



Fixed Rate Programming

9. After you have finished programming the gauge, the program rates appear. Verify that the settings are correct:
 - **Recorder #**, the gauge serial number.
 - **Date and Time Programmed**.
 - **Sample Rate, Duration, and # Samples**, for each test phase, including the automatically-programmed 13 samples at the beginning of the test.
 - **Overrun rate**, which defaults to 30 seconds. This is the rate at which the gauge will collect samples if it continues to run beyond the programmed duration.
 - **Programmed duration**, the length of time that you have programmed the gauge to collect samples.
 - **Number of samples used on recorder**.
 - **Temperature mode**, either high temperature or normal.
 - **Amp Hours** required for the test duration and for total duration, including overrun. Ensure that your battery capacity is enough to power the gauge for the expected test length. Standard cell capacity is 1.5 amp hours.

```

                                PROGRAM RATES
Recorder#: 9725
Date and Time Programmed: 12/08/2004 13:18:29

Sample Rate      Duration      # of Samples
HH:MM:SS        DDD:HH:MM:SS
00:00:05        000:00:01:00        12
00:00:05        040:09:57:20        698368

OVERRUN RATE
00:00:30        000:00:00:00

Programmed Duration      040:09:58:20
Total Duration Including Overrun      040:09:58:20
Number of samples used on recorder: 0
Tool has been programmed in NORMAL TEMPERATURE mode
AMP HOURS required for expected duration of 30 Days 0.544 AH
AMP HOURS required for Total duration including overrun 0.733 AH

```

Fixed Rate: Finish

10. Inspect the O-Rings and replace if necessary, as described in “To replace O-rings” on page 130.
11. Test and install the battery, as described in “Testing the Downhole Tool Battery” on page 120 and “Plugging the Battery into the Downhole Tool” on page 122.

Testing the Downhole Tool Battery

Before running the tools, it is important to ensure that the battery is operating properly.

Cal-Scan’s tools are designed so that the battery is attached to one end of the tool, and then encased in a protective steel cylinder. Half of the tool is actually the battery barrel, which is the battery component hidden inside the steel casing.

Note

You must test the tool battery every time you run the tool.

To check the battery in the downhole tool

1. If the battery is in the tool, do the following:
 - a. Make sure the tool is not connected to your laptop computer.
 - b. Unscrew the two halves of the tool casing and remove the battery barrel (the cylinder that protects the battery). The other half of the tool casing should remain intact.
 - c. Gently pull the battery out from its six-prong Lemo connection to the tool. Do not unscrew the battery, or you could accidentally pull the connecting wires apart and damage the battery component of the tool.
2. If the battery is cold, heat it up with your vehicle heater.
3. Gently tap the battery a few times on a flat surface, such as your windshield dashboard or a tabletop. This action breaks down the passivation film that forms around lithium batteries when they have been stagnant or cold for any length of time. If you do not break down the film, you will increase the power surge to the battery when you connect it to the battery tester, thus losing more battery power than is necessary.
4. Locate the red dot on the male 6-pin Lemo connector on the battery pack, and line it up with the red dot on the female 6-pin Lemo connector of the battery tester. Gently push the battery into the battery tester. Note that the battery tester does not require a battery to operate, since it draws on the power of the battery when it is inserted into the tester.
5. Press the red button to test the power of the battery. If the battery tester indicator shifts to the red or yellow areas at any time during the test, the battery has insufficient power, and must be replaced.
6. Gently pull the battery out from its six-prong Lemo connection to the battery tester. To install the battery, proceed to “Plugging the Battery into the Downhole Tool”.

Plugging the Battery into the Downhole Tool

After removing the passivation film and testing the battery, you can install it in the gauge and run the test.

Note

Downhole tool batteries have a built-in light emitting diode (LED) that blinks eight times when it is first plugged into a tool. If it fails to do so, there might be something wrong with the tool. The battery power may be insufficient, or the tool, battery, or LED may be damaged. To help prevent downhole failures, do not use a tool that fails this test.

To plug the battery into the downhole tool

1. Locate the red dot on the male Lemo connector on the battery pack, and line it up with the red dot on the female Lemo connector of the tool. Gently push the battery into the tool.
2. Check to see that the red LED (light emitting diode) flashes 4 short initialization signals to indicate that the battery has been engaged. If the flashes do not appear, disconnect the battery, and retest after 10 seconds.
3. Take note of the time at which the fifth blink appears. This flash indicates the first sample has been taken, and is the time you will use later when you download the data.
4. The LED flashes 3 more signals to indicate that the gauge is sampling. If this is the first time the gauge has been programmed, the flashes appear at 5 second intervals; otherwise, they appear at the programmed sample rate. If these flashes do not appear, do not run the tool. Send the battery in for repair.
5. After the recorder has started properly, slide the battery barrel over the battery and screw it on tightly until it is up against the pressure section of the tool. The gauge is now ready to run the gradient test.

Setting Up Surface Read Out

Surface Read Out allows you to use an appropriately equipped Hawk 9000 or Gopher e-line to display downhole data. The data is transmitted through a wire to the surface device.

Surface Read Out mode is programmed in the same way as regular downhole gauges, except that you must also set up the surface box to correctly display the transmitted values. In order to ensure that the raw data is correctly compensated, you must use the correct calibration file from the downhole gauge. The calibration file for the downhole gauge is automatically uploaded to your computer after you program the downhole gauge.

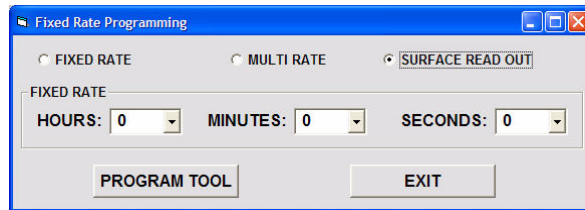
Programming Fixed Rate for SRO

When you program for SRO mode, you must program the downhole tool first, and then set up the SRO Box. This is because the calibration file is stored in the SRO Box for that particular tool. This ensures that the data appears on the surface device with the correct temperature and pressure. It also allows the data to be downloaded from the SRO box with all the information needed to compensate the bin file as if it was a downhole tool.

As a result, you must reprogram the surface box if you change the downhole gauge, since the existing calibration will be incorrect for the new tool, and the data will be wrong in the SRO Box.

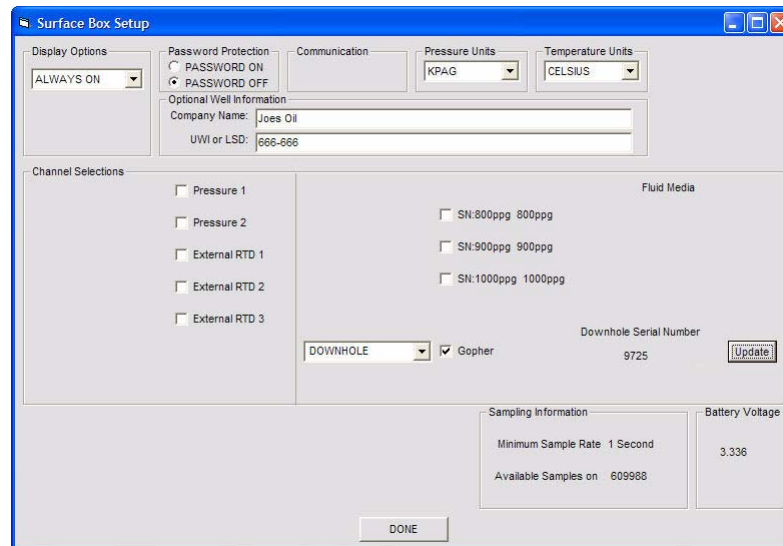
To program a gauge for SRO mode

1. Connect the gauge as described in “To program a gauge for an extended test” on page 110. On the **Program** menu, click **Program Tools**. Select the program type **Surface Read Out**. Program the tool as usual.



Programming SRO mode

2. Disconnect the downhole gauge and connect the surface box or E-line Gopher. On the **Program** menu, click **Program Tools**. The **Surface Box Setup** dialog box opens.



Surface Box Set Up

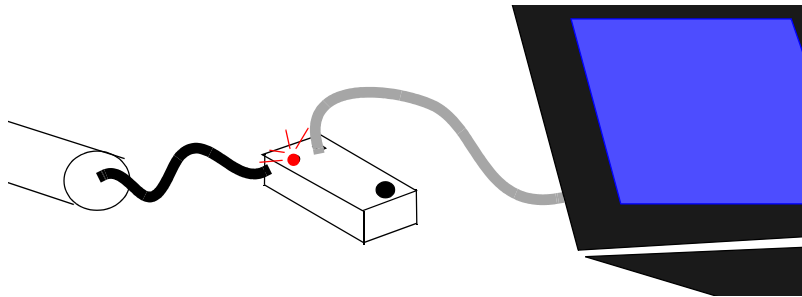
3. The downhole tool you programmed should be selected in the **Channel Selections** area. The serial number should match the number on the downhole gauge. If it is incorrect, click **Update**, and select the correct calibration file for the downhole tool.
4. Click **Done**.

Downloading and Viewing Data

After collecting data, you can retrieve and view data from the tool using Calvin. For more information about retrieving data, refer to the Calvin Reference Guide.

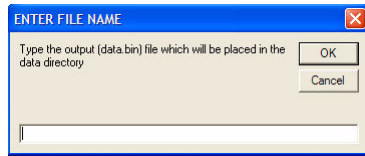
To download data from downhole gauges

1. Attach one end of a USB or serial cable to the USB & Serial Interface Box and the other end of the cable to the USB or serial port on your computer. Remember to insert a 9-volt battery into back of the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box cable to the top of the gauge.



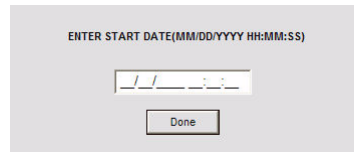
Downloading data

3. The red LED (light emitting diode) on the face of the Interface Box flashes four short signals (two flashes for 7-pin quartz gauges) to indicate that it is active. If the Interface Box LED does not flash these signals, do not run the recorder. Disconnect the cables and try again until you see the LED flashes.
4. Open Calvin. Click **Dump**. In the **Enter File Name** dialog box, type a name for the file and click **OK**. If a file with that name already exists, you can choose to overwrite the existing file or choose a new file name.



File Name

5. In the **Enter Start Date** dialog box, type the start date and time for the recorder. This is the time of the fifth blink of the battery LED when the battery was first plugged into the gauge, as described in “Plugging the Battery into the Downhole Tool” on page 122.



Start Time

6. The recorder will start uploading the binary (raw) data to the computer. You will see the samples counting down in the message window. After all of the samples have downloaded, the program will begin to compensate the binary data, that is, it will use the raw data with the calibration information to create real values, for example, 150 psi at 23°.
7. A dialog box appears that allows you to choose information to plot. Proceed to “Creating Simple Graphs” for information about graphing the data.

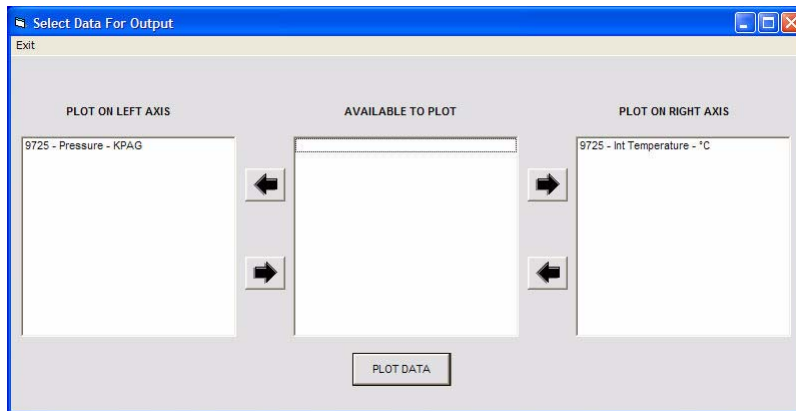
Creating Simple Graphs

After you finish downloading data from the gauge, Calvin automatically presents you with the option to graph the downloaded data.

You can also view previously downloaded data in graph format by selecting a saved data file. To do this, on the **Presentation** menu, click **Graph Data to Screen and Printer**.

To create a graph

1. The **Select Data for Output** dialog box automatically appears after downloading data.
2. In the **Select Data for Output** dialog box, choose the data to plot on the left and right axes. Select the axis to plot from the **Available** list and click the arrow buttons to move the selected data to the appropriate axis. Each axis can plot one unit only.



Select Output Data

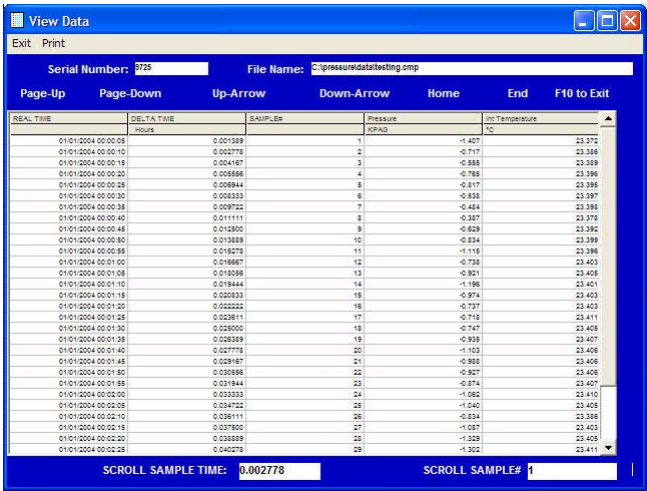
3. Click **Plot Data**. The data appears on the plot.

Viewing Data in Table View

The table view displays the data from a recorder in tabular format.

To view data in table view

1. On the **Presentation** menu, click **View Table**.
2. In the **Select cmp File** dialog box, select the file you want to view and click **OK**.



The screenshot shows a software window titled "View Data" with a menu bar (Exit, Print) and a toolbar. Below the menu bar are input fields for "Serial Number: 3725" and "File Name: C:\pressure\data\testing.cmp". A row of navigation buttons (Page-Up, Page-Down, Up-Arrow, Down-Arrow, Home, End, F10 to Exit) is present. The main area contains a table with the following columns: SERIAL TIME, DELTA TIME, SAMPLE, Pressure, and Gas Temperature. The table displays 29 rows of data. At the bottom, there are two input fields: "SCROLL SAMPLE TIME: 0.002778" and "SCROLL SAMPLE# 1".

