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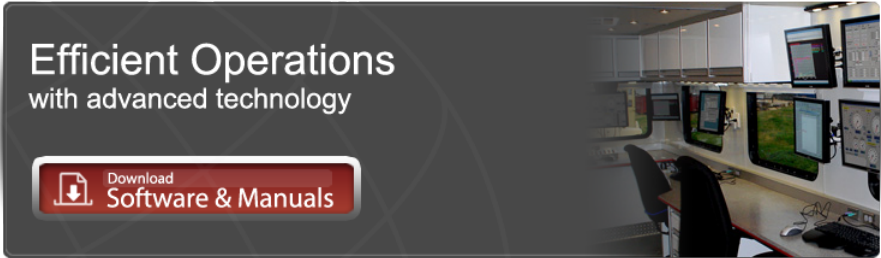
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AccuFrac™ Systems

Stewart & Stevenson pioneered the development of advanced electronic control systems for well servicing equipment. The AccuFrac blender control system is the most advanced system, incorporating a user-friendly touch screen PC interface to enhance slurry quality and operator performance through automatic control of density, flow rate and chemical additives. AccuFrac can be programmed to function on multiple-stage jobs, ramp jobs or any combination of the two. The AccuFrac-PC interface provides control of multiple blenders, hydration units and chemical additive units from the Data Acquisition and Control Center. UPS systems and solid-state CPU components provide reliable operation with backup systems.

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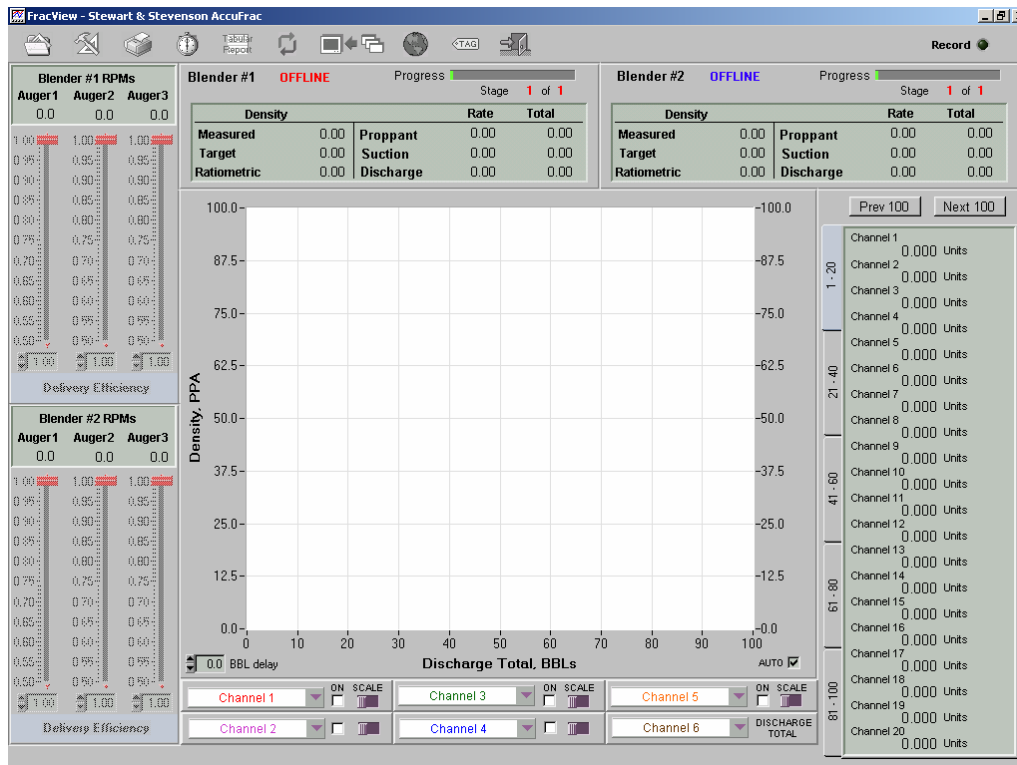
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This manual is not a textbook on mechanics, electronics, or hydraulics. Sufficient descriptive material and illustrations are included to enable the operator to understand the basic construction and theory of operation of this equipment. The intent of this manual is to guide the operators and maintenance personnel in the proper use of the equipment. This manual is not a substitute for properly trained personnel or common sense.

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All information in this manual is based on the latest production information available at the time of publication. Direct any questions concerning the contents or format of this manual to:

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Overview

The AccuFracPC™ software allows you to monitor, control, and record activities throughout a fracturing job. The software interfaces with two Data Acquisition Systems, two Blender Density Controllers, two Blender Chemical Controllers, and two Chemical Additive Systems. Each of these components provides specific functionality to the operator, and through multiple display screens, you can use the AccuFracPC™ software to control the equipment while up to four others can monitor the same job.

This software is designed for installation on a single computer and to control up to six pieces of equipment. The software is preconfigured to monitor and control two blenders, two chemical additive systems, and two data acquisition systems.

The AccuFracPC™ software can record up to 500 channels while a job is running. The user can configure each of these channels. Data selected by the user can be saved to a standard-formatted text file for use with other software applications, for later use, or for archiving.

System and Hardware Requirements

Table 1.1 shows the minimum system and hardware requirements to run the AccuFracPC™ software.

Table 1.1: Minimum System Requirements	
Item	Description
Computer	• IBM or fully compatible PC using a Pentium 200 MHz processor • CD ROM drive • RS232 serial port • Stewart & Stevenson registration code
Operating System	Windows 98, 2000, or XP
Memory	128 MB RAM; more is highly recommended
Disk Drive	A hard disk with at least 500 MB of free disk space
Mouse	A Windows compatible pointing device
Other Equipment	Windows supported printer

Installation & Setup

AccuFracPC™ can be downloaded from the internet at the following address: <http://www.ssss.com/petroleum/download.asp>. If you need to obtain the software on other media, please contact your sales representative for assistance.

To install the AccuFracPC™ software

1. Close any open application.
2. Close any virus-detection application.
3. Make sure your computer meets the minimum system requirements listed in **Table 1.1**.
4. Determine the drive where the software will be installed.
5. Check the amount of space available on the selected drive.
6. Unzip the downloaded file to a specified location on the hard drive or load the cd into the CD-ROM drive.
7. Using windows explorer, locate the extracted files or the CD-ROM drive containing the application.
8. Double click on "setup.exe".
9. Follow directions to install.

Starting the Software

Make sure the proper equipment is connected to the correct connector on the data van (i.e. blender to blender connector, CAS to CAS connector, etc). Turn on power to the equipment.

To start the software

1. Click the Windows **Start** button.
2. Select the Programs menu.
3. Select the Stewart & Stevenson AccuFracPC™ vx.x (x.x is the version number) program group.
4. Select the AccuFracPC™ program application

If this is the first time the program is run, it will prompt you for a registration code. Please call the number on the registration box to obtain your registration code.

Once you are registered, you need to setup the communication ports in order for the software to talk to the equipment. Please see **Section 2.1: Communicating with the Equipment** for more detailed.

Chapter 1:
Software Basics

1.0 Overview:

Initially after installation, AccuFracPC™ software starts by opening eight windows: two Blender windows, the FracView window, the Monitor window, and four customizable windows. All the windows are behind the *Blender 1* window.

Note: On the task bar containing the Start button, you should also notice several buttons. When you move the mouse over a particular button, a description pops up, showing the name of the window.

When you select a particular button, the appropriate window appears in front on the primary monitor. If the window is hidden or if you want to move a particular window, simply right-click on the button, corresponding to the interested window and select move with the left mouse button. Then the symbol  appears. Press the down arrow key and the mouse "grabs" the window. Move the mouse to the monitor of your choice and left click to "drop" it.

These windows contain data from two blenders, two chemical additive system units, and two data acquisition systems connected serially. You can record, manipulate, and graph data points coming from these equipments.

1.1 Blender Windows

There are two blender windows. One displays *blender 1*, including a blender, a chemical additive system (CAS), and a data acquisition system (DAS). The second window, *blender 2*, displays a second blender, a second CAS unit, and a second DAS. The *Blender* windows are the main AccuFracPC™ screens that display summaries of the status of the systems and the progress of currently running jobs. Each consists of eight sections:

1. Chemical Additive System
2. Blender Chemical
3. Blender Density
4. Data Acquisition
5. General Control Command Buttons (across the top of the window)
6. Blender Control Command Buttons
7. CAS Control Command Buttons
8. All System Control Command Buttons

Figure 1.1 shows the *Blender 1 Window*.

The *Blender* windows display a wealth of information about the equipment connected to the AccuFracPC™ software. The elapsed time at the top right corner of the *Blender* windows displays hours, minutes, and seconds. The timer begins when the software first starts.

1.2 Chemical Additive System (CAS)

The CAS section displays the clean suction rate and total, base rate 2 and total 2 (usually coming from the blender), and the rate and total

of up to 12 chemicals. It also displays the total stages and current stage of the job. The CAS section displays the job progress and the target in terms of rate or concentration for up to 12 chemicals. To change to concentration, click the Concentration box. The chemicals are named by the operator, and the CAS section displays their status (i.e. disable (D), manual (M), or automatic (A)). The CAS section also displays the status of the job, and whether it is aborted, running, etc.

The *Blender Chemical* section displays much of the same information as the *CAS* section.

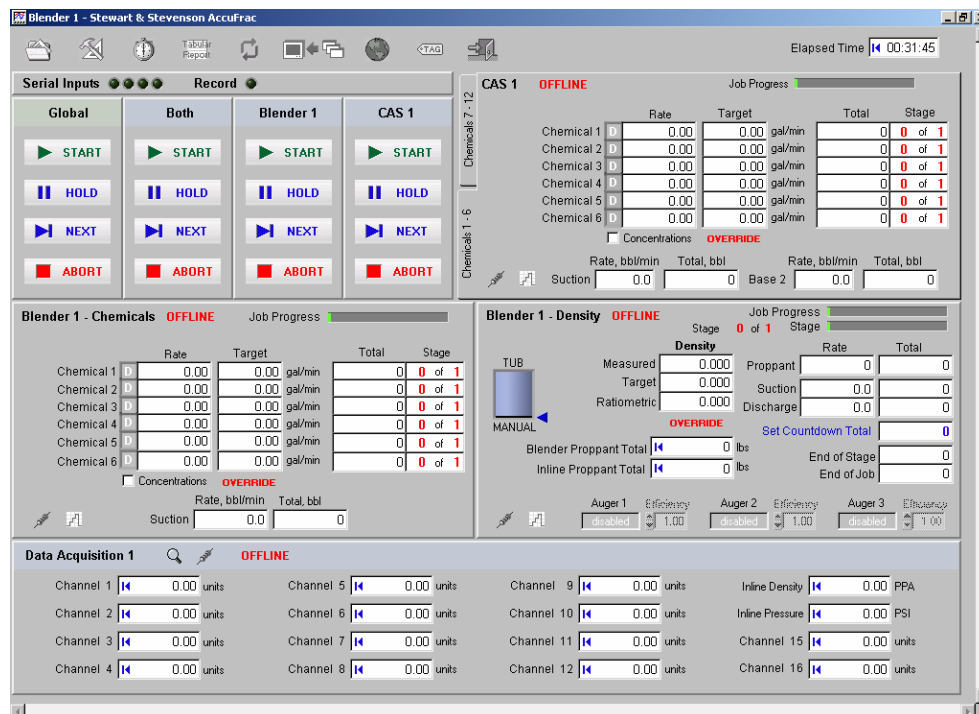


Figure 1.1: Blender 1 Window

1.3 Blender Density

The *Blender Density* section displays the state (i.e. Disabled, Automatic, or Manual) and delivery efficiency of the three augers. You can change the efficiency of the augers instantly by entering a new value or click the ▲/▼ arrows. Efficiency changes for different auger sizes. Lower efficiency speeds up the auger to draw more sand into the tub.

The combined proppant rate and total of 3 augers is also displayed in the *Blender Density* section. The section displays the measured density from the blender's densitometer, the target density of the current job stage, and the ratiometric density.

Note: By default, density is displayed as concentration of pounds of proppant added per gallon (PPA).

You can change this to specific gravity unit (SGU) by clicking the  button, choosing *Preferences*, and checking the box *Display densities in SGU*. If the augers are not turning, ratiometric density will be equal to the base fluid.

Displayed at the top right of the *Blender Density* section is the end of current stage and end of job discharge total in barrels (BBLs). It visually shows the job and current stage progress.

The Countdown Total is based on the discharge total, and is set by the operator. Once set, as the discharge total of the blender increases, the Countdown Total decreases. You can use this as a counter or marker to see what happens during a job when a certain amount of volume in barrels discharges.

Two calculated values are displayed in this section. The Blender Proppant Total is affected by the discharge rate, measured density, and proppant SGU of the blender. The Inline Proppant Total is affected by the discharge rate and proppant SGU of the blender, and the inline densitometer reading displayed in the Data Acquisition section.

Other applicable information in the Blender Density section includes the tub. The tub displays the measured level and the target level (arrow). The state (i.e. MANUAL or AUTO) is also displayed in the Blender Density section.

Note: There is no control of the tub within the AccuFracPC™ software.

1.4 Data Acquisition

The *Data Acquisition* section displays 16 values that come from the Data Acquisition System (DAS). Fourteen values are configurable and can be assigned to any frequency input or any analog input channel however, *Inline Density* and *Inline Pressure* are fixed. The *Inline Density* is used in the *Inline Proppant Total* calculation in the *Blender Density* section. The *OFFLINE* status shows the DAS is not connected. If the DAS is online, it will be blank.

Tables 2.1a and **Table 2.1b** display the command buttons on the *Blender Windows*.

Table 2.1a: Blender Window Items	
Item	Description
	Displays file management features. Refer to Section 7 for more information.
	- Loads & saves settings (including COM ports and channels). - Allows the operator to set <i>Preferences</i> such as which windows to open, displaying density in SGU or PPA, and selecting the executable program (i.e. Notepad.exe, Explorer.exe, etc) which the auxiliary button  from the monitor window will launch. - Selecting <i>Password Settings</i> allows the operator to change the current system password, and lock channels.
	Resets the elapsed time, all totals, groups totals, proppant totals, and any of the 500 channels that is setup as a total.
	Sets up the tabular report. Refer to Section 7 for more information.
	- Communicates with Blender 1 if pressed from the <i>Blender 1</i> window and Blender 2 if pressed from the <i>Blender 2</i> window. - Updates augers efficiencies on the <i>Blender</i> windows and the <i>FracView</i> window. - Also updates the graphs on the <i>FracView</i> window, showing Blender 1 job profile (cyan) and Blender 2 job profile (green).
	Places all windows behind the window on which this button was pressed.
	Displays the status of the equipment and if the equipment is online or offline.
	Assigned by the operator and attached to a recorded file. Refer to Section 7 for more information.
	Closes the AccuFracPC™ software and saves 500 channel setup and communication ports setup.

Table 2.1b: Blender Window Items

Item	Description
   	Job commands sent to each blender or to each CAS. The software can also send the same job command to one blender and one CAS. Refer to the <i>Blender Density</i> , <i>Blender Chemical</i> , and <i>CAS</i> sections for more information.
	For Data Acquisition, this command button opens a channel setup window. The operator can configure 16 channels from this window. Refer to the <i>Data Acquisition</i> section for more information.
	Opens a hardware setup window for the CAS, <i>Blender Chemical</i> , <i>Blender Density</i> , or <i>Data Acquisition</i> , depending on which section and window the button was pressed.
	Opens a job setup window for the CAS, <i>Blender Chemical</i> , or <i>Blender Density</i> , depending on which section and window the button was pressed.
	Displays the status of the external ASCII data coming in through serial port. Green LED indicates the presence of data.
	Displays the recording status. Green indicates the software is recording.

1.5 FracView Window

The *FracView* window displays data from two blenders. It provides status information about blender operations and overall jobs progresses. The *FracView* window also displays job profiles (blender 1 - cyan; blender 2 - green) and can graph the progress of up to five channels.

The *FracView* window (Refer to **Figure 1.2**) displays auger speed and the delivery efficiency of each auger from two blenders. The efficiencies can be changed in real time using the slider or numerical input. Other information displayed on the *FracView* window includes density data, proppant rate and total, suction rate and total, and discharge rate and total.

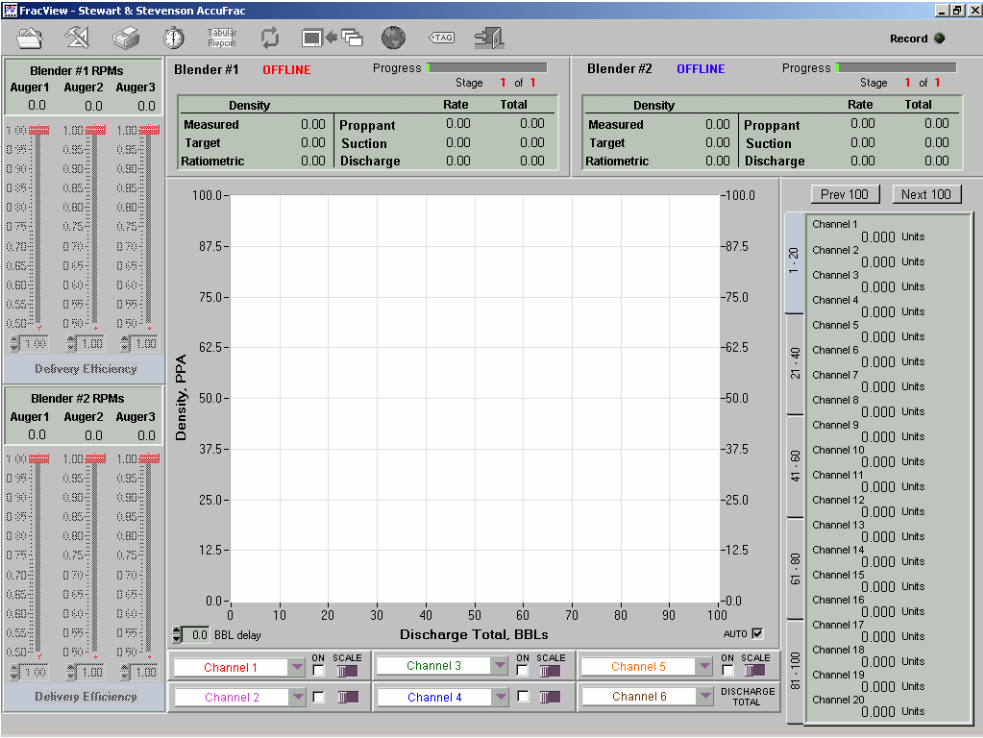


Figure 1.2: FracView Window

The box to the right of the graph on the *FracView* window displays the numerical value, description, and units of the 500 channels.

On the graph, the left y-axis is fixed to density in PPA or SGU and the x-axis is fixed to discharge total. To display any channel (up to 5) on the graph, click the **ON** box. To assign any of the five channels as the left y-axis, move the **SCALE** switch to the left as shown .

Note: In order to graph, the channel in the *Discharge Total* section must be a discharge total. Also, for the graph to make sense, any channel assigned to the left y-axis must be density (SGU) or concentration (PPA).

To assign a channel to the right y-axis, make the **SCALE** switch to the right as shown . When you select the **Auto** check box, the software will auto scale the maximum and minimum limits on the y-axis. If the **Auto** check box is not selected, the operator will have to manually enter the maximum and minimum limit by double clicking on highest number and the lowest number, respectively, on the y-axis.

By entering a number in the **BBL Delay** box in the lower left hand corner of the graph, the graph will shift the number of barrels entered to the right.

The command buttons at the top of the window are the same as those on the *Blender* windows. See **Table 2.1a** and **Table 2.1b** for descriptions. The  command button prints the current graph or a saved graph file. Refer to printing in section 8 for more information.

1.6 Monitor Window

The *Monitor* window (Refer to **Figure 1.3a**) provides a display for saved and live job data. There are two windows; however, only one can be shown at a time. At the top left of the panel, there are *COM* LEDs that illuminate when the corresponding serial COM Port is receiving data.

Note: The LEDs from left to right correspond to the Input/Output COM tabs 1 to 4, not the COM Port itself.

The *REC* LED displays the recording status. The green color indicates that the software is recording the 500 channels, and no green color indicates the software is only monitoring.