SERIAL TIME	DELTA TIME	SAMPLE	Pressure	Gas Temperature
	hours	SPAG	SPAG	°C
01/01/2004 00:00:08	0.001389	1	-1.407	23.372
01/01/2004 00:00:10	0.002778	2	-0.717	23.386
01/01/2004 00:00:18	0.004167	3	-0.886	23.339
01/01/2004 00:00:20	0.006986	4	-0.768	23.396
01/01/2004 00:00:28	0.008944	8	-0.817	23.399
01/01/2004 00:00:30	0.008333	6	-0.830	23.397
01/01/2004 00:00:38	0.009722	7	-0.484	23.396
01/01/2004 00:00:40	0.011111	8	-0.387	23.379
01/01/2004 00:00:48	0.012800	9	-0.629	23.382
01/01/2004 00:00:50	0.013689	10	-0.834	23.399
01/01/2004 00:00:58	0.016278	11	-1.119	23.396
01/01/2004 00:01:00	0.016967	12	-0.780	23.403
01/01/2004 00:01:08	0.018056	13	-0.821	23.406
01/01/2004 00:01:10	0.019444	14	-1.196	23.401
01/01/2004 00:01:18	0.020333	16	-0.874	23.403
01/01/2004 00:01:20	0.022222	16	-0.737	23.403
01/01/2004 00:01:28	0.023611	17	-0.718	23.411
01/01/2004 00:01:30	0.025000	18	-0.747	23.408
01/01/2004 00:01:38	0.026389	19	-0.938	23.407
01/01/2004 00:01:40	0.027778	20	-1.103	23.406
01/01/2004 00:01:48	0.029167	21	-0.900	23.406
01/01/2004 00:01:50	0.030556	22	-0.907	23.406
01/01/2004 00:01:58	0.031944	23	-0.874	23.407
01/01/2004 00:02:00	0.033333	24	-1.062	23.410
01/01/2004 00:02:08	0.034722	25	-1.040	23.408
01/01/2004 00:02:10	0.036111	26	-0.834	23.386
01/01/2004 00:02:18	0.037500	27	-1.037	23.403
01/01/2004 00:02:20	0.038889	28	-1.326	23.405
01/01/2004 00:02:28	0.040278	29	-1.302	23.411

View Data

3. You can now perform a number of operations with the data, as described in “Printing Data” on page 70, “Exporting Data” on page 75, and “Merging Data” on page 69 of the Calwin Reference Guide.

Downhole Gauge Maintenance

You should clean downhole tools after every test to remove debris and replace the lubricating grease around the transducer.

To clean a downhole gauge, you will need the following:

- Wrench
- Brush, such as a soft paintbrush
- Varsol
- Lubricating grease, if necessary

WARNING

IT IS IMPORTANT NOT TO TOUCH OR MARK THE TRANSDUCER.

To clean downhole tools

1. Use a wrench to remove the crossover or bullet nose of the tool.
2. Remove the screen from the end of the tool, and unscrew the disc that holds the transducer.
3. Carefully remove the teflon ring. *Do not touch the transducer.*
4. Using a soft brush and Varsol, degrease the base plug, screen, disc, teflon ring, and threads. Gently clean around the transducer.
5. Allow parts to dry. Add lubricating grease, and then reassemble.
6. Install new O-rings as appropriate to the well conditions.

Replacing Downhole Tool O-Rings

Replacing O-rings is not usually necessary during normal operation. This is usually done by Cal-Scan technicians.

To replace the O-rings on your tool, you will need the following:

- Tweezers
- X-acto knife/cutter
- O-ring lubricant
- O-rings suitable for your tool (2 per tool)
- Small crescent wrench
- Housing wrench
- Lemo Fish-thru rod
- Conformal coat
- Male Lemo
- Application brush

To replace O-rings

1. Plug the male Lemo into the top of the downhole tool. Unscrew the Lemo plug counter-clockwise using your crescent wrench. The Lemo plug should unthread smoothly, and extend approximately 1" outside the recorder barrel.
2. Using your housing wrench, unscrew the Lemo housing nut. Remove the Lemo housing nut by pulling the wires through the slit in the nut.
3. Grasp the recorder with both hands and unscrew the barrel from the base of the recorder.
4. Slowly pull on the base of the recorder, pulling the internal components through the barrel. Completely separate the internal components from the barrel.
5. Use your tweezers to lift one of the O-rings on the base of the recorder. While holding the O-ring with the tweezers, use the X-acto knife (or a pair of cutters) to cut off the old O-ring. Repeat for the next O-ring.

6. Slip a new O-ring over the top of the recorder, starting at the Lemo Plug. Slide the O-ring over the body of the circuitry to the base of the tool. At the base of the tool, roll the O-ring down over the threads into the first ridge. Repeat for the second O-ring
7. Apply a small amount of O-ring lubricant onto the O-rings using an application brush. Spread the O-ring lubricant evenly over both rings
8. Slide your Lemo Fish-thru rod into the barrel from the top, with the Lemo end of the rod going through the barrel first.
9. Connect the Fish-thru rod to the Lemo plug. Be sure that the tape on the circuitry is not loose, and that the small orange foam is sitting closest to the circuit board.
10. In one hand, hold the Fish-thru rod and in the other hold the base of the tool. In one slow motion slide the tool up into the barrel. This should slide in easily and not snag. Disconnect the Fish-thru rod from the Lemo plug.
11. Holding the base still, thread the barrel onto the base (do not thread the base into the barrel). This will prevent the internal components from twisting. Hint: While threading the barrel on, watch the wires on the other end; they should not spin. If they do, the components may be snagged and need to be removed. In this case, start over.
12. Apply a small amount of Conformal coat to the Lemo housing.
13. Place the Lemo housing nut back over the wires. Thread the Lemo housing nut into the barrel. Use your housing wrench to tighten. Hand tight is sufficient.
14. Reconnect the male Lemo to the Lemo plug. Apply a small amount of Conformal coat to the threads of the Lemo plug.
15. Holding onto the male Lemo in one hand and holding the recorder in the other, twist the wires counter-clockwise 5 times
16. Using your tweezers, assist the wires gently down into the barrel past the threads of the Lemo housing nut.

17. Screw the Lemo plug into the barrel. Use your crescent wrench to hand-tighten.

Downhole Gauge Operational Precautions

Cal-Scan's gauges are made to withstand considerable mechanical and chemical attack. However, the internal components, including the transducer, are sensitive. You should take precautions to ensure that these components are protected against damage.

The sensor and O-rings are susceptible to degradation by chemical agents. You can prevent this by inspecting and replacing the O-rings regularly, and by using the methods described in the following sections.

Preventing Mechanical Shock

Downhole gauges are designed to tolerate considerable mechanical shock to their ends, but gauges are more susceptible to damage caused by shock from the sides of the gauge. Smaller gauges are particularly sensitive to side shock, since the small diameter does not allow space for much internal shock protection. You should limit line speed to 100 or 150 feet per minute to reduce the chance of side shock.

Protecting the Transducer

If the well contains H_2S or other corrosive chemicals, you should protect the gauge transducer from direct contact with the well fluid.

The barrel of the gauges themselves are made of 718 or equivalent INCONEL™, which is largely impervious to chemical damage. Bombwells are not usually necessary.

Most of these methods use lubricating grease to prevent corrosive agents from coming into direct contact with the sensitive components. Because grease eventually breaks down, you should clean the tools and replace the grease regularly.

- *Pigtails* are oil-filled wire device attached to the base of quartz gauges. *Labyrinth oil traps* are similar, but are less commonly used.
- *Screens* with lubricating grease are often placed between the transducer and the bullet top in Badger and Mole gauges.
- Grease placed directly on the transducer surface.
- Ammonia in the transducer compartment neutralizes acids.
- *Bombwells* are fluid-filled tubes that you can place over gauges.

Chapter 13

Standard Hawk 9000 Setup

Setting up Hawk 9000 consists of the following tasks:

- Programming the sample rate and test duration for the types of data that you want to collect.
- Starting the data collection.

Hawk 9000 can be used to gather pressure and temperature data for a number of tests. In this chapter, we will describe the most common applications of the surface box: extended buildup, hydrostatic, flow proving, and production testing.

Programming Hawk 9000 is usually accomplished off-site, using a USB & Serial Interface Box and Calvin software. Note that you should not use the Interface Box in situations where explosive or flammable gases are present, due to risk of sparking. Program the Hawk 9000 at a safe location, before installing it on-site, or use Cal-Scan's Raven interface box.

You can also program Hawk 9000 to receive data transmitted by a downhole tool, as described in "Setting Up Surface Read Out" on page 123.



Connecting to Hawk 9000 using the Interface Box

Extended Buildup Test

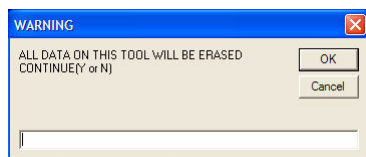
The extended buildup test provides information about the well reservoir, especially the ability of a formation to produce. You can also use this test to determine formation permeability, extent of wellbore damage or stimulation, reservoir pressure, and reservoir boundaries and heterogeneities.

This test is conducted by producing a well at constant rate for some time, shutting the well in, allowing the pressure to buildup in the wellbore, and recording the pressure in the wellbore as function of time. When recording the pressures at the surface, the bottomhole pressure is calculated by adding the weight of the fluid column to the surface pressure.

To conduct an extended buildup test, you will need to program the Hawk 9000 to collect data from both casing and tubing pressure channels at an appropriate sample rate.

To program Hawk 9000 for an extended buildup test

1. Attach one end of a USB or serial cable to of the USB & Serial Interface Box, and the other end of the cable to the appropriate port on your computer. Remember to insert a 9-volt battery into the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box 6-pin Lemo cable to the face of Hawk 9000 surface box.
3. Open Calvin. On the **Program** menu, click **Program Tool**. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the data.



Erase Data Warning

4. In the **Surface Box Setup** dialog box, do the following:
 - a. Enable the channels that monitor the tubing and casing pressure. From the list, choose appropriate labels for the channels, for example, **TUBING** and **CASING**.
 - b. Click **OK**.

The screenshot shows the 'Surface Box Setup' dialog box with the following settings:

- Display Options:** ALWAYS ON
- Password Protection:** PASSWORD OFF
- Communication:** (empty)
- Pressure Units:** KPAA
- Temperature Units:** CELSIUS
- Optional Well Information:** Company Name: Cal-Scan, UWI or LSD: (empty)
- Channel Selections:**
 - TUBING: checked, Pressure 1
 - CASING: checked, Pressure 2
 - METER: checked, External RTD 1
 - Diff: checked, 4 to 20ma
- Flow Calculations:** Off
- Sampling Information:** Dynamic Sampling: unchecked, Minimum Sample Rate: 2 Seconds, Available Samples on: 232106
- Battery Voltage:** 3.566

Buttons: OK

Surface Box Setup

5. Type the sample rate, typically 30 seconds, and then click **Program Tool**.

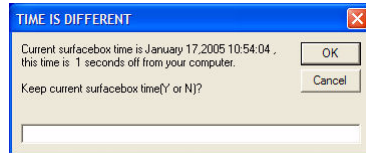
The screenshot shows the 'Fixed Rate Programming' dialog box with the following settings:

- Mode:** FIXED RATE (selected), MULTI RATE, SURFACE READ OUT
- FIXED RATE:** HOURS: 0, MINUTES: 0, SECONDS: 0

Buttons: PROGRAM TOOL, EXIT

Fixed Rate

6. Set the time on the surface box by typing **N** and clicking **OK**. The time used is the current on the laptop.



Time is different

7. Do not unplug the gauge or shut off the Interface Box while the gauge is being programmed. A message that shows the new program settings appears. Once you see this message, it is safe to disconnect the Interface Box.

Hydrostatic Test

The hydrostatic test can detect leaks in a pipe by monitoring fluid pressure changes.

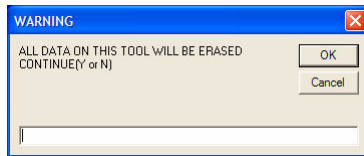
To conduct this test, the pipe is filled with a fluid (usually water), and the internal pressure and temperature is recorded for a period of time. By examining the pattern of pressure changes, and compensating for any changes due to fluid expansion caused by temperature changes, you can determine if the pipe is leaky.

Hawk 9000 is capable of recording pressure temperature at a resolution down to 0.1 kPa (0.015 psi). Hawk 9000's built-in data logging makes it ideal for hydrostatic pipeline testing.

To program the Hawk 9000 for hydrostatic testing, you will need to collect data from internal temperature and pressure channels, and set an appropriate sample rate.

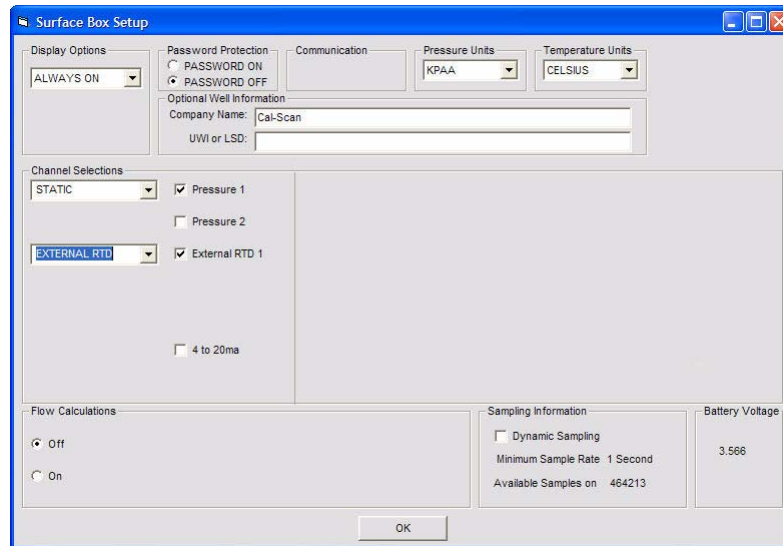
To program Hawk 9000 for a hydrostatic test

1. Attach one end of a USB or serial cable to the USB & Serial Interface Box, and the other end of the cable to the appropriate port on your computer. Remember to insert a 9-volt battery into the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box 6-pin Lemo cable to the face of Hawk 9000 surface box.
3. Open Calwin. On the **Program** menu, click **Program Tool**. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the data.



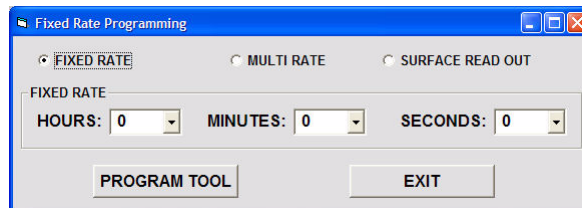
Erase Data Warning

4. In the **Surface Box Setup** dialog box, do the following:
 - a. Enable the channel that monitors the internal pressure. From the list, choose an appropriate label for the channel, for example, **TUBING**.
 - b. Enable the External RTD channel, and from the list, choose the label **EXTERNAL RTD**.
 - c. Click **OK**.



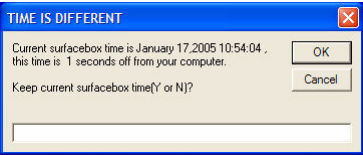
Surface Box Setup

5. Type the sample rate, typically 30 seconds, and then click **Program Tool**.



Fixed Rate

6. Set the time on the surface box by typing **N** and clicking **OK**. The time used is the current time on the laptop.



Time is different

- 7. Do not unplug the gauge or shut off the Interface Box while the gauge is being programmed. Once the new program settings appear, it is safe to disconnect the Interface Box.

PROGRAM RATES

Recorder#: 6313

Date and Time Programmed: 01/17/2005 11:09:41

Sample Rate HH:MM:SS	Duration DDE:HH:MM:SS	# of Samples
00:00:05	000:00:01:00	12
00:00:30	120:21:20:00	346160

OVERRUN RATE

00:00:30 000:00:00:00

Programmed Duration 120:21:21:00

Total Duration Including Overrun 120:21:21:00

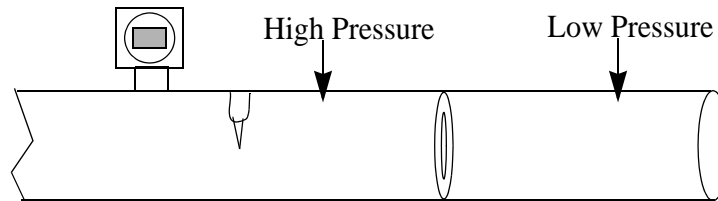
Number of samples used on recorder: 0

Display Option: Always On
Pressure Display Option: kPaa
Temperature Display Option: Celsius
Password Option: Off
Channel 1 Pressure: On Channel Name = TUBING
Channel 2 Pressure: On Channel Name = CASING
Channel 3 External RTD: Off
Channel 4 4 to 20ma: Off

Extended Test: Finish

Flow Proving

One method of measuring gas production is to attach a small meter run and an orifice plate.