Like the *FracView* window, there are channel boxes at the bottom of the window in which you can choose which channels display on the graph. In the *Monitor* window, you can display up to six channels. The *ON* check box displays the channel on the graph, and the *SCALE* switch indicates whether to use the left or right y-axis for the channel being graphed.

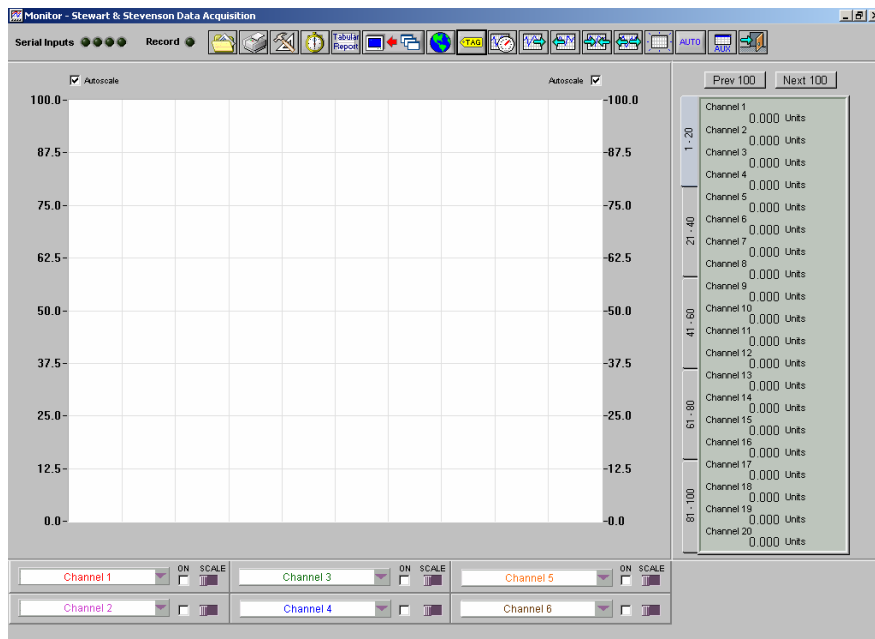


Figure 1.3a: Monitor Window #1

Unlike the *FracView* window, the x-axis is time based rather than discharge total. Thus, there will be a time stamp below the left y-axis when any of the *COM* LEDs are green. A second time stamp below the

right y-axis also appears, and it will increment. Also, unlike the *FracView* window, the left y-axis is not fixed.

When the **AUTOSCALE** check box above the left y-axis is checked, the AccuFracPC™ software automatically scales the maximum and minimum values of the left y-axis. Otherwise, you must manually enter the maximum and minimum values by double clicking on the highest number and the lowest number, respectively, on the y-axis. The right side of the window displays numerical values for each of the 500 channels.

Figure 1.3b (next page) shows the second *Monitor* window. Unlike the first *Monitor* window, it contains 4 y-axes. Like **Figure 1.3a**, the x-axis is also time based. From left to right, the first 2 channels correspond to the 2 y-axes, respectively, on the left side of the graph. The next 2 channels correspond to the 2 y-axes, respectively, on the right side of the graph. These four channels are part of the 500 channels you initially setup.

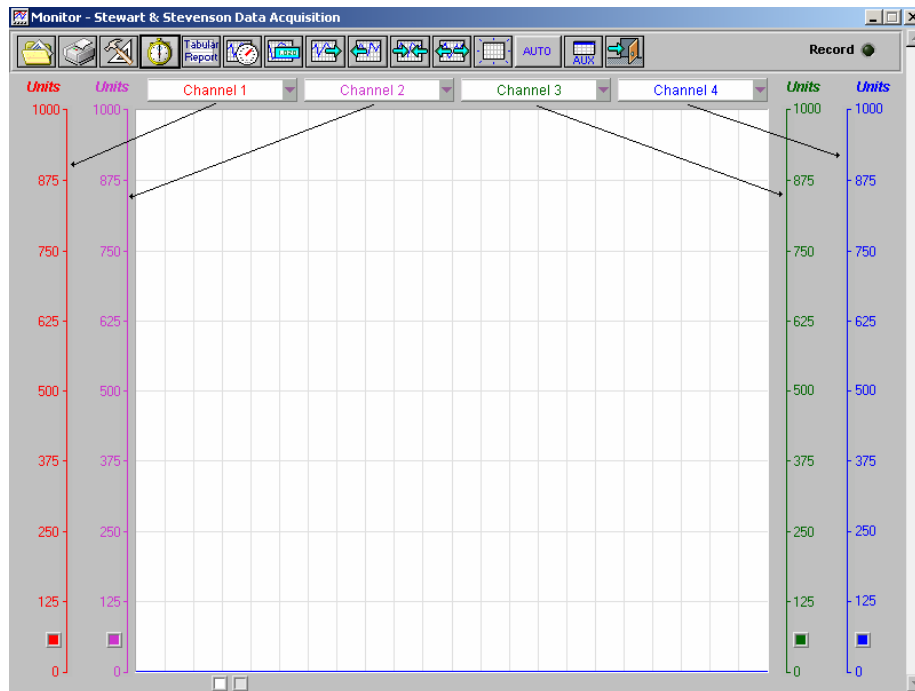


Figure 1.3b: Monitor Window #2

The four channels will have descriptions in the boxes and units above the appropriate y-axis once they are setup. You can change the color of the y-axis and the graph line by clicking on the color box next to the appropriate y-axis and selecting a new color. The left color box at the bottom of the graph corresponds to the background color, and the right color box corresponds to the color of the grid on the graph. To change, click on the box and select a color.

Digital display for the graph of each channel can be turned on or off by clicking the  button. After clicking the  button, the **Display**

Settings box will appear (Refer to **Figure 1.4**). Click the appropriate box to turn settings on or off.



Figure 1.4: Display Settings

Some command buttons at the top of the window are the same as those on the *System* windows and the *FracView* window. See **Table 1.1a** and **Table 1.1b** for descriptions. **Table 1.2** (next page) shows command buttons specific to the *Monitor* window.

Table 1.2: Monitor Window Command Buttons	
Item	Description
	Allows you to choose the kind of graphical display used on the <i>Monitor</i> Window. The AccuFracPC™ software shows examples of each display when you click the <i>Choose Display</i> button.
	The <i>Pan Graph</i> buttons let you pan the graph view portions that are not currently displayed. The arrows indicate the direction in which the graph will pan.
	The <i>Zoom Graph</i> buttons let you reduce or enlarge the graph displayed. The left button zooms out and the right button zooms in.
	The <i>Reset Graph</i> button clears the graph. The operator will be prompted before a reset.
	- The <i>Graph Scroll Mode</i> button lets you choose between two scroll modes: <i>AUTO</i> and <i>HOLD</i>. <i>AUTO</i> mode scrolls the graph to the right and continues graphing data points. <i>HOLD</i> mode stops the scrolling and takes a snap shot of the graph. The time stamp below the right y-axis stops in <i>HOLD</i> mode.
	- Launches the executable program setup by the operator. - Clicking and selecting <i>Preferences</i> lets the operator change the executable program.

1.7 Preferences

The *Preferences* window (**Figure 1.5**) can be reached by clicking , then *Preferences*. The *Preferences* window allows the operator to change the following settings:

- Display Densities in SGU.
- Display Monitor Window.
- Display FracView Window.
- Display Second Blender
- Display Customizable Windows.
- Set the Number of Customizable Windows (Maximum of 4).
- Set the Auxiliary Program.

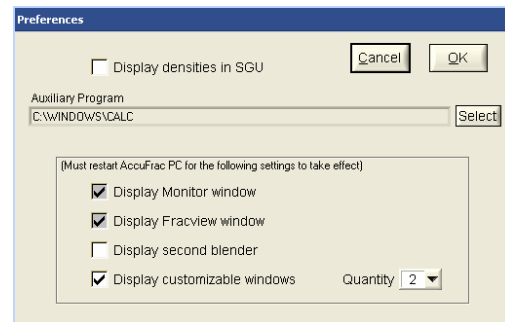


Figure 1.5: Preferences Window

Note: The operator must restart AccuFracPC for any changes made in the *Preferences* window to take effect.

1.8 Password Settings

The *Password Settings* window (**Figure 1.6**) can be reached by clicking , then *Password Settings*. The user will be prompted for a password before continuing. The *Password Protection Settings* allows the user to lock out specific channel ranges. Locking out channels is recommended to keep other users from modify and/or corrupting data.

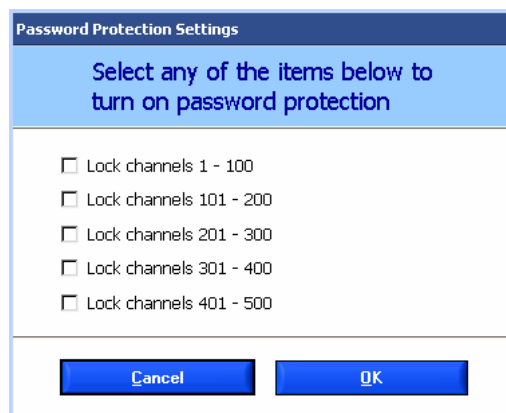


Figure 1.6: Password Settings Window

Chapter 2:
Communications

2.0 Overview

The network controllers interface with the AccuFracPC™ software through RS232 communication protocol. The software communicates with each network controller using three wires: (1) transmit (TX0 on the network controller), (2) receive (RX0 on the network controller), and (3) ground (GND on the network controller). These network controllers are usually mounted very close to the computer on which the AccuFracPC™ software is installed. Each network controller communicates with its corresponding equipment through a 2-wire RS485 communication protocol. The equipment includes: (1) a Blender; (2) a CAS; (3) a DAS; (4) a second Blender; (5) a second CAS, and (6) a second DAS. Once setup correctly, the software is essentially communicating with this equipment.

The software also outputs or receives up to four ASCII data serial streams. Thus, the computer on which the software is installed must be equipped with at least ten RS232 communication ports to utilize the full features of the AccuFracPC™ software.

2.1 Communicating with the Equipment

In order to communicate with the equipment, the serial ports on the computer must be setup correctly. To access the setup window, click  and select **Configure COM Ports**. The **COM Port Setup Window** will appear (Refer to **Figure 2.1**). The Input Streams section contains six tabs to identify the equipment. Each equipment tab must be setup with the following parameters:

1. **CTS Mode:** OFF
2. **XON/XOFF:** OFF
3. **Stop Bits:** 1
4. **Data Bits:** 8
5. **Parity:** None
6. **Baud Rate:** 57600

The *Com Port* number depends on where the network controllers are connected to the computer. There are 128 COM ports from which to choose. Use the ▲/▼ arrows or click within the box to make your selection. When you have setup the communication ports, click **OK** to exit the window.

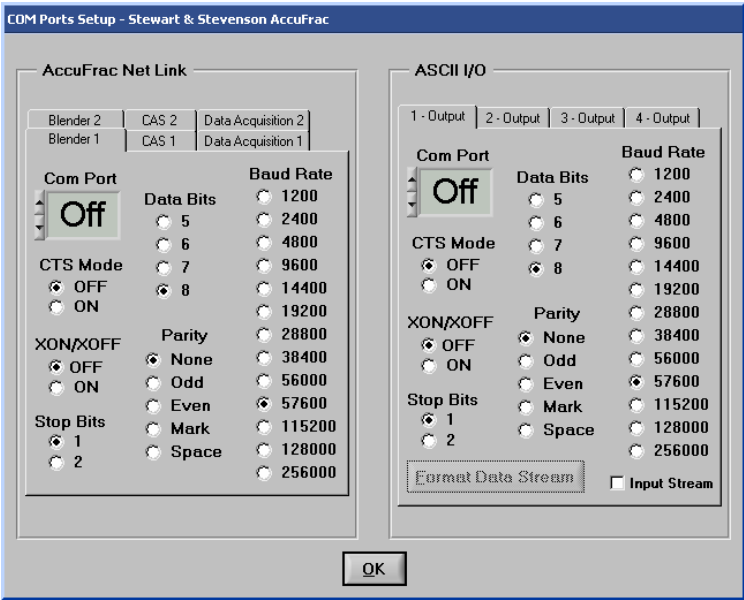


Figure 2.1: COM Port Setup Window

Next, verify that the network controllers are communicating with the software and that the equipment is online. The software communicates with the network controllers when the *COM* LEDs are green on the *Monitor* window. From left to right, the first LED is COM 1; second is COM 2; third is COM 3; and fourth is COM 4. You can also check the status of the network controllers and the equipment by clicking on  (Refer to **Figures 2.2a, 2.2b, or 2.2c**).

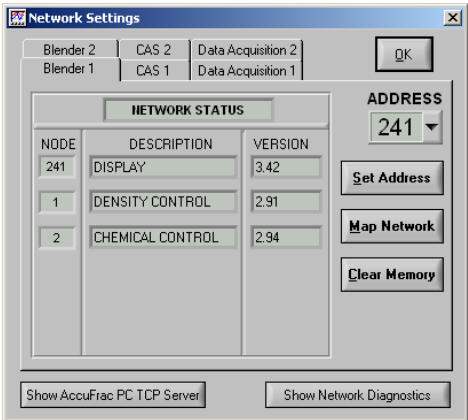


Figure 2.2a: Blender Network Settings

The Network Settings window contains six tabs, corresponding to the equipment connected. Each of the equipments is a network. Thus, there are 6 networks. Each network has only one master (address 240) and up to 3 slaves (address 241, 242, or 243). Except for Data Acquisition 1 and 2, each piece of equipments has two network controllers. The

network controller on the unit will be the master, and the network controller communicating with the software will be the slave. Its **ADDRESS** and **NODE** will be **241**, **242**, or **243**. If the address is not **241**, **242**, or **243**, you must select one of the three appropriate addresses and click **Set Address**. The software will prompt you to update the window by clicking **Map Network**. When the network controller is communicating with the software, the **DESCRIPTION** will be **Display**, and there will be a version number in the **VERSION** box. Each of the DAS has one network controller that must be the master.

Note: If there is not a master on the network real-time data will not be updated. Two masters on the network will result in a communication loss.

When Blender 1 or 2 is online, it will display what is shown in **Figure 2.2a**. **Figure 2.2b** shows CAS 1 or 2 online. **Figure 2.2c** displays Data Acquisition 1 or 2 online.

Note: If the first line is grayed out, the software is not communicating with the network controller, and thus, it will not communicate with the equipment. Make sure that the equipment is connected correctly to its corresponding network controller. The blender cannot be connected to a CAS network controller or vice versa.

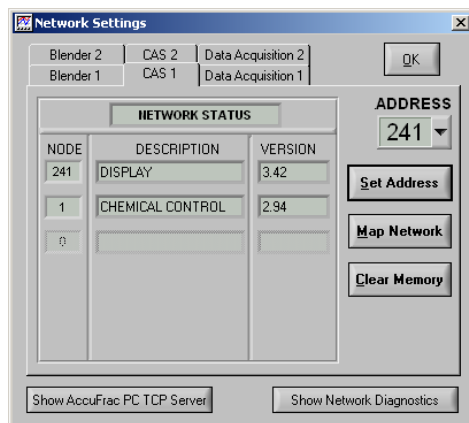


Figure 2.2b: CAS Network Settings

Map Network finds any equipment that is connected. **Clear Memory** resets the network controller communicating with the software. It also clears the descriptions and units for Data Acquisition, the chemical descriptions on the Blender, and the chemical descriptions on the CAS. **Clear Memory** only affects the tab that is selected when you press the **Clear Memory** button.

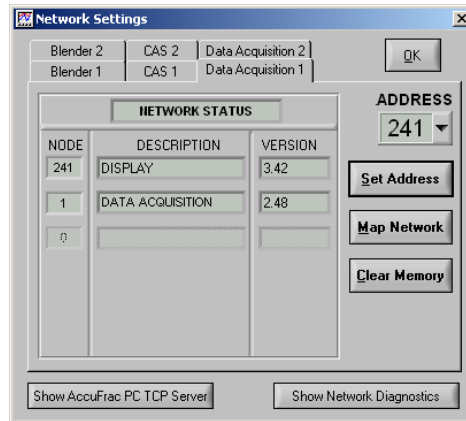


Figure 2.2c: DAS Network Settings

2.2 Communicating with Another Computer

The software is capable of outputting an ASCII data stream to four RS232 serial ports. The stream contains a time stamp, a delimiter, up to 128 values, and a terminator. To setup the output data, the hardware parameters (Refer to **Figure 2.3: Serial Data Output**) for the selected **Output** tab must match the parameters setup on the external computer.

To access the data stream setup, click **Format Data Stream**. The **Format Data Stream** window appears (Refer to **Figure 2.3**).

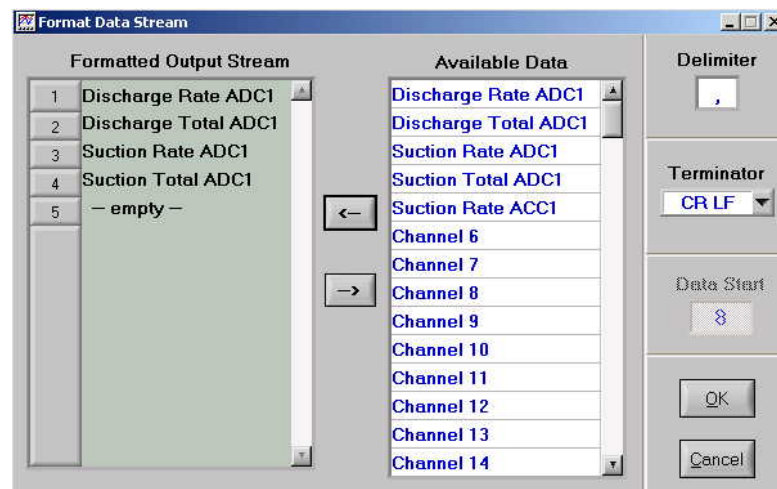


Figure 2.3: Serial Data Output

Use the arrows to add or remove the available data from the stream. You can also enter any character as a delimiter, and select your terminator. Press **OK** to accept your changes or **Cancel** to abort changes.

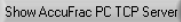
Instead of using the port as output, you can also set them up as input to read any incoming ASCII data stream. To setup, simply check the **Input Stream** box and pick the COM port where the data stream is connected. The rest of the parameters (i.e. baud rate, parity, etc.) should match with the source where the ASCII data stream originated. Select the **Format Data Stream** button to continue with the setup. Additional parameters for set up include the delimiter (a character that separates one value from the next in the data stream), the terminator (one or two characters that signify the end of one set of data and the beginning of the next set), and the data start (the number of characters to skip in order to read the first data point).

2.3 Saving and Loading Communication Setup

To save or load the communication parameters simply click  and select **Load Settings**, **Save Settings**, or **Save Settings As**. Load Settings loads a cfg file that contains the communication parameters. Save Settings saves the communication parameters to "last.cfg" file. Save Settings As saves the communication parameters to a user-defined name.

Note: The AccuFracPC™ software creates a backup of the "last.cfg" file when the program starts up. It will be named "last.x", where x is a consecutive integer number. These files are stored in the cfg folder where the software is installed.

2.4 AccuFracPC TCP Server

The *AccuFracPC TCP Server* allows Intelligent Pump Control (IPC-PC) to connect to AccuFracPC and receive **Inline Pressure** data. The operator can navigate to the *AccuFracPC TCP Server* screen (**Figure 2.4**) by clicking the  button on the *Network Settings* window shown in **Figure 2.2a**.

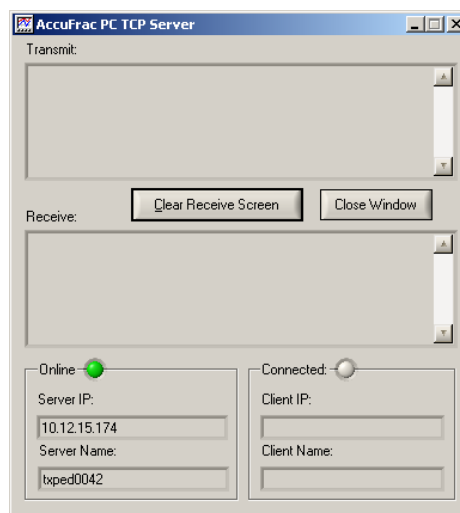
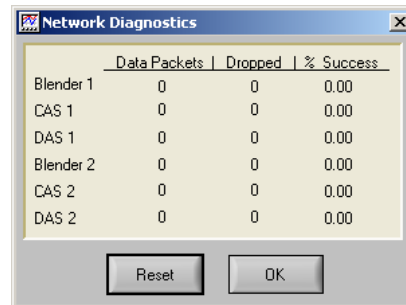


Figure 2.4: AccuFracPC TCP Server Window

2.5 Network Diagnostics

The *Network Diagnostics* screen (shown below in **Figure 2.5**) allows the operator to test if data is being sent/received over the AccuFracPC network. To navigate to this screen click the  button on the *Network Settings* window shown in **Figure 2.2a**.