Flow Proving

You can determine the flow rate by measuring the static pressure upstream, the differential pressure across the orifice plate, gas composition, and the gas flow temperature.

Flow provers vent the low pressure side to atmosphere or sent to flare. This simplifies the test, since a differential meter is not needed. Instead, the differential pressure is determined by using the static pressure and subtracting the average atmospheric pressure for that area.

To ensure accuracy, it is important to keep the static pressure greater than twice atmospheric pressure; otherwise changes in atmospheric pressure will affect the test results.

To program flow proving, you will need the external RTD to collect the temperature of the gas and one pressure sensor to measure the upstream static pressure.

To program Hawk 9000 for flow proving

1. Attach one end of a USB or serial cable to the USB & Serial Interface Box, and the other end of the cable to the appropriate port on your computer. Remember to insert a 9-volt battery into the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box 6-pin Lemo cable to the face of Hawk 9000 surface box.
3. Open Calwin. On the **Program** menu, click **Program Tool**. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the data.
4. The **Surface Box Setup** dialog box opens.
 - a. Select the pressure and **External RTD** channels.
 - b. In the **Flow Calculations** area, click **On**. Note that the channel selections become locked to STATIC and METER.
 - c. In the **Flow Method** area, click **Flow Prover**.
 - d. From the **Gas Flow Unit** list, choose the appropriate flow unit.
 - e. From the **Compressibility Type** list, choose **Standard**. Use **Detailed** only when you know the exact gas composition of the well. See the Calwin reference for more details.
 - f. Click **OK**.

Surface Box Setup

Display Options
 ALWAYS ON

Password Protection
☐ PASSWORD ON
☒ PASSWORD OFF

Communication

Pressure Units
 KPAA

Temperature Units
 CELSIUS

Liquid Flow Units
 Flow Rate Units
 Flow Accum Units
 bbl US

Optional Well Information
 Company Name: p-2-78-2-2 N0u@-e-PF-1p-2-78-2-2 N0u@-e-PF-1p-2-78-2-2
 UWI or LSD: -2- N0u@-e-PF-1p-2-78-2-2 N

Channel Selections
 STATIC
 CASING
 METER
☒ Pressure 1
☒ Pressure 2
☒ External RTD 1
☐ 4 to 20ma

Flow Calculations
 Flow Method
☒ Flow Prover ☐ Orifice Diff ☐ Turbine
 Gas Flow Unit: 10^3 m^3
 Compressibility Type: Detailed
 Select Gas Channel Name: LIQUID FLOW 1
☒ Turbine 1
☐ Turbine 2

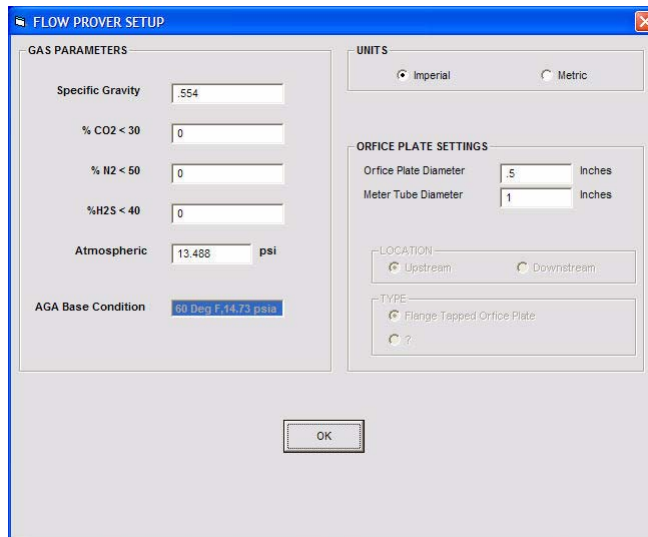
Sampling Information
☐ Dynamic Sampling
 Minimum Sample Rate 3 Seconds
 Available Samples on 232106

Battery Voltage
 3.566

OK

Surface Box Setup

5. In the **Flow Prover Setup** dialog box, specify the following:
 - a. The gas composition. The level of detail of the composition depends on the compressibility type you selected in the surface box setup.
 - b. **Atmospheric** pressure.
 - c. **Orifice Plate Diameter** and **Meter Tube Diameter**.
 - d. If you selected **Standard** compressibility type, type the expected **Specific Gravity**, **% Nitrogen**, **% Carbon**, and **% H₂S**. If you do not know the exact composition, use an average specific gravity value, such as 0.65.
 - e. Click **OK**.



FLOW PROVER SETUP

GAS PARAMETERS

Specific Gravity: .554

% CO2 < 30: 0

% N2 < 50: 0

% H2S < 40: 0

Atmospheric: 13.488 psi

AGA Base Condition: 60 Deg F, 14.73 psia

UNITS

☒ Imperial ☐ Metric

ORFICE PLATE SETTINGS

Orifice Plate Diameter: .5 Inches

Meter Tube Diameter: 1 Inches

LOCATION

☒ Upstream ☐ Downstream

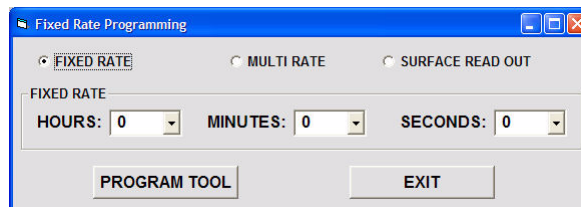
TYPE

☒ Flange Tapped Orifice Plate ☐ ?

OK

Flow Prover Setup: Standard

6. Type the sample rate (typically 30 seconds), and then click **Program Tool**.



Fixed Rate Programming

☒ **FIXED RATE** ☐ MULTI RATE ☐ SURFACE READ OUT

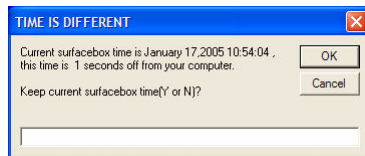
FIXED RATE

HOURS: 0 MINUTES: 0 SECONDS: 0

PROGRAM TOOL EXIT

Fixed Rate

7. Set the time on the surface box by typing **N** and clicking **OK**. The time used is the current time on the laptop.



Time is different

8. Do not unplug the surface box or shut off the Interface Box while the box is being programmed. A message that shows the new program settings appears. Once you see this message, it is safe to disconnect the Interface Box.

```

                                PROGRAM RATES

Recorder#: 6313

Date and Time Programmed: 01/17/2005 11:16:32

Sample Rate      Duration      # of Samples
HH:MM:SS        HH:MM:SS
00:00:05        000:00:01:00        12
00:00:30        096:17:04:00        278528

OVERRUN RATE
00:00:30        000:00:00:00

Programmed Duration  096:17:05:00
Total Duration Including Overrun  096:17:05:00
Number of samples used on recorder:  0

Display Option: Always On
Pressure Display Option: kPa
Temperature Display Option: Celsius
Password Option: Off
Channel 1 Pressure: On Channel Name = STATIC
Channel 2 Pressure: On Channel Name = CASING
Channel 3 External RTD: On Channel Name = METER
Channel 4 4 to 20ma: Off
Gas Flow Units: 10^3m^3
Gas Flow Calculation Through: Flow Prover
Gas Flow Calculation Type: Standard

Standard Compressability Values
0.5540 - Specific Gravity
20.0000 - CO2
0.0000 - H2
0.0000 - H2S

```

Flow Prover: Finish

Production Testing

Like flow proving, production testing measures the production of fluids from a well: typically gas, water, oil, or condensate. However, it involves collecting more detailed information.

More accurate gas flow rates are monitored with a differential sensor. Fluids (such as oil or water) are also separated and monitored. Two surface gauges are used. One surface gauge is used to monitor the gas flow, and is typically equipped with turbines that monitor the fluid flow. A second surface gauge is attached to the wellhead to collect tubing and casing pressure, and flow temperature as it leaves the well.

Since gases are compressible, gas measurements are adjusted to standard values using Hawk 9000's built-in AGA8 flow calculations. For more information about gas compressibility, see "Basic Gas Measurement Theory and Practice" on page 187.

To program production testing, you will need to collect internal temperature, and the upside and downstream pressure of the flow stream. You can program Hawk 9000 for many different types of production tests. The following example sets up a flow test for a device with one turbine.

To program Hawk 9000 for production testing (example)

1. Attach one end of a USB or serial cable to the USB & Serial Interface Box, and the other end of the cable to the appropriate port on your computer. Remember to insert a 9-volt battery into the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box 6-pin Lemo cable to the face of Hawk 9000 surface box.
3. Open Calwin. On the **Program** menu, click **Program Tool**. If there is data in the gauge memory that has not yet been downloaded, you can choose to continue with the programming (losing the data), or cancel and resume programming after you have downloaded the data.

4. The **Surface Box Setup** dialog box opens. Configure the flow calculation by doing the following:
 - a. In the **Flow Calculations** area, click **On**. Note that the channel selections become locked to STATIC and METER.
 - b. In the **Flow Method** area, click **Orifice Diff**.
 - c. From the **Gas Flow Unit** list, choose the appropriate standard unit. This unit controls for temperature and pressure, to ensure that each unit of gas is consistent in density.
 - d. From the **Compressibility Type** list, choose **Standard**.

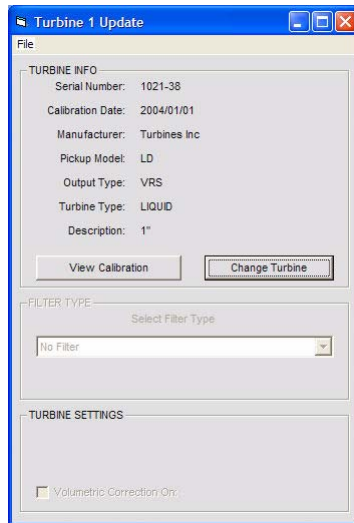
The screenshot shows the 'Surface Box Setup' dialog box with the following configuration:

- Display Options:** ALWAYS ON
- Password Protection:** PASSWORD OFF
- Communication:** (empty)
- Pressure Units:** KPAG
- Temperature Units:** CELSIUS
- Liquid Flow Units:** bbl/day US
- Flow Accum Units:** bbl US
- Optional Well Information:** Company Name: (empty), UWI or LSD: 123-456
- Channel Selections:**
 - STATIC: ☒ Pressure 1
 - TUBING 1: ☒ Pressure 2
 - METER: ☒ External RTD 1
 - Diff: ☒ 4 to 20ma
 - 4 to 20 mA Range 0 to 72.18238 psi
- Fluid Media:** OIL, Update
- Flow Calculations:**
 - Flow Method: ☒ Orifice Diff
 - Gas Flow Unit: 10³ m³
 - Compressibility Type: Standard
 - Select Gas Channel Name: GAS FLOW
- Sampling Information:**
 - Dynamic Sampling: ☐
 - Minimum Sample Rate: 3 Seconds
 - Available Samples on: 398677
- Battery Voltage:** 3.644
- OK** button

Surface Box Setup

5. Select the **Turbine 1** checkbox and configure the turbine by doing the following:
 - a. From the **Fluid Media** list, choose the type of fluid, such as **OIL**.
 - b. Click **Update**.

6. In the **Turbine Update** dialog box, do the following:
 - a. Click **Change Turbine**. Choose the calibration file for the turbine and click **OK**.
 - b. On the **File** menu, click **Save**.
 - c. On the **File** menu, click **Exit**.



Turbine Update

7. The **Orifice Meter Setup** dialog box opens. Type the expected **Specific Gravity**, **% CO₂**, **% N₂**, and **% H₂S**, and click **Done**. If you do not know the exact composition, use an average specific gravity value, such as 0.65.

ORFICE METER SETUP

GAS PARAMETERS

Specific Gravity: .65

% CO2 < 30: 0

% N2 < 50: 0

% H2S < 40: 0

Atmospheric: 93.011 kpa

AGA Base Condition: 60 Deg F, 14.73 psia

UNITS

☐ Imperial ☒ Metric

ORFICE PLATE SETTINGS

Orifice Plate Diameter: 12.7 millimeters

Meter Tube Diameter: 50.8 millimeters

LOCATION

☒ Upstream ☐ Downstream

TYPE

☒ Flange Tapped Orifice Plate ☐ ?

DONE

Orifice Setup

8. Type the sample rate (typically 30 seconds), and then click **Program Tool**.

Fixed Rate Programming

☒ FIXED RATE ☐ MULTI RATE ☐ SURFACE READ OUT

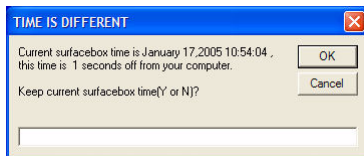
FIXED RATE

HOURS: 0 MINUTES: 0 SECONDS: 0

PROGRAM TOOL EXIT

Fixed Rate

9. Set the time on the surface box by typing **N** and clicking **OK**. The time used is the current on the laptop.



Time is different

10. Do not unplug the surface box or shut off the Interface Box while the box is being programmed. A message that shows the new program settings appears. Once you see this message, it is safe to disconnect the Interface Box.

```

                                PROGRAM RATES

Recorder#:

Date and Time Programmed: 01/25/2005 09:13:16

Sample Rate      Duration      # of Samples
HH:MM:SS        DD:MM:SS
00:00:05        00:00:01:00      12
00:00:30        161:12:01:30    465123

OVERRUN RATE
00:00:30        000:00:00:00

Programmed Duration  161:12:02:30
Total Duration Including Overrun  161:12:02:30
Number of samples used on recorder: 0

Display Option: Always On
Pressure Display Option: kPag
Temperature Display Option: Celsius
Password Option: Off
Channel 1 Pressure: On Channel Name = STATIC
Channel 2 Pressure: On Channel Name = TUBING 1
Channel 3 External RTD: On Channel Name = METER
Channel 4 4 to 20ma: On Channel Name = Diff
Channel 5 Turbine Flow Meter 1: On Channel Name = Liquid Flow
Channel 6 Turbine Flow Meter 2: Off
Gas Flow Units: 10^3m^3
Gas Flow Calculation Through: Orifice Diff
Gas Flow Calculation Type: Standard

Standard Compressability Values
0.6500 - Specific Gravity
0.0000 - CO2
0.0000 - N2
0.0000 - H2S

Turbine 1 Serial Number: 1021-38

Calibration Date: 2004/01/01
Turbine Manufacturer: Turbines Inc
Turbine Pick Up Model: LD

```

Production Test Example: Finish

Starting the Hawk 9000 Surface Box

After you have programmed the Hawk 9000, it will be running in low power mode, and the clock on the unit will display the number 5 . 00. You will need to activate the box to resume sampling.

To start Hawk 9000 after programming

1. Remove the Interface Box cable. The Hawk 9000 will not start sampling if the 6-pin Lemo connector is connected to the unit.
2. Quickly press the toggle button at least 5 times within 3 seconds, until you see pressures or temperatures displayed. If the number 5.00 reappears, you were not successful in starting the Hawk 9000, and it is not running. Repeat this step. Make sure that you are pressing the button fast enough.
3. The Hawk 9000 will not start sampling until the internal clock reaches an even minute. This makes synchronizing time easier when you are running more than one gauge.
4. To toggle between various sensor readings on the Hawk 9000 display, press the toggle button.