	Data Packets	Dropped	% Success
Blender 1	0	0	0.00
CAS 1	0	0	0.00
DAS 1	0	0	0.00
Blender 2	0	0	0.00
CAS 2	0	0	0.00
DAS 2	0	0	0.00

Reset OK

Figure 2.5: Network Diagnostics Window

Chapter 3:
PID Controllers

3.0 Overview

If you understand PID controllers fairly well, you can skip chapter 3 and move on to chapter 4.

PID stands for the three modes of control. These are Proportional, Integral, and Derivative. PID is a mathematical algorithm that is executed frequently (typically every second or faster) within the control system. It is responsible for regulating pressure, level, temperature, and flow, etc. It takes in the measurement and the set point, compares the two, and manipulates the output to obtain and maintain the measurement to the set point. For example, the auger is currently spinning at 100 rpm. We want it to turn at 150 rpm. The control system containing the PID will essentially give the hydraulic motor more flow in order to make the auger turn at 150 rpm. It will also maintain this flow to keep the auger turning at 150 rpm.

To express mathematically, the PID that exists in our controller is:

$$\text{Output} = (K_p \times E) + (K_i \times \int E \, dt) + (K_d \times dE/dt) \quad (\text{Equation 3.1})$$

E - error ($E = \text{set point} - \text{measurement}$)

K_p - proportional term

K_i - integral term

K_d - derivative term

$\int E \, dt$ - summation of the error over a period of time

dE/dt - the changes in error over a period of time

3.1 Proportional Control (K_p)

With the proportional control mode, the controller output changes in proportion to the error. K_p , which is entered into the controller by the operator, is the constant proportional term. Using the proportional control mode only, the system will never reach the set point. Thus, an offset, which is a sustained error that cannot be eliminated, exists. For example, consider controlling the water level in the tank in **Figure 3.1** with a proportional controller only.

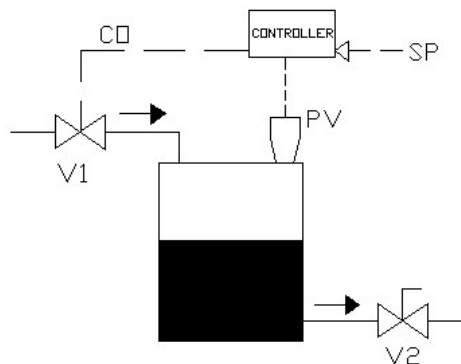


Figure 3.1: Tank Level Control

Figure 3.1 shows a controller with a Set Point (SP) that you can adjust to the desired tank level. The Controller Output (CO) controls the valve, V1, to let fluid into the tank. Finally, the controller has some indication of the tank level or Process Variable (PV) through the level sensor. If you open V2, the tank level decreases and the error (set point - tank level measurement) increases. The proportional controller increases the controller output proportional to this error. Thus, V1 will be open wider and more water flows into the tank. V1 will continue to open wider until the inflow matches the outflow. At this point, the tank level and the error remain constant. Since the error remains constant the proportional controller will keep its output constant and V1 will hold its position. The system now remains at balance with the tank level below its set point.

3.2 Integral Control (Ki)

To remove the offset, you must use integral control (Ki). The integral control mode of a controller produces a long-term corrective change in controller output, driving the error or offset to zero. From Equation 3.1, the error is summed over a period of time and then multiplied to Ki, a value entered into the controller by the operator. This result added to the proportional control raises the controller output far enough to bring the level back to its set point.

3.3 Derivative Control (Kd)

Derivative control is rarely used in controllers. It is very sensitive to measurement noise, makes tuning very difficult, and causes system instability. Derivative control is normally introduced to increase damping in the system. Choosing the right Kd value makes the system respond faster and with less overshoot.

3.4 Controller Tuning

When tuning, unless a specific set point is given, tune to a set point that is half of the device range. For example, a liquid add pump operates in a range from 1 to 20 gallons per minute. Tune this pump at a rate of 10 gallons per minute. Ideally you want to achieve a fast start up, a fast rise to the set point and little overshoot upon reaching the set point. While tracking the set point, the output should be relatively smooth. **Figure 3.2** shows typical system responses to PID tuning.

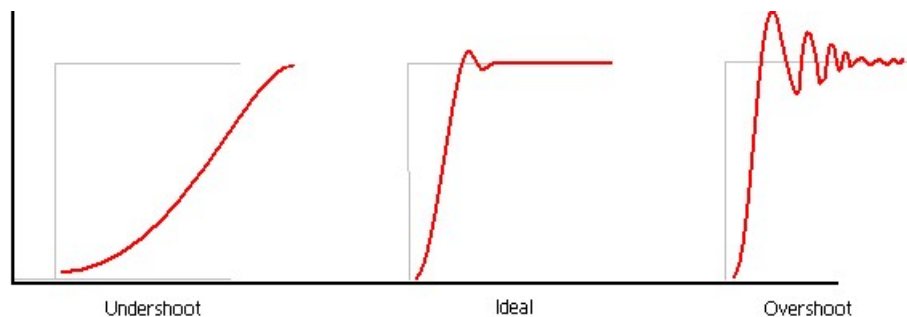


Figure 3.2: System Response to PID Tuning

Start tuning the K_p value first. Set both K_i and K_d to zero. Start with a small value (i.e. 0.5). This will avoid driving the output erratically. Then increase the value gradually. K_p can be related to how fast the system changes as the set point changes. The higher the K_p , the faster the system will respond.

Note: A K_p value that is too small will result in an undershoot response. On the other hand, too large of a K_p value will make the system overshoot the desired set point and could cause oscillating (continually overshooting then undershooting the set point).

Find the K_p value that almost makes the system go into oscillation. For our system, K_p usually ranges from 1 to 10.

Begin entering the K_i value. This value is usually between 0 and 1 for our system. For example, start with 0.01 and increase gradually. K_i can be related to the number of corrections per minute that the output will make while it is tracking the set point. You should be looking to reduce the time it takes the output to track the set point and the stability of the output as it tracks the set point. Unlike K_p value, any small change to K_i causes noticeable response to the system.

Note: A K_i value that is too large will cause the output to overcorrect, and will result in an output that jumps all over trying to follow the measured value (overshoot response - **Figure 3.2**).

K_d is usually reserved for slower processes (i.e. burners, slow level fills). Use this parameter sparingly as it amplifies the existing noise, which can cause the system to be unstable or go into oscillation. Like K_i , K_d is between 0 and 1 for our system. Unlike the K_p value, a small change to K_d results in noticeable response to the system.

Note: A K_d value that is too large will cause the system to oscillate.

Chapter 4:

Data Acquisition System

4.0 Overview

The Data Acquisition System (DAS) provides more input channels in the event that you want to add an external flow meter, densitometer, pressure transducer, etc. There are only fourteen physical channels where the sensors are connected. There are eight analog input channels and six frequency channels, including one quadrature channel (frequency 6 only). In addition to rate/speed and total, frequency 6 will be able to give direction information. See **Table 4.1** below for connector pinouts:

Table 4.1: DAS Pinouts		
Pin	Frequency Input	Analog Input
A	+12 VDC	+24 VDC
B	GND	GND
C	+ Signal	+ Signal
D	- Signal	- Signal
E	GND	
F (Freq 6 only)	Channel B	

4.1 Setting Up Display Channels

The Data Acquisition System (DAS) contains sixteen display channels. Each display channel is customizable to read a frequency input, an analog input, or an arithmetic combination of two physical channels. The AccufracPC™ software is used to customize the display channels via a serial communication port.

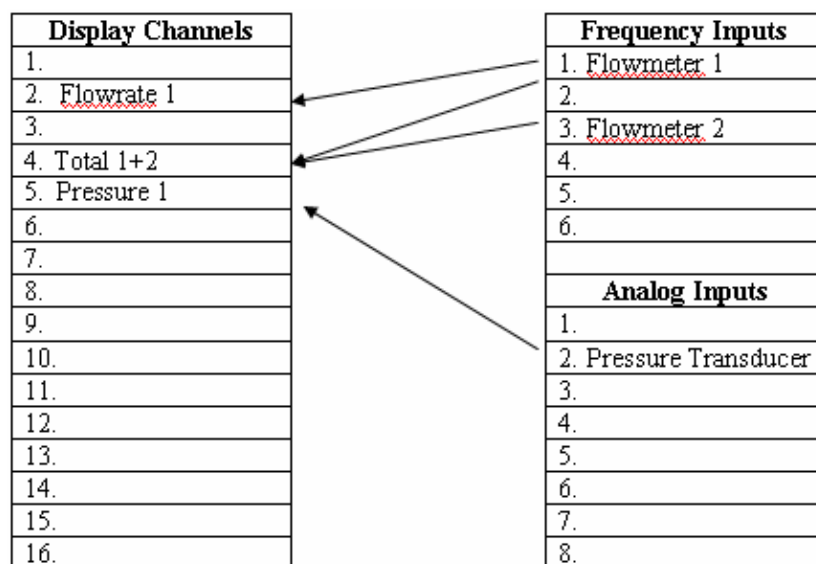


Figure 4.1: DAS Display Channels

For example, the customer wants to hook up an external flow meter to frequency input 1 and wants to display it on display channel 2. Suppose we are working with *Data Acquisition 1* and it is not offline.

Go to the *Blender 1* window and click on the magnifying glass button  in the *Data Acquisition 1* section. The software communicates with the network controller to get the existing descriptions and units, and it communicates with the DAS controller via the network controller to obtain the channel assignments. Then, the AccuFracPC™ software fills out the panel displayed in **Figure 4.2**.



	Descriptions	Units	Type 1	Channel	Operation	Type 2	Channel
1	Analog 8	Volts	Analog	8	Add	Disable	1
2	External Flow	bpm	Frequency	1	Add	Disable	1
3	Analog 8 - 7	Volts	Analog	8	Subtract	Analog	7
4	Total Flow 1&2	bbl	Total	1	Add	Total	3
5	Pressure 1	psi	Analog	2	Add	Disable	1
6	Analog 4 + 5	Volts	Analog	4	Add	Analog	5
7	Total 6 - 2	pulses	Total	6	Subtract	Total	2
8	Analog 1	Volts	Analog	1	Add	Disable	1
9	Total 2	pulses	Total	2	Add	Disable	1
10	Total 1	pulses	Total	1	Add	Disable	1
11	Total 1 + 2	pulses	Total	1	Add	Total	2
12	Total 6	pulses	Total	6	Add	Disable	1
13	Inline Density	PPA	Analog	1	Add	Disable	1
14	Total 6 + 2	pulses	Total	6	Add	Total	2
15	Total 1 + 6	pulses	Total	1	Add	Total	6
16	Rate1+Analog5	Marks	Frequency	1	Add	Analog	5

Figure 4.2: DAS Channel Setup

Go to row 2; type in your new description and unit. Select "Frequency" for *Type 1* and enter 1 for *Channel*. Select "Disable" for *Type 2*. Press **Set**.

Note: A confirmation message should appear stating that the channels have been setup. Otherwise, the equipment did not receive the parameters.

If the customer wants to connect a second flowmeter on frequency input 3 and a pressure transducer on analog input 2, and wants to show the summation of totals from flowmeter 1 and flowmeter 2 on display channel 4 and the pressure on channel 5, follow the procedures listed below.

Go to row 4; type in your description and unit. Select "Total" for *Type 1* and enter 3 for *Channel*. Select "Add" for *Operation*. Select "Total" for *Type 2* and enter 1 for *Channel*. For the pressure transducer, go to row 5; again enter your description and unit. Select

"Analog" for *Type 1* and enter 2 for *Channel 1*. Select "Disable" for *Type 2*. Now press **Set**. You should again get a confirmation message stating that the channels have been setup.

If the *Data Acquisition 1* was offline, you can configure the sixteen channels and save it to a file. Once the equipment is online, open the file and press **Set** to send to the equipment.

4.2 Setting Up Hardware Channels

The next step is getting the sensors to display values that you understand. To do this you must configure the frequency inputs and the analog inputs. To get to the hardware channels, click on the resistor button  on *Blender 1* or *Blender 2* window in the *Data Acquisition 1* or *Data Acquisition 2* section, depending on how the DAS is set up serially. The window shows six frequency input channels and eight analog input channels. As you select each tab, the software communicates with the DAS controller via the network controller to obtain the existing information (K-factor, coefficients, average count, etc.). **Figure 4.3a** below displays the frequency input channel.

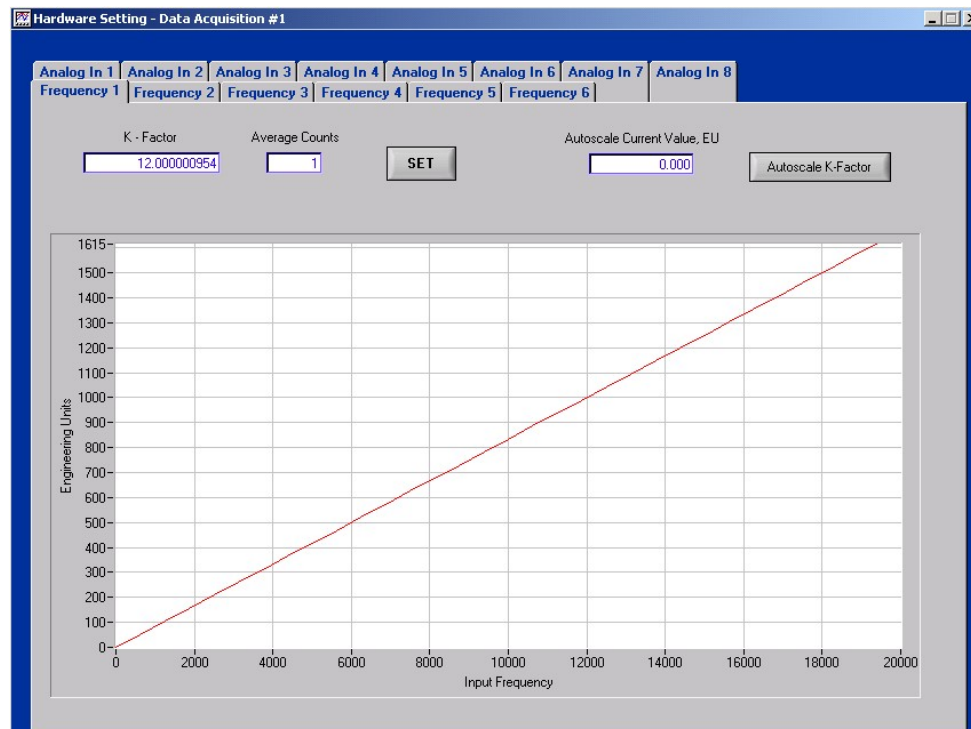


Figure 4.3a: DAS Hardware Setup - Frequency Input

4.3 Configuring the Frequency Inputs

The K-Factor converts the input frequency to engineering units. The following formula is an example of how the K-Factor is used to calculate a flow rate for a frequency of 100Hz and a K-Factor of 500 pulses/gallon:

$$\text{RATE} = (100 \text{ pulses/sec}) \times (60 \text{ sec/min}) \div (500 \text{ pulses/gal})$$

$$\text{RATE} = 12 \text{ gal/min}$$

The vendor for the measuring device (in our example, it would be the flowmeter) usually gives the K-Factor. Enter the K-Factor in its field and press the **Set** button.

Note: A confirmation message must appear, stating that the channel has been set in order for the DAS to accept the settings.

If the K-Factor is not available, you can use *AutoScale K-Factor*. For example, if you know the flow rate to be 24 gal/min, enter 24 in the *Autoscale Current Value, EU* field and press the **AutoScale K-Factor** button. A new K-Factor will appear in the *K-Factor* field. Press **Set** to send it to the DAS.

Note: AutoScale K-Factor only works if the current K-Factor in the DAS is not zero.

The average count field tells the processor how many readings are used to acquire an average value.

Note: Increasing Average Counts will reduce the effect of noise on the value. A large Average Counts will result in a slowed system response.

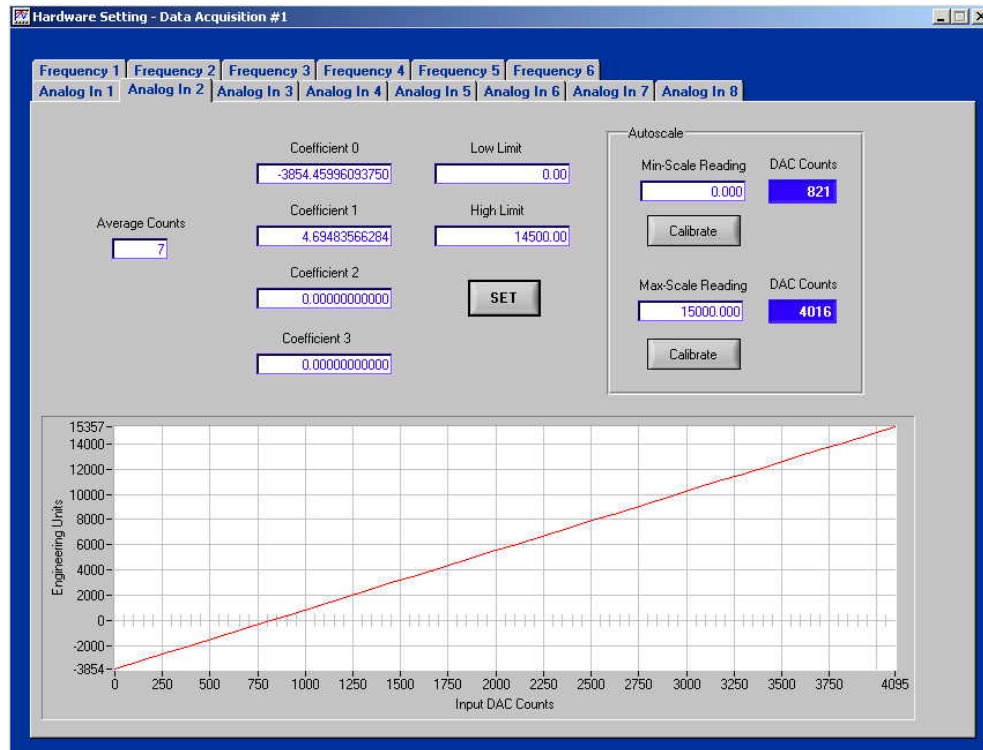


Figure 4.3b: DAS Hardware Setup - Analog Input

4.4 Configuring the Analog Inputs

Some typical devices that require an analog channel to translate the signal into engineering units include a thermal couple, a pressure transducer, and a densitometer. These devices output 0 to 5 Vdc, 0 to 10 Vdc, -10 to +10 Vdc, 0 to 20 mA, or 4 to 20 mA. The devices that output current (milliAmps (mA)) are more reliable since they are less affected by noise. Almost all of these devices are linear; therefore, use autoscaling to configure the analog input channel.

Analog input 5 is configured for a pressure transducer that outputs 4 to 20 mA at 0 to 15,000 psi, respectively. Once the transducer is connected properly to the right channel, enter 0 for the **Min-Scale Reading** field and 15000 for the **Max-Scale Reading** field. At this point, there is zero pressure on the transducer, and the transducer should output 4 mA. Press the **Calibrate** button under the **Min-Scale Reading** field. A **DAC Counts** of 700 to 900 should appear.

Note: If the number is 4095, check the controller board (DAS) and make sure a jumper is present on the 2-pins header for the analog input channel in question. If the number is less than 100 and the jumper is present, the pressure transducer is not outputting a signal or the transducer is connected on the wrong channel.

Next, simulate the maximum output (20 mA) of the pressure transducer and press the **Calibrate** button under the *Max-Scale Reading* field. A *DAC Counts* of 3900 to 4095 should appear. If simulating the maximum output is not possible, leave the *DAC Counts* at 4095.