Remote Communication

Hawk 9000 can be equipped with an intrinsically safe RS-485 communication port to communicate with devices such as laptops, satellite, or radio. These third-party devices must be connected through a certified barrier, such as Raven. These barriers protect Hawk 9000 from high voltages that may result from catastrophic equipment failure.

You can use a Raven communication device to monitor Hawk 9000 data remotely in real time. Raven connects to Hawk 9000 from up to 1000 feet away through a RS-485 cable. This enables you to safely retrieve data from the surface box in locations where a USB & Serial Interface Box would pose a risk due to sparking.

Raven enables you to connect to a number of Hawk 9000 boxes, using Y-cables and additional long cables.

Note

To save power, Hawk 9000 is designed to put itself to sleep when it is not collecting a sample. This means that Calvin will periodically lose communication with the box. Raven attempts to communicate with the connected surface box until it takes a sample and becomes active again. You can also manually awaken the Hawk 9000 by pressing the button on the front or side of the box. It will stay awake for a full minute after you press the button.

Real Time Monitoring Hawk 9000 with Raven

Raven connects to Hawk 9000 similarly to the USB & Serial Interface Box, but uses long cables that allow you to retrieve data from up to 1000 feet away.

Connecting Hawk 9000 to Raven

Using RS-485 has advantages over using a wireless connection. It is immune to interference, and because it does not transmit the data, it is very secure.

When connected through Raven, you can perform any task that you can when you are connected through a USB & Serial Interface Box, such as programming and downloading. You can also graphically monitor data collected. Calvin updates the graph as each sample is received from the gauge.

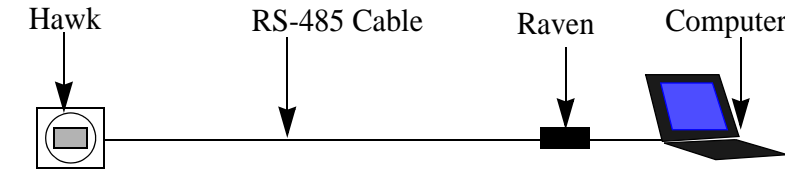
Note

When Calvin is connected to a Raven at the same time as it is connected with other Interface Boxes, it will communicate only with Raven, and ignore any other connected Interface boxes.

To connect to Hawk 9000 using Raven

1. Connect one end of the RS-485 cable to the Hawk 9000.
2. At a safe location, attach the other end of the cable to the Raven.

3. Open Calvin and connect Raven to your computer with a USB cable. Calvin should detect the connection. You can now proceed to program the Hawk 9000, view data, or download data.



Connecting using Raven

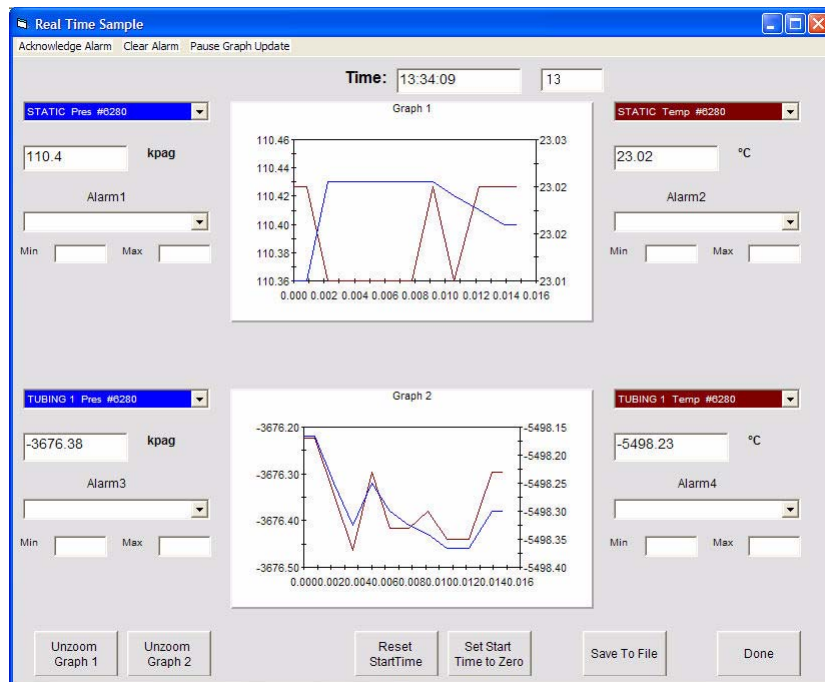
Viewing Real Time Hawk 9000 Data

You can use Calvin to graph Hawk 9000 data in real-time. Data from all channels will appear on the graph.

There are two view modes: simple graph and deadweight mode. Deadweight mode displays two numerical measurements in a window that can be resized on your computer screen, to enable you to see the data at a distance.

To view real-time Hawk 9000 data in graph format

1. Connect your computer to Hawk 9000 using Raven, as described in “Real Time Monitoring Hawk 9000 with Raven” on page 153.
2. On the **Presentation** menu, point to **Real-time**, and click **Real-time plot**. The data collected by Hawk 9000 appears in graph form.

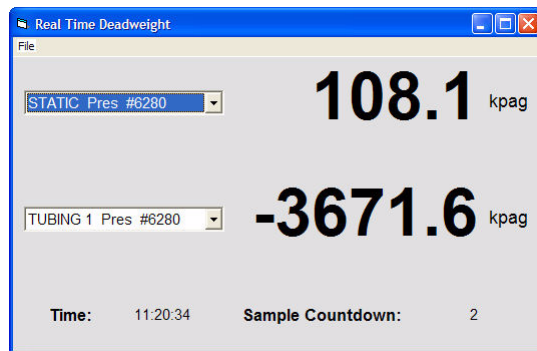


Viewing Real-Time Data

3. To close the graph, click **Done**.

To view real-time Hawk 9000 data in deadweight mode

1. Connect your computer to Hawk 9000 using Raven, as described in “Real Time Monitoring Hawk 9000 with Raven” on page 153.
2. On the **Presentation** menu, point to **Real-time**, and click **Real Time Deadweight**. The pressure data collected by Hawk 9000 appears.



Viewing Real-Time Data: Deadweight Mode

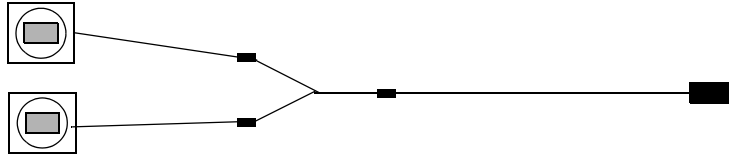
3. To change the data displayed, choose a different channel from the lists.
4. To close the data view, click the X in the upper right corner of the window, or on the **File** menu, click **Exit**.

Working with Multiple Hawk 9000 Boxes

You can connect to up to four Hawk 9000 devices at once. This is accomplished by using Y-cables to daisy-chain the devices to the Raven. You can then configure, program, monitor, and download from multiple surface boxes from one computer.

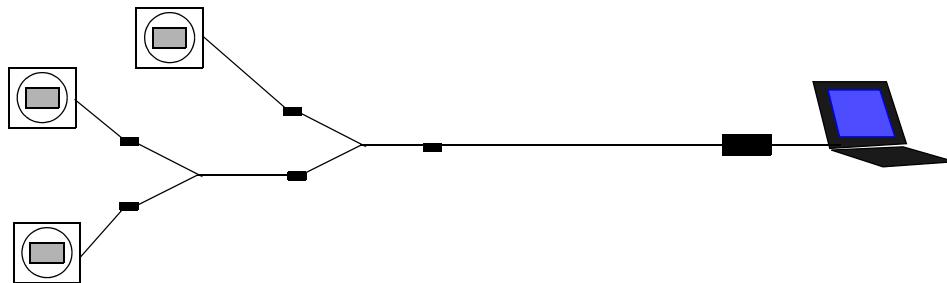
To connect to multiple Hawk 9000s using Raven

1. Connect one end of a RS-485 cable to each Hawk 9000.
2. Attach the end of each cable to an arm of a Y-cable.
3. Connect an RS-485 cable to the tail of the Y-cable. At a safe location, attach the cable to the Raven.



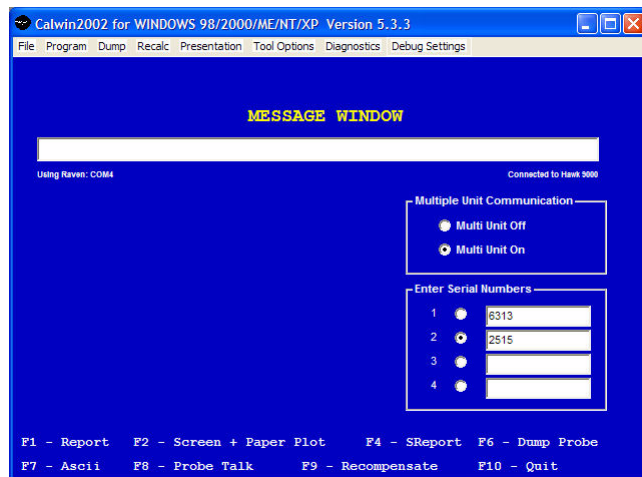
Connecting multiple Hawk 9000s

4. If you are connecting more Hawk 9000 boxes, use additional Y-cables to create as many branches as you need.



Connecting more than two Hawk 9000s

5. Open Calwin and connect Raven to your computer with a USB cable. On the **Software Options** menu, click **Configuration**. In the **Multiple Unit** box, click **On**. Click **Done** to return to the main window.
6. In the main window, click **Multi Unit On**. In the **Enter Serial Numbers** area, type the serial number for each Hawk 9000.



Add serial numbers

7. Calvin automatically monitors all surface boxes connected to the RS-485 network after you have entered the serial numbers of the units. To select a Hawk 9000 to program or download, click the button corresponding to the serial number of the unit. You can then use Calvin to work with the selected gauge normally, as if connected through an Interface Box.

Downloading Hawk 9000 Data

After collecting data, you can retrieve and view data from Hawk 9000 using the Interface Box, an SD/MMC, or Raven. For more information about retrieving data, refer to the Calvin Reference Guide.

SD/MMC is the best way to download data. This method allows you to download data safely, and is up to 10 times faster than using an Interface Box.

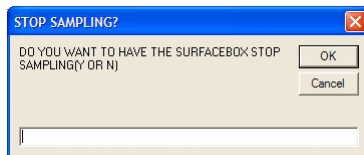
Downloading with the Interface Box

Note

Do not use the serial port on the Hawk 9000 in hazardous locations. Download the data from the Hawk 9000 with a multimedia card or Raven instead. You may also do a sniff check to confirm that there is no hazardous gas present, and then download the Hawk 9000 data with the serial port, but this is not recommended.

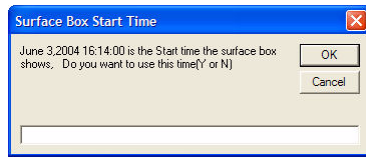
To download Hawk 9000 data with an Interface Box

1. Attach one end of a USB or serial cable to the USB & Serial Interface Box, and the other end of the cable to the appropriate port on your computer hard drive. Remember to insert a 9-volt battery into the Interface Box when using a serial cable.
2. Line up and attach the gray Interface Box 6-pin Lemo cable to the face of Hawk 9000 surface box.
3. Click **Dump**. In the dialog box that appears, type **Y** to stop the Hawk 9000 sampling. If you type **N**, then the Hawk 9000 will resume sampling after the interface box is disconnected, and you will lose the data collected while the Interface Box is plugged in.



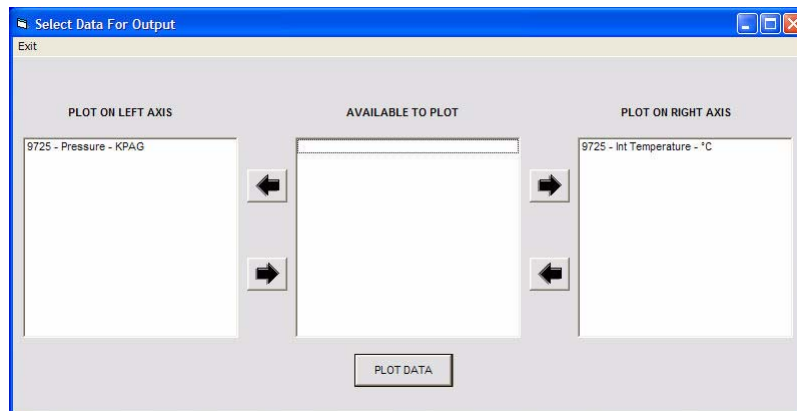
Hawk 9000 Sampling

4. In the **Save** dialog box, type the file name you want to use. If a file with that name already exists, you can choose to overwrite the existing file, or choose a new file name.
5. The time the Hawk 9000 was started appears. You can use this time by choosing **Y**, or you can enter your own time, by selecting **N**.



Hawk 9000 Start Time

6. The recorder will start uploading the binary (raw) data to the computer. You will see the samples counting down in the message window. After all of the samples have downloaded, the program will begin to compensate the binary data.
7. In the **Select Data for Output** dialog box, choose the data to plot on the left and right axes. Select the axis to plot from the **Available** list and click the arrow buttons to move the selected data to the appropriate axis.



Select Output Data

8. The program will plot the channels you select.

Downloading with Raven

Raven works in the same way as a regular USB & Serial Interface Box. Because it is insulated against sparking, it is safe to use in the presence of flammable or explosive gases.

Raven connects to your computer using long USB or RS-485 cables, up to a maximum of 1000 feet. See “Remote Communication” on page 152 for information about connecting to Raven.

Downloading with a Multimedia Card (MMC)

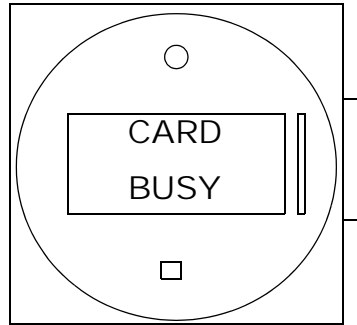
You can use the SD/multimedia card slot on Hawk 9000 to safely download the data without performing a sniff check. This method is certified safe to use in hazardous locations.

Hawk 9000 will continue to sample during downloading, so that no data is lost while you retrieve data. In addition, the data remains in the Hawk 9000 after you download with the MMC, so that if you lose or damage the original card, you can download the data again from the Hawk 9000.

After the data has been downloaded onto the multimedia card, insert the MMC card into a PCMCIA or USB MMC reader connected to your computer in a safe location.

To download Hawk 9000 data with a multimedia card

1. Insert the multimedia card into the memory card slot on the face of the Hawk 9000. The conductors on the card should face the right side of the slot, in order to make contact with the prongs.
2. Press the toggle button on the Hawk 9000 to begin dumping the data onto the multimedia card. The LCD displays a **Card Busy** message, indicating that the dump is taking place. A countdown of the remaining percentage of data appears.



Downloading data with MMC

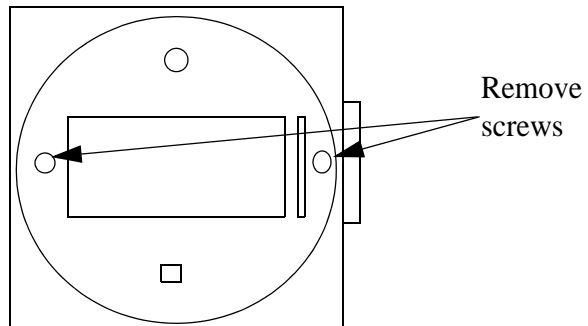
3. When the data has been downloaded, the LCD displays a **Card Done** message. You can now remove the multimedia card.
4. Press the button to reactivate the Hawk 9000 and return it to the normal display. You now have the binary (raw) data on the multimedia card, and you manually compensate the data on your computer at a safe location. Insert the MMC card into a PCMCIA or USB MMC reader connected to your computer to copy the data file to your hard drive.

Maintaining Hawk 9000

The Lithium battery pack in the Hawk 9000 is designed to last for at least a year under normal working conditions. When the battery power is low, the battery icon on the face of the unit appears. Once the battery icon appears, you have approximately one month of power left, based on a 30 second sample rate.

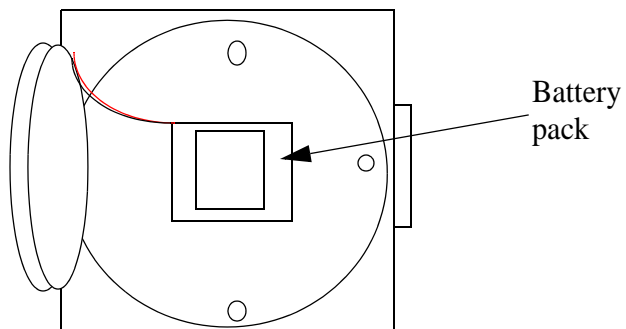
To change the Hawk 9000 battery

1. Remove the protective case on the Hawk 9000. Set it aside.
2. With a standard screwdriver, unscrew the two white plastic screws on either side of the face of the Hawk 9000 unit.



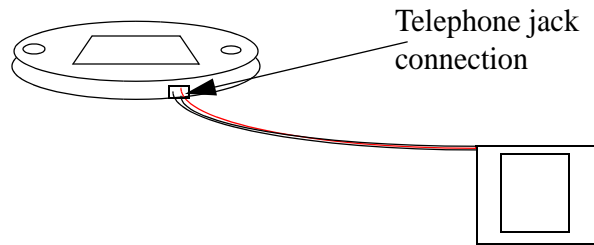
Remove screws

3. Without pulling the wires out, gently lift the face of the unit so it can rest on the outside of the unit's casing.



Open the unit and locate the battery

4. Locate the battery pack in the center of the unit, and gently remove it from its Velcro connection.
5. Locate the red and black wires coming out of the battery pack, and follow them up to the small telephone jack connection. Gently remove the battery wires from the unit's board.



Remove battery from the board

6. Insert a new battery pack into the unit, and attach the unit to its Velcro connection.
7. Insert the red and black battery pack wires into the small telephone jack, and gently place the face of the Hawk 9000 back into its original position on the unit.
8. Screw the white plastic screws tightly in place, and dispose of the old battery pack appropriately.
9. Replace the protective outer case.

Hawk 9000 Operational Precautions

Hawk 9000 can withstand a wide range of conditions, if you protect the sensors from mechanical and chemical damage.

- Water in Hawk 9000 case can damage sensitive electronics.
- Ensure that the protective lid is fully closed.
- Do not use a sealing quick connect. Changes in ambient temperature can cause large pressure changes inside the line, since liquids have limited compressibility. These pressure changes can overpressure the sensor, leading to damage.

- Transducers are sensitive to corrosive chemicals, such as H₂S. Usually, grease in the transducer sub is sufficient protection. Pigtails are oil-filled wire device attached to the base of surface gauges that prevent the corrosive material from coming into direct contact with the sensitive parts. Labyrinth oil traps are similar, but are less commonly used.
- Water that freezes next to the pressure sensor will cause damage. In subfreezing temperatures, you must keep the sensors dry, or use methanol injection to clear water from the sensors.

Permanent Hawk 9000 Setup

When Hawk 9000 is installed permanently, there are a few special considerations to keep in mind, such as wiring, communication, and safety precautions. Otherwise, permanent Hawk 9000 programming is the same as standard Hawk 9000.

The main difference between standard and permanent versions of Hawk 9000 is how data is stored in memory. The standard Hawk 9000 collects data continuously, until data is full, and then stops. Permanent Hawk 9000 uses a first-in, last-out method, where the most recent values are stored in the device, and older values are discarded.

The permanent Hawk 9000 stores the data as actual values; that is, the raw data is already compensated with the calibration data. This may pose a disadvantage, since you cannot recompensate the data if you need to update the calibration.

The Hawk 9000 can communicate through Modbus on a Half Duplex RS-485 system at either 9600 or 38 400 bps. The each byte sent has no parity, a word length of 8 bits, and one stop bit (N, 8, 1).

When setting up the Hawk 9000 for Modbus communication, there are three parameters that need to be set up:

- *Baud Rate*: The serial communication speed, either 9600 or 38 400 bps
- *Modbus Device ID* or Address: This is the Modbus address that the Modbus Master will send to communicate with the Hawk 9000.

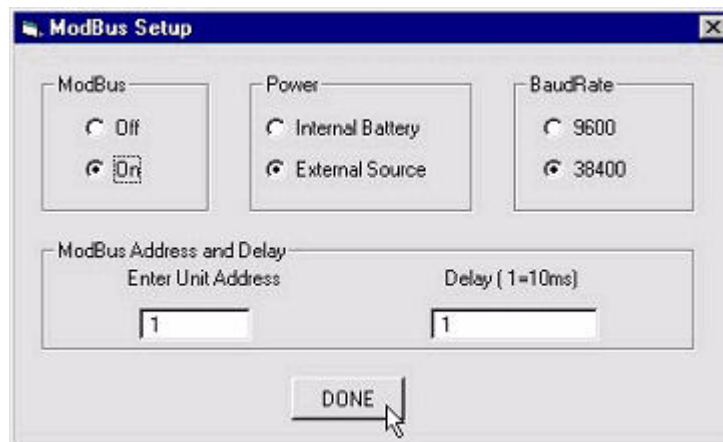
- *Response Delay*: This is the delay in 10 millisecond increments that the Hawk 9000 will delay the response to the Modbus master. Usually a value of 1 (10 ms) will work on most systems.

To program the permanent Hawk 9000

1. On the **Tool Options** menu, point to **Permanent Surface Box** and click **Initial settings**.
2. The **Modbus Setup** dialog box appears.

Note

You will need the RS-485/Power card for the Modbus to operate correctly. If you have the RS-485 card, click **On** to enable Modbus; otherwise, click **Off** to shut off Modbus to conserve power.



Modbus Setup

3. Configure the following:
 - a. **Power** setup. **Internal Battery** means the unit is running solely on the internal battery. **External Source** means it is running on power supplied through the RS-485/Power Card. When running on an external power source, the Hawk 9000 will not go to sleep, to allow

the Modbus communication to poll more easily. If a power failure is detected, the Hawk 9000 will switch to backup power and keep sampling, and disable Modbus communication to conserve power.

- b. **Baud Rate:** The serial communication speed, either 9600 or 38 400 bps
 - c. **Modbus Address:** This is the address that the Modbus Master will send when communicating with the Hawk 9000.
 - d. **Response Delay:** This is the delay, in 10 millisecond increments, that the Hawk 9000 will use in the response to the Modbus master. A value of 1 (10ms) will work on most systems.
4. The **Surface Box Setup** dialog box appears. Configure the data inputs and sample rate as described in “Standard Hawk 9000 Setup” on page 135.

Connecting to a Half-Duplex RS-485 Network

The RS-485 standard permits a balanced transmission line to be shared in a party line or multidrop mode. As many as 32 driver/receiver pairs can share a multidrop network.

In a typical two-wire multidrop network, the transmission line is terminated on both ends of the line, but not at drop points in the middle of the line. Termination should only be used with high data rates and long wiring runs. The signal ground line is also recommended in an RS-485 system to keep the common mode voltage that the receiver must accept within the -7 to +12 volt range.

Since the Hawk 9000 uses a half duplex interface, the Modbus master must tristate the TX line when it is not sending any information. If you are connecting the Hawk 9000 to a computer, you should use a RS-232 to RS-485 driver with automatic send data control, such as Cal-Scan’s Raven. This type of interface has special circuitry that enables the driver when data is being transmitted, and then disables the driver within one character length of the end of transmission. This is the preferred method of RS-485 interfacing, since it reduces software overhead and the number of potential pitfalls for the programmer.

Termination

Termination is used to match impedance of a node to the impedance of the transmission line being used. When impedances are mismatched, the transmitted signal is not completely absorbed by the load, and a portion is reflected back into the transmission line.

If the source, transmission line, and load impedance are equal, these reflections are eliminated. There are disadvantages of termination:

- Increases load on the drivers
- Increases installation complexity
- Changes biasing requirements
- Makes system modification more difficult.

Normally, the Hawk 9000 does not need termination. You should consider the cable length and data rate used by the system when deciding whether to use termination. Generally, if the propagation delay of the data line is much less than one bit width, termination is not needed. This rule assumes that reflections will damp out in several trips up and down the data line. Since the receiving UART will sample the data in the middle of the bit, it is important that the signal level be solid at that point. For example, in a system with 2000 feet of data line, the propagation delay can be calculated by multiplying the cable length by the propagation velocity of the cable. This value, typically 66 to 75% of the speed of light (c), is specified by the cable manufacturer.

For example, a round trip covers 4000 feet of cable. Using a propagation velocity of $0.66 \times c$, one round trip is completed in approximately $6.2 \mu\text{s}$. If we assume the reflections will damp out in three “round trips” up and down the cable length, the signal will stabilize $18.6 \mu\text{s}$ after the leading edge of a bit. At 9600 baud, one bit is $104 \mu\text{s}$ wide. Since the reflections are damped out much before the center of the bit, termination is not required.

Connecting to a Full Duplex Interface

Devices configured for four wire communications bring out A and B connections for both the transmit and the receive pairs. You can connect the transmit lines to the receive lines to create a two-wire configuration. The latter type device provides the most configuration flexibility. Note that the signal ground line should also be connected in the system. This connection is necessary to keep the Vcm common mode voltage at the receiver within a safe range. The interface circuit may operate without the signal ground connection, but may sacrifice reliability and noise immunity.

The Modbus Protocol

Modicon developed the Modbus Protocol in 1979 to establish master-slave/client-server communication between intelligent devices. It is the most widely used network protocol in the industrial manufacturing environment.

This is a brief description of the Modbus protocol. If you are writing a Modbus master interface from scratch, read *Modbus Application Protocol v1* from www.modbus.org for complete information.

Modbus Data Encoding

For addresses and data items, Modbus sends the most significant byte first when a numerical quantity larger than a single byte is transmitted. For example:

Register size	Value
16 - bit	0x1234 (The first byte sent is 0x12, then 0x34)

Modbus Data Model

Modbus bases its data model on a series of tables that have distinguishing characteristics. The four primary tables are:

Primary Tables	Object Type	Access Type	Comments
Discrete Inputs	Single bit	Read-Only	This data type is provided by an I/O system
Coils	Single bit	Read-Write	This data type is alterable by an application program
Input Registers	16-bit word	Read-Only	This data type can be provided by an I/O system
Holding Registers	16-bit word	Read-Write	This data type is alterable by an application program

The distinctions between inputs and outputs and between bit-addressable and word-addressable data items do not imply any application behavior. It is acceptable and common to regard all four tables as overlaying one another, if this is the most natural interpretation on the target machine in question. For each of the primary tables, the protocol allows individual selection of 65 536 data items, and the operations of read or write of those items are designed to span multiple consecutive data items up to a data size limit which is dependent on the transaction function code. All the data handled through Modbus (bits, registers) must be located in device application memory, but physical address in memory should not be confused with data reference. The only requirement is to link data reference with physical address.

Modbus logical reference numbers, which are used in Modbus functions, are unsigned integer indices starting at zero.

Modbus Function Codes

Hawk 9000 supports the following Modbus Function Codes:

- 03 (0x03) — Read Holding Registers
- 04 (0x04) — Read Input Registers is supported
- 16 (0x10) — Write Holding Registers

These function codes are used to read from 1 to 50 contiguous input registers in a remote device. The Request PDU specifies the starting register address and the number of registers. Registers are addressed starting at zero. Therefore, input registers 1-16 are addressed as 0-15.

Request

Address	1 Byte	0x01 to 0xFF
Function code	1 Byte	0x04
Starting Address	2 Bytes	0x0000 to 0xFFFF
Quantity of Input Registers	2 Bytes	0x0001 to 0x0032
16 Bit CRC	2 Bytes	

Request Example

01 04 00 63 00 02 81 D5
(Read two input register starting at address 100)

Response

Address	1 Byte	0x01 to 0xFF
Function code	1 Byte	0x04
Byte count	1 Byte	2 x N*
Input Registers	N* x 2 Bytes	

16 Bit CRC	2 Bytes	
------------	---------	--

*N = Quantity of Input Registers

Response Example

01 04 04 47 AE 42 CE 3F E5 (Send back four bytes)

Error

Address	1 Byte	0x01 to 0xFF
Error code	1 Byte	0x84
Exception code	1 Byte	01 or 02 or 03 or 04
16 Bit CRC	2 Bytes	

Floating Point Byte Order

There are several implementations of sending a IEEE float using Modbus registers. Each implementation sends the byte order in different ways. The Hawk 9000 uses the byte order on standard Modicon Systems.

If in the preceding response example the two registers were holding a float:

HH

MH

ML

LL

47 AE 42 CE = IEEE Float =

42 CE 47 AE (High to Low byte

103.14 =

0x42CE47AE)

The byte order in a Modbus float is ML - LL - HH - MH

Modbus Register List (04) (SB v3.16+)

These addresses are not offset, either internally or externally to the device. Most Modbus drivers will subtract one from, or add 3000 or 30 000 (3001 or 30 001) to the address provided by the operator. These drivers will remove these extra operations when preparing the RTU packet. The operator must ensure that the outgoing packets' address are exactly as shown.

All the registers are accessed using the Modbus Query: 04 - Read Input Registers or the Modbus Query. The following tables show all the real-time registers available, and the registers used to access any record stored in the Hawk 9000. It is used in conjunction with the holding register 100.

The maximum size of Modbus packet is 100 registers (200 bytes).

Note

Any register that holds yesterday's values will have a value of 0.0 until the end of the day has been reached. At this point, yesterday's daily averages are updated with the new data. The end of the day is not necessarily midnight. It is a programmable setting between 0:00 AM and 10:00 AM

Hawk 9000 Real-Time Input Registers

Register(hex)	Name	Format	Description
100 (0x64)	RTU Time	32 - Bit	Time in seconds since Jan. 1, 1990 00:00
102 (0x66)	Pressure Units	16 - Bit	0 = kPa, >0 psi
103 (0x67)	Pressure Mode	16 - Bit	0 = Absolute, >0 Gauge
104 (0x68)	Temperature Units	16 - Bit	0 = Celsius, >0 Fahrenheit
105 (0x69)	Differential Pressure	16 -Bit	0 = kPa, >0 inH2O

Register(hex)	Name	Format	Description
106 (0x6A)	Liquid Turbine Rate Units	16 - Bit	
107 (0x6B)	Gas Volume Units	16 - Bit	0 = 103m3,1= mscf,2=scf, >0 mcf
108 (0x6C)	reserved	-	Return 0
109 (0x6D)	reserved	-	Return 0
110 (0x6E)	Channel 1 Pressure	IEEE Float	Units set by register 102 and 103
112 (0x70)	Channel 1 Temperature	IEEE Float	Units set by register 104
114 (0x72)	Channel 2 Pressure	IEEE Float	Units set by register 102 and 103
116 (0x74)	Channel 2 Temperature	IEEE Float	Units set by register 104
118 (0x76)	Channel 3 External RTD1 Temperature	IEEE Float	Units set by register 104
120 (0x78)	Channel 4 4/20 mA Input Differential Pressure	IEEE Float	Units set by register 105
122 (0x7A)	Channel 5 Turbine 1 Accumulated Volume	IEEE Float	Units set by register 106. If a gas turbine, this value is the accumulation in ACF of the last SAMPLE
124 (0x7C)	Channel 5 Turbine 1 Current Flow Rate /day	IEEE Float	Units set by register 106. IF a gas turbine this value is the gas rate in ACF/Day of the last SAMPLE.