Like the frequency inputs, the *Average Counts* field tells the processor how many readings are used to acquire an average value.

Note: Increasing *Average Counts* will reduce the effect of noise on the value. A large *Average Counts* will result in a slowed system response.

Coefficient 1 and *Coefficient 2* fields should now have new non-zero values and *Coefficient 3* and *Coefficient 4* fields should be zero. You can also enter the low and high limits for the analog channels. In the example, you can enter 0 and 14,500 PSI for low and high limit, respectively, for analog input channel 2 (**Figure 4.3b**). This is useful to setup an alarm if the pressure reading is out of this range. Press the **Set** button to send to the controller.

Note: You should receive a confirmation message, stating that the equipment has accepted the parameters. Otherwise, no parameters will be set in the equipment.

Chapter 5:

Blender Density Controller

5.0 Overview

The density control component of the AccuFracPC™ software is the Blender Density Controller. Its basic function is to create a mixture of base fluid and proppant. The job density profile is programmed into the control system through the user interface. When the job is running, the density controller calculates how much proppant is required to achieve the programmed target density based on the discharge rate, base fluid density, and proppant density. Thus, the density control component is responsible for controlling the augers and the tub level.

Most of the major functions of the Blender Density Controller are accessed and monitored from the *Blender* windows and *FracView* window.

5.1 Setting Up a Job

A job can be divided into as many as 100 segments, called stages. The stages are programmed into the controller on the Job Setup window and are defined by six properties:

1. **Volume of Stage** - the length of the stage in total control volume. For example, if stage three is programmed for 100 barrels, and the stage began at 250 barrels, stage three will end at 350 barrels. The time required to complete each stage depends on the control flow rate.
2. **Proppant SGU** - the mass (in kilograms) of proppant required to displace one liter of water.
3. **Proppant Bulk Density** - the dry density of the proppant (lb/ft³ or kg/m³).
4. **Fluid SGU** - the density of the base fluid in specific gravity units (kg/liter).
5. **Slurry Start** - the target density (SGU) or proppant concentration (PPA) at the beginning of the stage.
6. **Slurry End** - the target density or proppant concentration at the end of the stage.

Two types of stages exist. The first, a **step change**, has the slurry start and the slurry end values set to the same number. Stages 1, 2, 4 and 6 in **Figure 5.1** are examples of a step change. A **ramp change** has the slurry start and the slurry end values set to different numbers. The Density Controller calculates a gradual and linear slope to change the concentration from the starting value to the ending value over the duration of the stage. Stages 3, 5, & 7 in **Figure 5.1** show a ramp change.

In the example shown in **Figure 5.1**, the base fluid is water (SGU=1.0). Therefore stage one, which has a target density of 1.0, does not require proppant. Stage one is programmed for a volume of 100 units. When the control volume reaches 100, stage two begins. Stage two is a step with both **Slurry Start** and **Slurry End** programmed for 1.2. The length of stage two is 150 units. When the control volume reaches 250 (100 + 150), stage three begins. The volume for stage three is 150

units, the **Slurry Start** is 1.2, and the **Slurry End** is 1.4. The result is a ramp as shown. Stage four begins when the control volume reaches 400 (100 + 150 + 150), and so on until stage seven completes. Stage eight is programmed with a length of zero.

Note: A volume of zero indicates the end of the job.

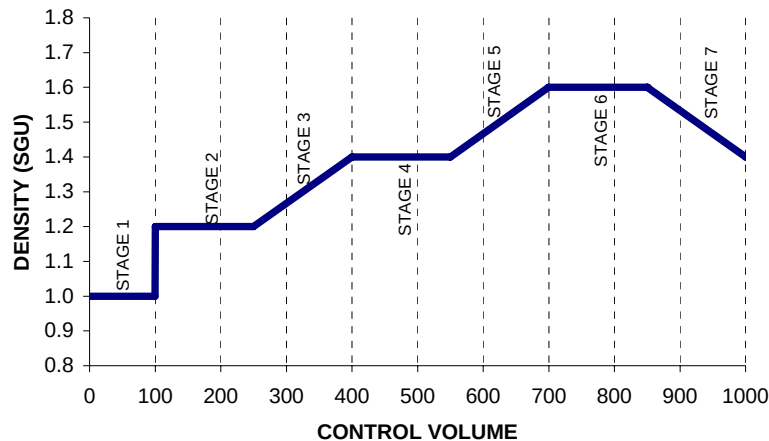


Figure 5.1: Typical Job Schedule Graph

The **Slurry Start** and **Slurry End** can be programmed in either SGU (density), or sand concentration.

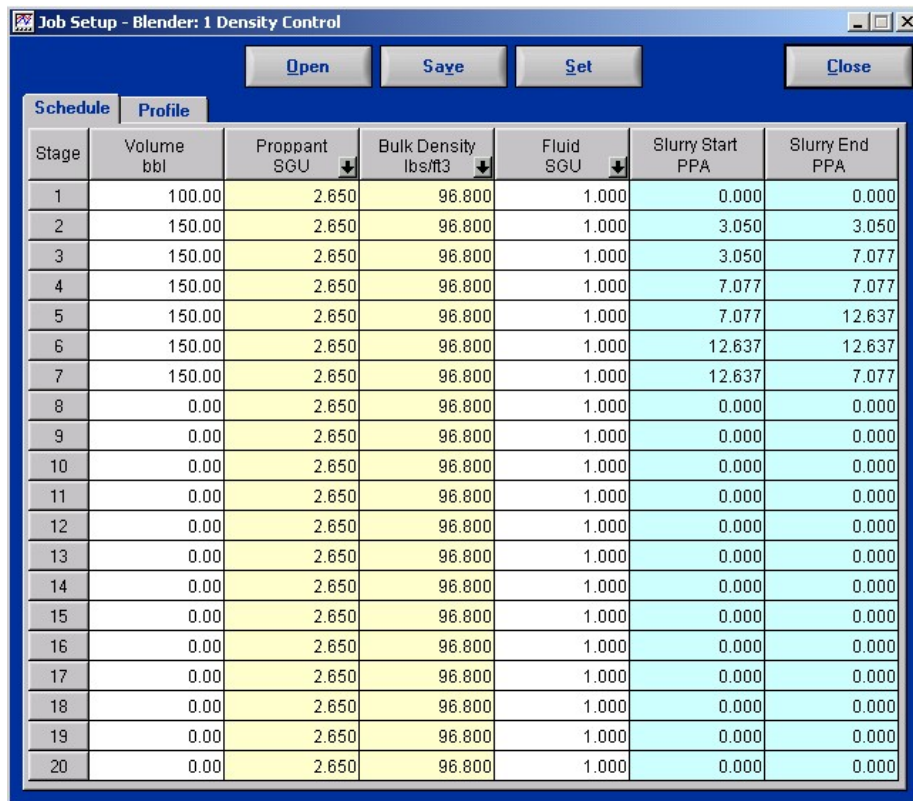
Note: The target density must be greater than or equal to the base fluid SGU, and less than the proppant SGU.

To access the job setup window, simply click  in the **Blender 1 - Density** section on **Blender 1** window or in the **Blender 2 - Density** section on **Blender 2** window.

Note: Both Blender 1 and Blender 2 share the **Blender Density Job** Setup window. Thus, only one job setup window is shown at a time. The title displays the active blender.

For each stage, enter the volume in barrels, the proppant specific gravity unit, the bulk density of the proppant in lbs per cubic feet,

the medium fluid specific gravity unit, starting slurry in PPA, and ending slurry in PPA. Since the proppant specific gravity unit, the bulk density of the proppant, and the medium fluid specific gravity unit are constant throughout the job, simply click  to copy the value in stage 1 to stages 2 through 20.



Stage	Volume bbl	Proppant SGU	Bulk Density lbs/ft3	Fluid SGU	Slurry Start PPA	Slurry End PPA
1	100.00	2.650	96.800	1.000	0.000	0.000
2	150.00	2.650	96.800	1.000	3.050	3.050
3	150.00	2.650	96.800	1.000	3.050	7.077
4	150.00	2.650	96.800	1.000	7.077	7.077
5	150.00	2.650	96.800	1.000	7.077	12.637
6	150.00	2.650	96.800	1.000	12.637	12.637
7	150.00	2.650	96.800	1.000	12.637	7.077
8	0.00	2.650	96.800	1.000	0.000	0.000
9	0.00	2.650	96.800	1.000	0.000	0.000
10	0.00	2.650	96.800	1.000	0.000	0.000
11	0.00	2.650	96.800	1.000	0.000	0.000
12	0.00	2.650	96.800	1.000	0.000	0.000
13	0.00	2.650	96.800	1.000	0.000	0.000
14	0.00	2.650	96.800	1.000	0.000	0.000
15	0.00	2.650	96.800	1.000	0.000	0.000
16	0.00	2.650	96.800	1.000	0.000	0.000
17	0.00	2.650	96.800	1.000	0.000	0.000
18	0.00	2.650	96.800	1.000	0.000	0.000
19	0.00	2.650	96.800	1.000	0.000	0.000
20	0.00	2.650	96.800	1.000	0.000	0.000

Figure 5.2a: Job Setup Window - Schedule Tab

Note: Once the job has been setup, you must press **Set** to send to the equipment. Without a confirmation message, the equipment did not accept the parameters.

You can also save the current job to a file. You can open a previous job. Again, you must press **Set** to send the previous job to the equipment, overwriting the current job.