Register(hex)	Name	Format	Description
126 (0x7E)	Channel 6 Turbine 2 Accumulated Volume	IEEE Float	Units set by register 106
128 (0x80)	Channel 6 Turbine 2Current Flow Rate /day	IEEE Float	Units set by register 106
130 (0x82)	Channel 7 Turbine 3 Accumulated Volume	IEEE Float	Units set by register 106
132 (0x84)	Channel 7 Turbine 3Current Flow Rate /day	IEEE Float	Units set by register 106
134 (0x86)	Channel 8 External RTD2 Temperature	IEEE Float	Units set by register 104
136 (0x88)	Channel 9 External RTD3 Temperature	IEEE Float	Units set by register 104
138 (0x8A)	reserved	IEEE Float	Return 0
140 (0x8C)	reserved	IEEE Float	Return 0
142 (0x8E)	reserved	IEEE Float	Return 0
144 (0x90)	reserved	IEEE Float	Return 0
146 (0x92)	reserved	IEEE Float	Return 0
148 (0x94)	reserved	IEEE Float	Return 0
150 (0x96)	AGA Gas Flow Rate /day	IEEE Float	Units set by register 107

Register(hex)	Name	Format	Description
152 (0x98)	AGA Gas Accumulated Volume So far today	IEEE Float	Units set by register 107
154 (0x9A)	Flow Time Today So far	16 - Bit	Minutes
155 (0x9B)	Flow Time Yesterday	16 - Bit	Minutes
156 (0x9C)	AGA Gas Accumulated Yesterday's Total Vol.	IEEE Float	Units set by register 107
158 (0x9E)	Flow Yesterday's Average Static Pressure	IEEE Float	Units set by register 102
160 (0xA0)	Flow Yesterday's Average Temperature	IEEE Float	Units set by register 104
162 (0xA2)	Flow Yesterday's Average Differential Pressure	IEEE Float	Units set by register 102

The following table is used to access a record stored in flash memory in the Hawk 9000. If you want to poll in real-time (the most current value), use this table. See “Modbus Holding Register List (03 & 16)” on page 178 to learn how to find a record stored in the Hawk 9000.

Hawk 9000 Real-Time Input Registers

Register(hex)	Name	Format	Description
1000 (0x64)	RTU Time Stamp	32 - Bit	Time in seconds since Jan. 1, 1990 00:00

Register(hex)	Name	Format	Description
1002 (0x66)	Pressure_Sensor2	IEEE Float	0 = kPa, >0 psi
1004 (0x67)	Temperature_Sensor2	IEEE Float	0 = Absolute, >0 Gauge
1006 (0x68)	Pressure_Sensor1	IEEE Float	0 = Celsius, >0 Fahrenheit
1008 (0x69)	Temperature_Sensor1	IEEE Float	0 = kPa, >0 inH2O
1010 (0x6A)	Pressure420ma	IEEE Float	
1012 (0x6B)	Temperature External RTD	IEEE Float	0 = 103m3, >0 mcf
1014 (0x6C)	Gas Accumulation SCF	IEEE Float	Return 0
1016 (0x6D)	Turbine1_Accum	32 - Bit	Return 0
1018 (0x6E)	Turbine2_Accum	32 - Bit	Units set by register 102 and 103
1020 (0x70)	Turbine3_Accum	32 - Bit	Units set by register 104
1022 (0x72)	TempertureExRTD2	IEEE Float	Units set by register 102 and 103
1024 (0x74)	TempertureExRTD3	IEEE Float	Units set by register 104
1026 (0x76)	Future1	IEEE Float	Units set by register 104

Register(hex)	Name	Format	Description
1028 (0x78)	Future2	IEEE Float	Reserved if read value 0.0
1030 (0x7A)	Future3	IEEE Float	Reserved if read value 0.0
1032 (0x7C)	Future4	IEEE Float	Reserved if read value 0.0
1034 (0x7E)	Future5	IEEE Float	Reserved if read value 0.0
1035 (0x80)	Future6	IEEE Float	Reserved if read value 0.0

Modbus Holding Register List (03 & 16)

By writing to record 100 using the Write Holding Registers 16 (0x10) command, Hawk 9000 will look for the closest record in the flash memory for that time. That record can be accessed from Address 1000 in the holding registers, as shown in the following table. If the time falls between samples, it will find the next largest record. If the time is before the oldest record, the oldest record will be found. If it is close to the newest record, the newest record will be found. The date can be confirmed when reading the RTU time stamp from the flash input registers.

Hawk 9000 Flash Record Input Registers

Register(hex)	Name	Format	Description
100 (0x64)	FlashRecordDate	32-Bit	Setting this value with the time in seconds since Jan. 1, 1990 00:00, causes the unit to search its internal memory for a record stored in Flash

CSA Intrinsically Safe Installation

Permanent IS CSA/UL certification is pending. These are the expected installation requirements if running permanent Hawk 9000 off of instrumentation power.

Use in Hazardous Locations

- Intrinsically Safe for Class I, Division 1, Groups A, B, C & D
- Outdoor hazardous locations
- Temperature Class: T4 Ambient temperature: 50° C

Entity Parameters for CSA

- Intrinsically safe ratings are as follows:
 - Maximum Input Voltage (V_{max}) = 30 V
 - Maximum Input Current (I_{max}) = 100 mA
 - Maximum Input Power (P_{max}) = 770 mW
 - Maximum Internal Capacitance (C_i) = 0 uF
 - Maximum Internal Inductance (L_i) = 0 uH
- Associated apparatus (CSA certified barriers)
 - Maximum output voltage (V_{oc}) = 30 V
 - Maximum output current (I_{sc}) = 100 mA
 - Maximum output Voltage (P_{max}) = 770 mW

Installation of Hawk 9000 for CSA

- All wiring shall comply with the Canadian Electrical Code Part I and local electrical codes
- Instrument modifications or parts replacement by other than authorized representatives of Cal-Scan Services is prohibited, and will void Canadian Standards Intrinsically Safe Certification

UL Intrinsically Safe Installation

Permanent IS CSA/UL certification is pending. These are the expected installation requirements if running permanent Hawk 9000 off of instrumentation power.

Use in Hazardous Locations

- Hawk 9000 is applicable for use in hazardous locations
- Intrinsically Safe for Class I, Division 1, Groups A, B, C & D
- Outdoor hazardous locations
- Temperature Class: T4 Ambient temperature: 50° C

Entity Parameters for UL

- Intrinsically safe ratings are as follows:
 - Maximum Input Voltage (V_{max}) = 30 V
 - Maximum Input Current (I_{max}) = 100 mA
 - Maximum Input Power (P_{max}) = 770 mW
 - Maximum Internal Capacitance (C_i) = 0. μ F
 - Maximum Internal Inductance (L_i) = 0 μ H

- Associated apparatus (UL certified barriers)
 - Maximum output voltage (V_{oc}) = 30 V
 - Maximum output current (I_{sc}) = 100 mA
 - Maximum output Voltage (P_{max}) = 770 mW
- Entity Installation Requirements
 - $V_{max} = V_{oc}$ or V_t , $I_{max} = I_{sc}$ or I_t , P_{max} (IS Apparatus = P_{max} (Barrier)
 - $C_a = C_i + C_{cable}$, $L_a = L_i + L_{cable}$

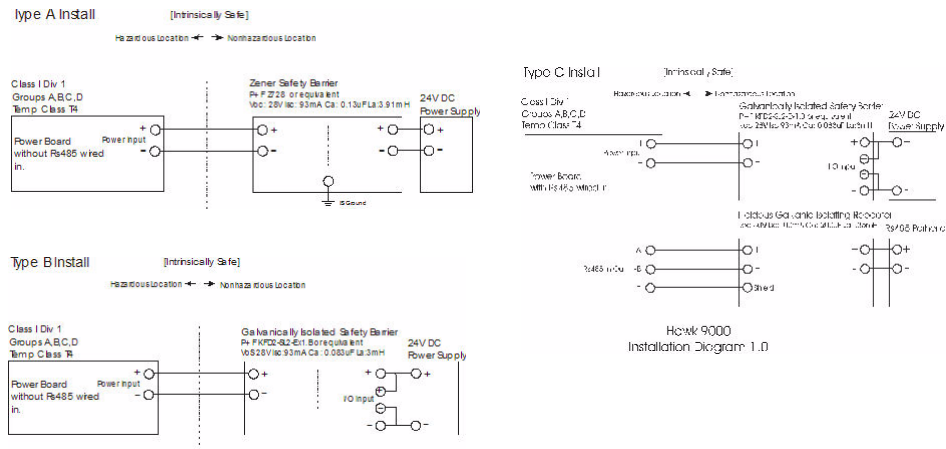
Installation of Hawk 9000 for UL

- Barriers must be installed in an enclosure that meets the requirements of ANSI/ISA S82.01
- Control equipment connected to a barrier must not use or generate more than 250 V AC RMS or V DC
- Installation should be in accordance with ANSI/ISA RP12.6 *Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations* and the National Electric Code (ANSI/NFPA 70)
- Follow associated apparatus manufacturers' installation drawings when installing this apparatus.

Maintenance of Permanent Hawk 9000

Modifying the instrument or replacing parts (by other than authorized representatives of Cal-Scan) is prohibited, and will void UL Intrinsically Safe Certification.

Internal Wire Hookups of Hawk 9000

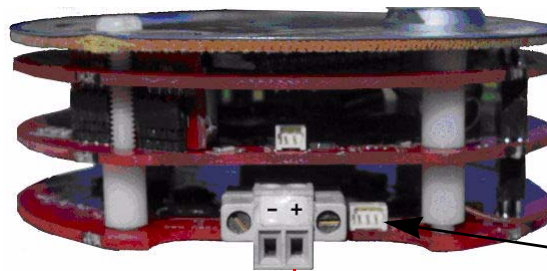


Installing Permanent Hawk 9000

Use only properly rated cables for best performance and IS safety.

The included battery pack supplies the real-time clock in the event of power failure. This preserves the time if the main power fails. After connecting the main power and starting the Hawk 9000, attach the battery to the battery backup connection. Make sure to use a tie wrap to secure the wires to prevent the wires coming loose.

Use tie
wrap to
secure



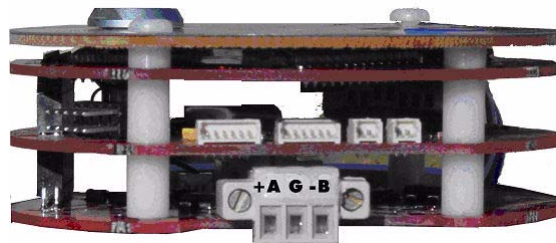
Battery
Backup

+9V dc to +28V dc

Ground

Main Power

Use tie
wrap to
secure



Shielded
cable: use
shield as
ground
return

RS485 Connection

Field Wiring Specifications for Hawk 9000

Shielded, twisted pair cable made specifically for Fieldbus has the characteristics that are important for good signal transmission, and comply with the Fieldbus standard.

Compatible cable can be obtained from:
BELDEN WIRE & CABLE COMPANY
2200 U.S. Highway 27 South
Richmond, IN 47374USA

Tel: 888-235-3368
Fax: 765-983-5536
<http://www.belden.com>

Wire Type: RS-485 FieldBus

Use the following wire or equivalent:

**Div 1 Class 1 Fieldbus Cable: Databus 3073F Twinax -
DataTray 600V Industrial Twinax Single pair**

AWG	Stranding	Type	Insulation	Insulation Thickness	Shield
18	(7x26)	Tinned Copper	Polyethylene	0.04100"	Aluminum Foil-Polyester Tape/Braid Shield

Jacket	Jacket Thickness	Nom. Core OD	Nom. OD	Nom. Cond. DCR (Ohms/M')	Nom. Imp. (Ohms)	Nom. Vel. of Prop.	Nom. Cap. (pF/ft)
PVC	0.0530"	0.2460"	0.3880"	5.800	100.0	64.5%	17.500

Wire Type: Power

Use the following wire or equivalent:

**UPower Cable: Instrumentation Cable 1120A Paired -
600 Volt Tray Cable Single Pair**

AWG	Stranding	Type	Insulation	Insulation Thickness	Shield
18	(7x26)	Bare Copper	PVC/Nylon	0.01600"	Aluminum Foil- Polyester Tape

Jacket	Jacket Thickness	Nom. Core OD	Nom. OD	Nom. Cond. DCR (Ohms/M')	Nom. Cap. (pF/ft)
PVC	0.0480"	0.1820"	0.2780"	5.860	41.000

Appendix A

Basic Gas Measurement Theory and Practice

In production testing, you are measuring the rate of production of any fluids produced by a well. These are typically water, oil, condensate, and gas. Measuring gas flow has become especially important since the 1970s, as the home heating, petrochemical, and power generation markets expand. Rising demand for gas makes accurate data collection critical, to ensure that reservoir engineers can optimize gas production of wells.

There are three ways to use Hawk 9000 to measure gas flow: an orifice plate, turbine, and optical flow meter. In order to use these methods, you should understand the physical characteristics of the gases you will be measuring.

Standard Units & Gas Laws

Hawk 9000 uses the raw gas rates to convert the actual rates to standard units. Standard units are necessary to offset the effects of gas compressibility, since the volume of a gas varies with pressure and temperature.

Typically, standard units are 65° F at 14.75 psi or 15° C at 101 kPa.

Standard Pressure

Pressure affects the properties and behavior of gases. For example, if you compress a balloon, the balloon gets smaller, but the amount of air inside stays the same. This is an illustration of Boyle's law: the volume of a gas is inversely proportional to the pressure. That is, if you decrease the size of a container by half, the pressure of the gas within doubles.

It is important to keep pressure constant when trading in gas, to ensure that each unit of volume contains the same amount of gas. The buyer and seller agree on a pressure standard, such as 15 psi, so that if you have a cubic foot of gas at 45 psi, you would convert the volume to what it would be if the pressure was at 15 psi. This can be expressed by the following formula, where V is the volume and P is the pressure:

$$\frac{V_{\text{standard}}}{V_{\text{actual}}} = \frac{P_{\text{actual}}}{P_{\text{standard}}}$$

or

$$V_s = \frac{P_a V_a}{P_s}$$

Using the equation, you can convert the 1 cubic foot of gas at 45 psi to its standard equivalent at 15 psi:

$$V_s = \frac{45 \cdot 1}{15\text{psi}} = 3$$

The standard pressure normally used in trade is 14.73 psi or 101 kPa.

Standard Temperature

Temperature must also be standardized when measuring gas. Gases expand as the temperature increases, and becomes less dense, much like the air in a hot air balloon. The decreased density (less air inside) of the heated air is what causes the balloon to float. Similarly, as temperature drops, the volume also decreases.

The following formula uses standardized temperature of 15° C or 60° F:

$$\frac{V_s}{V_a} = \frac{T_s}{T_a}$$

or

$$V_s = V_a \frac{T_s}{T_a}$$

To use this formula, you need to convert the temperature to an absolute scale, such as in degrees Kelvin or Rankine. At zero degrees in these scales, all atomic motion stops — the coldest possible temperature. To convert to an absolute scale, add 459.67 to the temperature in Fahrenheit or 273.16 to the temperature in Celsius.

For example, to convert the cubic foot of gas at 40° C to standard units at 15° C, you first convert the temperature to degrees Kelvin. The volume is smaller at the lower temperature, since gas becomes more dense as temperature decreases:

$$V_s = V_a \frac{T_s}{T_a} = (1) \frac{15 + 273.16}{40 + 273.16} = \frac{288.16}{313.16} = 0.92$$

You can then combine the formulae for standard pressure and temperature into one:

$$V_s = V_a \frac{P_a T_s}{P_s T_a}$$

Supercompressibility

Unfortunately, simple gas laws do not account for actual experimental results. As pressure increases, hydrocarbon gas volume decreases more than predicted. To correct these errors, an experimentally determined supercompressibility factor, Z, is used.

You will need to know the composition of the gas mixture when calculating supercompressibility. A number of formulae have been developed to correct for errors in calculating standard units at high temperature or pressure. Hawk 9000 uses the American Gas Association Report 8 (AGA8-92) formulas. These formulae calculate the supercompressibility for most combinations of hydrocarbons.

Measuring Static Pressure

Flow rates and AGA gas compressibility are referenced to the upstream static pressure. If you use downstream pressure, you must add the differential pressure to the downstream pressure to convert the upstream pressure. This results in a small error, since both the differential and static pressure errors can affect the upstream pressure accuracy.

Paper Chart Recorders

Paper chart recorders are still the most common method to measure gas rate. Because of their construction, the static pressure needs to be plumbed in on the downstream side. The chart itself adds the differential to the downstream static pressure to calculate the upstream pressure.

Meter Runs

A *meter run* is a straight length of pipe before and after a measuring device. This allows the gas to stabilize and flow smoothly, creating a laminar flow. Turbulent flow creates a spiral pattern, which is difficult to measure accurately. Use an appropriately sized meter run: generally, length of ten pipe diameters upstream and five diameters downstream. The actual meter run length you use will depend on the specifics of your setup; for example, an acute bend in the pipe or a valve before the measuring device will necessitate a longer run. Refer to AGA's Gas Measurement Manual, Part Three for more information about meter runs.

Turndown Ratio

All fluid flow measurement sensors have limits to what they are capable of measuring. The *turndown ratio* indicates the range of flow that the sensors can measure. The ratio is calculated as the maximum flow rate divided by the minimum flow rate. For example, a device that can measure between 20 and 4 gallons per minute would have a turndown ratio of 5. A large turndown ratio is needed when the flow you are measuring varies, such as with coal bed methane.

Measuring Gas Flow with Orifice Plates

Using an orifice plate is one of the oldest methods of measuring gas flow. An orifice plate is a round metal disc with a precision-cut hole in the center. It is placed within a pipe to restrict the flow of gas. As the gas flows through the

orifice, it expands as it loses pressure and accelerates. The effect is similar to closing off the end of a water hose with your thumb: as the water escapes past your thumb, it loses pressure and sprays out.

During controlled testing, it has been determined that this pressure drop is useful for calculating gas flow rate.

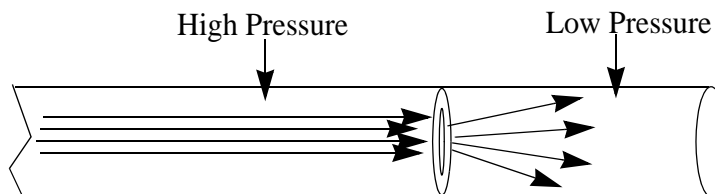
The flow rate is calculated by using the following information:

- Gas Density
- Flow temperature
- Upstream static pressure
- Pressure drop across the orifice plate
- Inside diameter of the meter run
- Orifice plate diameter

Orifice plates are precision-machined to specifications described in AGA Gas Measurement Manual, Part Three. Because the flow rate calculations are based on empirical formulas, following these specifications ensure that the flow calculations are accurate.

Typically, orifice plate systems have a turn down ratio between 5 and 10. This ratio can be increased by using multiple orifice plates of different sizes.

Handle orifice plates carefully. Nicks, incorrect installation, or damage can result in inaccurate flow rate measurements.

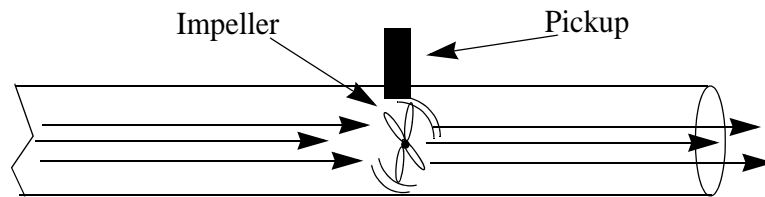


Orifice Plate

Measuring Gas Flow with Turbines

Gas turbines measure gas flow by taking advantage of the fact that the faster a gas flows, the faster it will cause a propeller will turn.

A precision-cut steel impeller on low-friction bearings pass a magnetic pickup coil as the blades turn. Each blade sends a pulse as they pass the coil. Flow rate is calculated by counting the number of pulses received by the coil during a given time interval.



Turbine

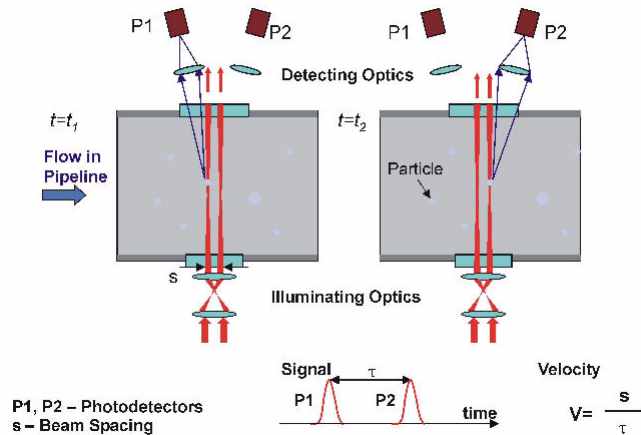
Each turbine is individually calibrated by counting pulse rate against a known gas flow rate. Turbines do not stand up well to sand— it wears down the impellers, and can get into the bearings. You should check the calibration of turbines annually, since any wear can shift the calibration.

There is very little pressure drop across the blades of a turbine. In some cases, such as when measuring wet gas, liquid can drop out when using an orifice plate. The low pressure drop on a turbine helps to prevent this from happening.

Turbines have a low turn-down ratio This the highest possible flow reading divided by the lowest possible reading. An orifice plate typically has a turn-down ratio of 1:5. Turbines can have turn-down ratios of 80:1, up to 400:1. Orifice plates circumvent this problem by using many plates to extend the ratio.

Optical Flow Meters

Optical flow computers (OFM) use laser light to measure the speed of natural flowing particles in the fluid.



OFM

The OFM measures the speed of gas by shining two low-power lasers into the flow stream at right angles to the direction of gas flow. Tiny, naturally occurring particles in the gas are detected by the sensor as they pass through the parallel beams of light. The flow speed is calculated with the time it takes for the particles to pass from the first to the second beam. Using OFM does not result in a pressure drop, such as when using turbines or orifice setups. OFM is also resistant to corrosive gas, such as in flare stacks, and has a large turndown ratio of greater than 1000:1.

Appendix B

Installing USB Drivers

In order to use the Interface Box, or Raven, you must have the correct USB drivers installed on your computer.

Note

The following instructions describe installing drivers using Windows XP. If you are running a different version of Windows, the procedure will vary.

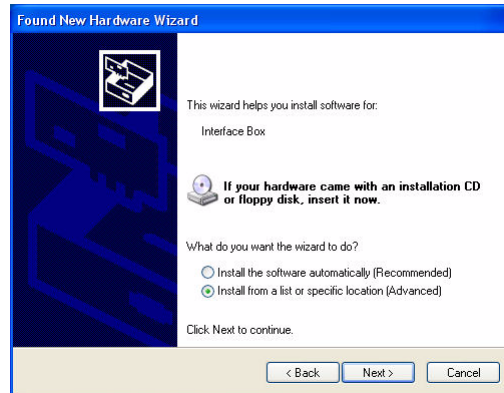
To install USB drivers for the Interface Box

1. Plug the Interface Box or Raven into your computer's USB port.
2. The **New Hardware Wizard** opens. The Windows Update dialog box may appear. If it does, click **Not this time**.



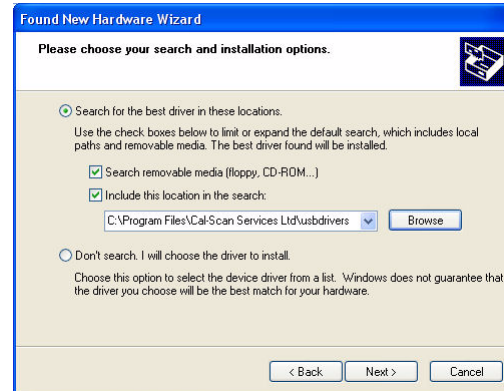
New Hardware Wizard

3. Click **Install from a list or specific location**, and click **Next**.



New Hardware Wizard

4. Select **Include this location in the search**, and click **Browse**.



New Hardware Wizard

5. Browse for the folder that contains drivers. This will usually be C:\Program Files\Cal-Scan Services Ltd\usbdrivers. Click **OK**.



Browse for Folder

6. You will return to the **New Hardware Wizard**. Click **Next**. Drivers will start to be copied. Click **Finish**.



New Hardware Wizard

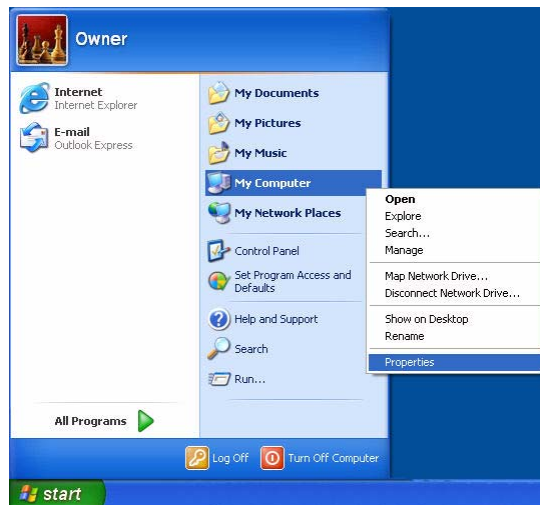
7. The New Hardware Wizard reappears. Repeat steps 2 to 6.

USB Troubleshooting

If the New Hardware Wizard does not appear when you connect the Interface Box, you may need to uninstall then reinstall the COM port and serial converter drivers.

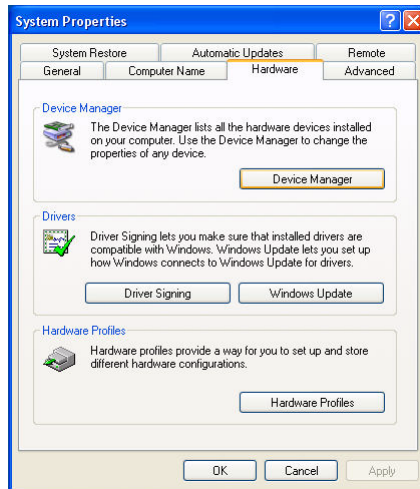
To troubleshoot USB installation

1. On the **Start** menu, right-click **My Computer**, and click **Properties**.



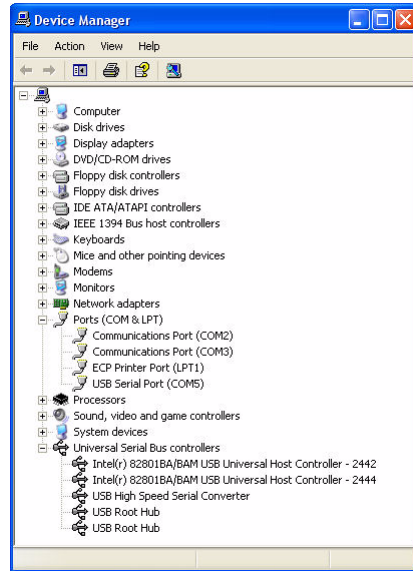
My Computer

2. **System Properties** opens. On the **Hardware** tab, click **Device Manager**.



System Properties

3. On the Device Manager, expand **Ports (COM&LPT)** by clicking the + next to the folder.



Device Manager

4. Look for USB Serial Port (COM *portnumber*). If there is a yellow exclamation mark next to it, right-click the port, and click **Uninstall**. If a warning message appears, click **OK**.
5. Expand **Universal Serial Bus controllers** by clicking the + next to the folder. Look for USB High Speed Serial Converter. If there is a yellow exclamation mark next to it, right-click it, and click **Uninstall**. If a warning message appears, click **OK**.
6. Unplug the Interface Box, wait five seconds, then plug it in again. The New Hardware Wizard should appear. Proceed with “To install USB drivers for the Interface Box” on page 195.

Glossary Of Terms

absolute pressure

Pressure relative to a perfect vacuum. It is the sum of gauge pressure and atmospheric pressure.

AC

Alternating current.

AC adapter

A power pack that enables you to adapt a device that uses direct current to alternating current.

advanced filter

A feature in Calwin that enables you to reduce data by eliminating some of the samples. For example, select every third sample, unless the pressure changes by an amount you specify. See Filter.

AGA Flow

American Gas Association.

Amphenol connector

A connection commonly used to communicate using electricity.

ASCII

A standard file format that the oil industry uses to present information from downhole and surface gauge recorders.

atmospheric pressure

It is the pressure indicated by a barometer. Standard atmosphere is the pressure equivalent.

Badger

Cal-Scan's silicon strain downhole gauge that measures internal pressures and temperatures at a one second sample rate.

Badger Tri Tool

Cal-Scan's silicon strain downhole memory recorder that measures extremely fast external temperatures, while still giving accurate pressure readings at a one second sample rate.

battery barrel

The tubular steel casing that protects the battery on Cal-Scan's downhole gauges.

battery icon

The image of a battery that appears on Cal-Scan's Hawk 9000 display when the battery is low and needs to be replaced.

Bin file

Binary file. Bin files contain raw data that needs to be recompensated or recalculated from machine language before it can be understood by humans.

BNC connector

Bayone-Neill-Concelman connector. Standard connector used to connect 10Base2 coaxial cable.

bullet nose

The end of the Cal-Scan's downhole gauges that has a point, like the end of a bullet.

calendar time

The actual time, as opposed to Delta time.

calibration

A process of dividing and numbering the scale of an instrument, correcting or determining the error of an existing scale, or of evaluating one quantity in terms of readings of another.

Calwin

Cal-Scan's software program that interfaces with all of the company's downhole gauges, surface gauge recorders, and E-Line Surface Readout tools.

Com port

A communication port on the back of your computer that allows you to connect your mouse, the Interface Box, and other devices to your computer. Each com port can accommodate one device. Com ports are NOT intended for use in hazardous locations.

configuration

A feature in Calvin that enables you to view or change the gauge program.

delta time

Measuring time relative to the start time, regardless of the real time of day.

diagnostics

A component of Calvin that enables you to set or change the initial settings for Cal-Scan's gauges.

differential pressure

The difference between cut-in and cut-out pressure of a control.

directory

An entity in the Windows computer operating system that groups and stores files and folders. There are several directories that store similar files. For example, C: directory stores your computer hard drive files, and A: directory is designated for floppy disc files.

downhole gauge

A memory gauge that is placed underground to record data relevant to pressures and temperatures.

download

To transfer data or software from one file or computer system to another. Also referred to as dumping.

dump box

A communication device that interfaces with Cal-Scan's downhole and surface gauge tools and your computer. Also called the Interface Box, or USB & Serial Cable Box.

E-Line

Electric line.

even minute

The moment the second hand of the unit's internal clock reaches 12.

file directory

A method of grouping and storing files in the Windows computer operating system. There are several directories that store similar files of a similar. For example, C: directory stores your computer hard drive files, and A: directory is designated for floppy disc files.

file extension

Every computer file has an extension, such as .prg, at the end of the file name, to signify what type of file it is. In this case, the .prg signifies that this file is a program file.

filter

To reduce data to 20 000 samples or fewer when plotting data on a graph by eliminating some of the samples. For example you can select every third sample. See Advanced Filter.

fixed rate

Running the recorder at one sample rate until the memory is full.

flow rate

The volume of solution that passes through a given quantity of resin within a given time. Usually expressed in terms of feet per minute per cubic foot of resin or as milliliters per minute per milliliter of resin.

folder

A method of manually grouping and storing files on your computer hard drive. A folders can be likened to a briefcase, in which you store files related to one particular project.

fracing

Hydraulic fracturing.

Gopher

Cal-Scan's Surface Readout Tools that allow all of its standard Badger, Mole and Wolverine downhole gauges to communicate to the surface through an electric line. Also called the SRO Box.

Gopher E-Line SRO

Cal-Scan's Surface Readout tool that is designed for temporary use on a wireline truck. An SRO Box.

Gopher P-SRO

Cal-Scan's Surface Readout tool that is designed for permanent mounting on a well site. An SRO Box.

Hawk 9000

Cal-Scan's low-powered surface box recorder that can monitor two pressure inputs: external temperature through an RTD, and differential pressure through a 4/20ma input. The sensors allow you to monitor oil and gas well buildups, do flow line analysis (with the optional external RTD or differential pressure sensor), as well as monitor general pressure and temperature. The onboard LCD display allows the operator to view the pressure and temperature on both pressure sensors, as well as the temperature on the external RTD.

hex wrench slot

A ring of six ridges on a tool designed to make contact with a wrench.

hours on tool

A feature in Calwin that displays the number of hours that the gauge has used. The hours on the gauge can only be reset by a Cal-Scan representative.

hydrostatic pressure

The pressure at any point in a liquid at rest; equal to the depth of the liquid multiplied by its density.

Hz

Hertz; a unit of frequency measurement.

INCONEL™

A superior brand of steel that Cal-Scan uses to manufacture its gauges.

Interface Box

Cal-Scan's communication device that interfaces with its downhole and surface gauge tools and your computer. Also called the Dump Box or USB & Serial Cable Box.

Kapton tape

A heat-stable adhesive tape used with the SRO Unit.

kbps

Data transfer rate; Kilobytes per second.

kPaa

Kilopascals absolute; gauge pressure plus atmospheric pressure.

kPag

Kilopascals gauge.

LCD

Liquid Crystal Display. The part of the unit that displays numbers, messages and icons such as a battery warning image.

LED

Light Emitting Diode. A red light that flashes to indicate the equipment is active.

Lemo connector

A connector commonly used to communicate with computers. Lemo connectors usually have six pins, or prongs, (male end) which make contact with six holes (female end) to communicate.

Ma

Milliampere.

Main Screen

The home page of Calvin.

memory card slot

The slot in Cal-Scan's Hawk 9000 Surface Gauge Box and Gopher E-Line Surface Readout Box that holds a multimedia card for downloading gauge data in hazardous locations.

MMC

Multimedia card.

Mole

Cal-Scan's silicon strain downhole gauge that measures internal pressures and temperatures at a one second sample rate.

multimedia card

A computer card that is inserted into Cal-Scan's Hawk 9000 Surface Gauge Box and Gopher E-Line Surface Readout Box to safely download gauge data in hazardous locations. Later, you can download the data from multimedia card, into your computer at a safe location.

multimeter

An electronic measuring instrument that combines several functions in one unit, such as an ammeter, voltmeter, and ohmmeter.

NC Pin

National Course

NPT Connection

National Pipe Thread. A connection commonly used for pipes and pressure. The thread is measured in centimeters or inches to indicate the size of the NPT connection.

Ohms

The unit of electrical resistance equal to the resistance through which a current of 1 ampere will flow when there is potential difference of one volt across it.

Ohm's Law

The relationship between current and voltage in a circuit: current is proportional to voltage and inversely proportional to resistance. Expressed algebraically, in DC circuits $I=E/R$; in AC circuits $I=E/Z$.

orifice

Accurate-size opening, as in an orifice plate, for controlling fluid flow.

overwrite

To replace the existing data, in a file, with new data. When you overwrite the data in a file, you destroy it.

passification film

A film that forms around lithium batteries when they are cold or have been stagnant for any period of time.

pressure

The force exerted by a liquid or gas per unit of area, usually measured in pounds per square inch (psi).

pressure gauge

Instrument for measuring pressure.

multirate

Program that schedules the gauge to run up to 15 different sample rates during a particular test.

psi

Pounds per square inch.

Psia

Pounds per square inch absolute; gauge pressure plus atmospheric pressure.

pSig

Pressure in pounds per square inch gauge.

raw data

Information on a gauge or in a binary file that needs to be recompensated or recalculated from machine language before it can be understood by humans.

real time graph

A graph that plots samples as they are being recorded by the gauge.

recompensate

To translate raw data (in machine language), into a format that is readable by humans.

recorder

A downhole gauge or surface box gauge which is designed to record pressures, temperatures, and flow.

resolution

Ability to distinguish between separate points or objects.

sample rate

The interval between samples. For example, to record a sample every 30 seconds, you would set a sample rate of 30 sec.

sample to terminal

A feature in Calvin that displays the samples as they are being recorded by the gauge.

sensor/sensing device

A device that monitors a measured condition and its fluctuations. If the measurement varies sufficiently, the device sends a signal to revise the operation of the system to offset the change.

serial cable

A cable that connects Cal-Scan's Interface Box to its downhole and surface gauge tools and to your computer.

serial port

A communication port on the back of your computer that allows you to connect your mouse, the Interface Box, and other devices to your computer. Each serial port can only accommodate one device. Serial ports are NOT intended for use in hazardous locations. Also called a Com Port.

SmartDisk

A floppy disk housing into which you insert a multimedia card, so you can insert the card into your computer. Newer computers have a multimedia card slot, and do not require a SmartDisk.

SRO

Surface Readout System.

SRO Box

Gopher Surface Readout Box.

start time

The time that the battery was plugged into the gauge.

static pressure

The normal force per unit area exerted by a moving fluid on an immersed body carried within the fluid. The normal force per unit area at a small hole in a wall of the duct through which the fluid flows (piezometer), or on the surface of a stationary tube at a point where the disturbances created by inserting the tube cancel.

surface box

A memory gauge that is placed above ground to record data relevant to pressures, temperatures, and flow.

Surface Readout system

Gopher. Enables Cal-Scan's standard Badger, Mole and Wolverine downhole gauges to communicate to the surface through an electric line. Also called the SRO, SRO Box, or Gopher

toggle button

The button on Cal-Scan gauges that turns the unit on and off, and activates the unit's various modes. By repeatedly pressing the toggle button, you will switch between the unit's modes.

transducer

The means by which the gauge converts a signal from the sensing device into data.

USB & Serial Interface Box

A communication device that interfaces with Cal-Scan's downhole and surface gauge tools and your computer. Also called the Dump Box, or Interface Box.

USB cable

A cable that connects Cal-Scan's Interface Box, surface gauge tools, and your computer.

Wolverine

Cal-Scan's quartz strain downhole gauge that measures pressures and temperatures with unparalleled stability and resolution. this gauge allows the operator to capture fast pressure pulses with a 1/10th of a second sample rate that other downhole recorders would miss.

Index

A

- AGA flow settings 90
- ammonia 133
- amp hours 114, 119
- approvals, safety 104
- ASCII 75
 - filtered 77
- atmospheric pressure 108

B

- Badger 97
 - specifications 98
- Badger Tri Tool 99
 - specifications 100
- battery 162
- battery testing 120
- bombwell 133

C

- calibration 84
 - downloading 87
- Cal-Scan, about 1
- CalWin
 - about 3
 - connecting 15
 - downhole gauge 15
 - Hawk9000 16
 - installing 6
 - menu 10
- cleaning tools 129
- com ports 94
- configuration 92

D

- data encoding 169
- data model 170
- deadweight mode 154
- diagnostics 83
- differential plots 67
- downhole extended test 108
 - programming 110
- downhole gauge
 - connecting 15
 - testing 108

- downhole gradient 115
 - programmings 115
- downloading
 - downhole gauges 51
 - dump 51
 - find end of memory 89
 - manually 88
- downloading data 125, 158
 - with MMC 161
 - with Raven 161
- dump
 - manual 88
- Dump Box 3

E

- expected downhole temperature 110
- exporting data 75
- exporting to file 75
 - FAS 82
 - filtered 77
 - set start or end time from graph 67, 80
- extended buildup test 136

F

- FAS 82
- field wiring specifications 184
- file tools 91
 - getting tool data 92
 - setting start time 91
- files
 - splitting 94
- find end of memory 89
- fixed rate 19, 44
- floating point byte order 172
- flow proving 142
- function codes 171

G

- gauges
 - downloading calibration 87
 - downloading data 51
 - get hours on 85
 - inserting calibration 84
 - monitoring operation 86
 - programming 19

- fixed 19
 - multirate 22
- serial numbers 84
- get hours on tool 85
- graphs 63, 127
 - changing start or end time 67
 - differential plots 67
 - options 64
 - printing 65
 - real time 67
 - setting scale 66
 - zoom 66
- grease 133

H

Hawk 9000

- about 103
- AGA flow settings 90
- connecting 16
- maintenance 162
- Modbus 169
- permanent 165
- precautions 164
- programming 31
- real time monitoring 153
- restarting 48
- setup 135
- specifications 105
- starting 152
- turbines 38

headers 61

high temperature mode 112, 117

holding register list 178

hydrostatic test 138

I

installation 6

- file locations 7
- troubleshooting 7

Interface Box 3

L

labyrinth oil traps 133

line speed 132

low power mode 153

M

maintaining Hawk 9000 162

maintenance 129

- battery installation 122
- battery testing 120
- cleaning 129
- O-rings 129

manually dumping data 88

menu bar

- Dump 11
- File 10
- Presentation 11
- Program 10
- Recompensate 11
- Software Options 13
- Tool Options 12

menus 10

merging data 69

meter run 190

Modbus 169

- data encoding 169
- data model 170
- floating point byte order 172
- function codes 171
- holding register list 178
- register list 173

Mole 97

- specifications 98

multimedia cards

- clearing 5
- options 4
- passwords 4
- updating surface box settings with 34

multirate 22, 45

O

operational precautions 132, 164

- line speed 132

optical flow meters 193

orifice settings 90

O-rings, replacing 129

overrun rate 113, 119

P

- passification film 121
- permanent Hawk 9000 165
 - CSA installation requirements 179
 - field wiring 184
 - maintenance 181
 - Modbus 169
 - UL installation requirements 180
 - wire hookups 182
- pigtails 133
- precautions 132, 164
- presentation 61
 - graphs 63, 127
 - headers 61
 - importing 63
 - merging data 69
 - table view 68, 128
- printing
 - graphs 65
 - spreadsheet view 70
- procedures, to
 - change orifice settings 90
 - change the graph scale 66
 - change the Hawk 9000 battery 162
 - change the start or end time 67
 - change the time format in graphs 67
 - check the battery in the downhole tool 121
 - clean downhole tools 129
 - clear MMC 5
 - configure turbine settings 40
 - connect a downhole gauge to your computer and the Interface Box 15
 - connect Hawk 9000 using Raven 153
 - connect multiple Hawks using Raven 156
 - connect the Hawk9000 surface box 17
 - create a differential plot 68
 - create a graph 63, 127
 - create a turbine calibration 42
 - download a recorder calibration file 87
 - download data
 - with MMC 161
 - download data from a downhole gauge 125
 - download data from a surface box with an Interface Box 53
 - download data with a multimedia card 53
 - download data with an Interface Box 159
 - edit an existing turbine calibration file 43
 - export compensated data to filtered ASCII 78
 - export compensated data to standard ASCII 75
 - get tool data from a file 92
 - import header information 63
 - insert recorder calibration 85
 - install CalWin from CD-ROM 6
 - install CalWin from website 6
 - locate the end of memory 89
 - manually download data 88
 - manually recompensate or redecode data 57
 - merge data 69
 - open a saved program 28, 48
 - plug the battery into the downhole tool 122
 - print a graph 65
 - print table data 70
 - program a gauge for a downhole gradient 116
 - program a gauge for an extended test 110
 - program a gauge for SRO mode 123
 - program a gauge using fixed rate sampling 20
 - program a surface box using fixed rate sampling 44
 - program gauges using multirate 23
 - program Hawk 9000 for a hydrostatic test 139
 - program Hawk 9000 for extended buildup test 136
 - program Hawk 9000 for flow proving 143
 - program Hawk 9000 for production testing 147
 - program Hawk9000 with multirate 45
 - program the permanent Hawk 9000 166
 - replace O-rings 130
 - restart the Hawk9000 surface box 48
 - save a program to disk 27, 47
 - set header options 61
 - set the start time in a binary file 91
 - set up com ports 94
 - set up MMC passwords 5
 - set up the Hawk9000 surface box 31
 - start Hawk 9000 after programming 152
 - use an MMC to update Hawk9000 settings 34
 - view a gauge's program 29
 - view data in table view 68, 128
 - view hours on a tool 85
 - view real-time Hawk 9000 data in deadweight mode 155
 - view real-time Hawk 9000 data in graph format 154
 - view recorder parameters 83
 - view samples to terminal 86
 - zoom into an area on the graph 66
- production testing 147

- programming 19
 - fixed rate 19, 44
 - multirate 22, 45
 - saving to disk 27, 47
 - viewing the program 28
- programming Hawk 9000 31

Q

- quartz gauges 101
 - specifications 102

R

- Raven 152
 - real time monitoring 153
- real time graphs 67
- real time monitoring with Raven 153
- recalculating, redecoding, or recompensating 57
- recorder calibration, downloading 87
- recorder calibration, inserting 84
- recorder parameters 83
- register list 173
- remote communication 152
- resetting serial numbers 84
- restarting the Hawk 9000 surface box 48
- retrieving data 125
- RS-485, connecting Hawk 9000 167

S

- safety approvals 104
- sample rate 110
- sampling to terminal 86
- saving a program to disk 27, 47
- screens 133
- serial numbers, resetting 84
- setup 107
 - downhole extended test 108, 110
 - downhole gradient 115
- silicon strain gauges 97
 - specifications 98
- specifications 105
 - Badger and Mole 98
 - Badger Tri Tool 100
 - Wolverine 102
- splitting files 94
- starting Hawk 9000 152

- surface box
 - programming
 - fixed 44
 - multirate 45
 - setting up 31

T

- table view 68, 128
- termination 168
- test duration 110
- tool options 83
- turbines 38
 - calibration files 41

U

- USB & Serial Cable Interface Box 3
- USB & Serial Interface Box 159

V

- viewing data 125
 - graphs 127
 - real time 154
 - table view 128

W

- wire hookups 182
- Wolverine 101
 - specifications 102

Z

- zoom back one 66
- zooming 66