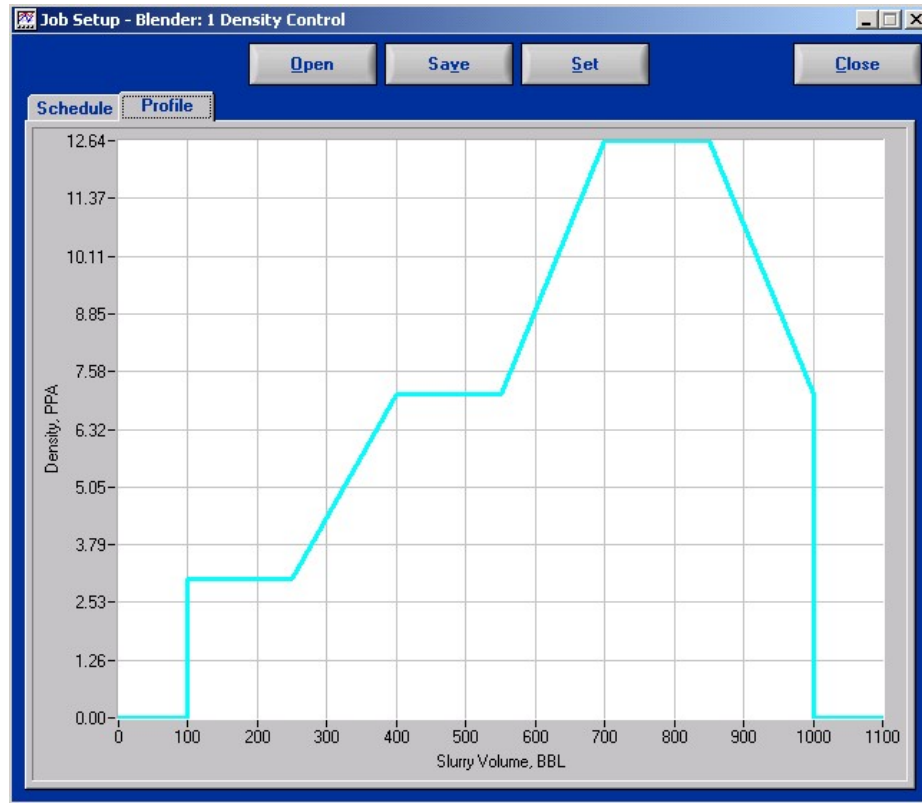


Figure 5.2b: Job Setup Window - Profile Tab

5.2 Setting Up the Hardware

The blender density controller allows configuration of the input frequency, average counts, PID controller variables, and calibration coefficients. These values are changed from the *Hardware Settings* window.

Note: For each tab, the operator must press Set to send the new parameter settings to the controller. If you do not receive a confirmation message, the controller did not accept the parameters.

To access the blender density controller hardware setup window, simply press  in the *Blender Density* section of the *Blender* windows.

Note: Blender 1 and 2 Density Control share the Hardware Settings window. Thus, only one hardware setup window is shown at a time. The window title displays the active blender.

Table 5.1 shows the input/output channels being used on the blender density controller.

Table 5.1: Input/Output of Blender Density Controller			
Component	Frequency Input	Analog Input	Analog Output
Auger 1	1	-	1
Auger 2	2	-	2
Auger 3	3	-	3
Densitometer	-	5	-
Suction	6	-	-
Discharge	5	-	-
Pressure 1	-	7	-
Pressure 2	-	8	-

5.3 Augers

A digital input is associated with each auger. The state of the input determines whether the auger is in automatic or manual mode. Normally, a switch on the blender unit panel is used to set the mode. When the auger is in manual mode, the blender density controller does not try to control it and the system does not take into account any proppant added by the augers. The total proppant load is shifted to the remaining augers that are in automatic mode. Follow the same procedures to setup all three augers.

The augers can be *Disabled* or setup as a *Metered* or *Feed* mode. The available auger sizes are *6 inch*, *12 inch*, *14 inch*, or *Fixed*. The *Metered* mode indicates that the blender density controller will reference standard sand tables for calculating the amount of sand per auger revolution. After you choose an auger size, use the *Delivery factor* field to enter delivery efficiency.

Note: Delivery efficiency of the auger can be changed in real-time on the *System* windows or the *FracView* window.

The *Fixed* setting indicates that the system will use a given amount of proppant per revolution. This amount is specified in the *Fixed Delivery Only* field. The *Disabled* setting indicates that the auger will not be used for the current job.

Note: In practice, the auger delivery efficiency number is from 0 to 1. The efficiency number is used when it is in automatic mode. The higher the auger efficiency number, the slower the auger will spin based on target proppant rate.

The *Current Value* field displays how fast the auger is turning in revolutions per minute (RPM) when its frequency input channel is setup. To configure the frequency input channels, see **Configuring the**

Frequency Inputs in section 4.3. Tab *Auger 1 Input Curve* displays graphically the characteristics of the frequency input channel of auger 1. The **Target** field displays how fast auger 1 should be turning in RPMs in the current stage when a job is running.

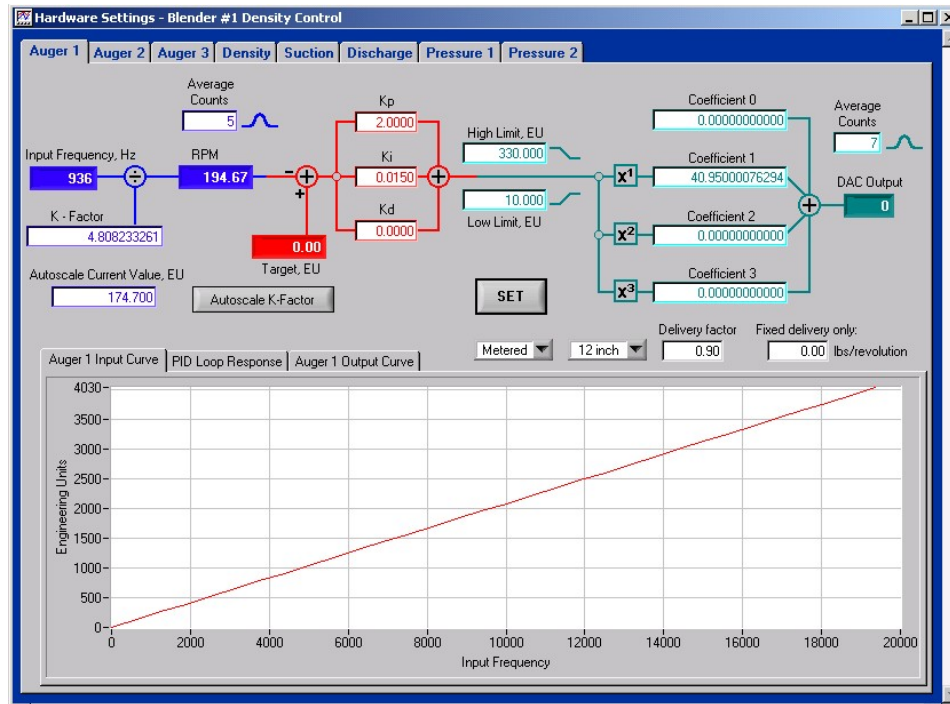


Figure 5.3a: Hardware Settings

The **Low Limit** setting is the threshold value for the minimum engineering unit (EU) setting. The **High Limit** is the threshold value for the maximum EU setting. Both limits are in revolutions per minute (RPM).

Note: The auger will turn at the low limit if the target speed is below the low limit set and will turn at the high limit if higher than the high limit set.

The coefficients apply to the analog output of the blender density controller. The tab *Auger 1 Output Curve* displays graphically the characteristics of the analog output for auger 1.

Note: All coefficients, except **Coefficient 1**, are zeros. **Coefficient 1** must be **40.95**

The **Average Counts** field next to the coefficients tells the process how many readings are used to acquire an average value. A value of 5 is sufficient.

Note: Increasing *Average Counts* will reduce the effect of noise on the value. A large *Average Counts* will result in a slowed system response.

The *DAC Output* field is for diagnostic purposes. The value varies from 0 to 4095. The *DAC Output* field tells the operator how hard the controller is working to turn auger 1.

Once the job stages have been programmed and auger 1 is setup, you should do a test run to tune auger 1. The operator must enter Kp, Ki, and Kd values in order to make the *Current Value* match the *Target* rpm. The operator can use the tab *PID Loop Response* to track the measured and the target value while tuning. Refer to Section 3 for PID overview and tuning. Repeat tuning for augers 2 and 3.

5.4 Suction and Discharge

Both the suction and discharge use the frequency channels on the blender density controller. The *Current Value* field displays the flow rate in barrels per minute (BPM) when its frequency input channel is setup. To configure the frequency input channels, see **Configuring the Frequency Inputs** in Section 4.3. The graph displays the characteristics of the frequency input channel.

Note: The *Autoscale Current Value* field is measured in barrels per minute.

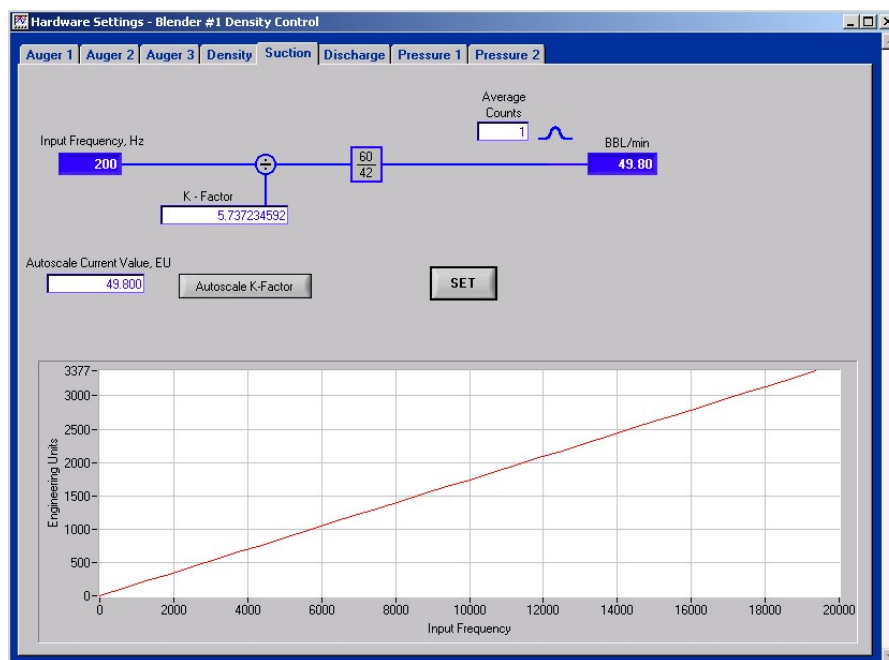


Figure 5.3b: Hardware Setup - Suction Tab

5.5 Densitometer, Pressure 1, and Pressure 2

The densitometer, pressure 1, and pressure 2 use the analog input channels on the blender density controller. For the densitometer, the *Current Value* displays only in specific gravity units (SGU).

Note: The *Min-Scale Reading* and *Max-Scale Reading* must be entered in SGU.

To configure the analog input channels, see **Configuring the Analog Inputs** in Section 4.4.

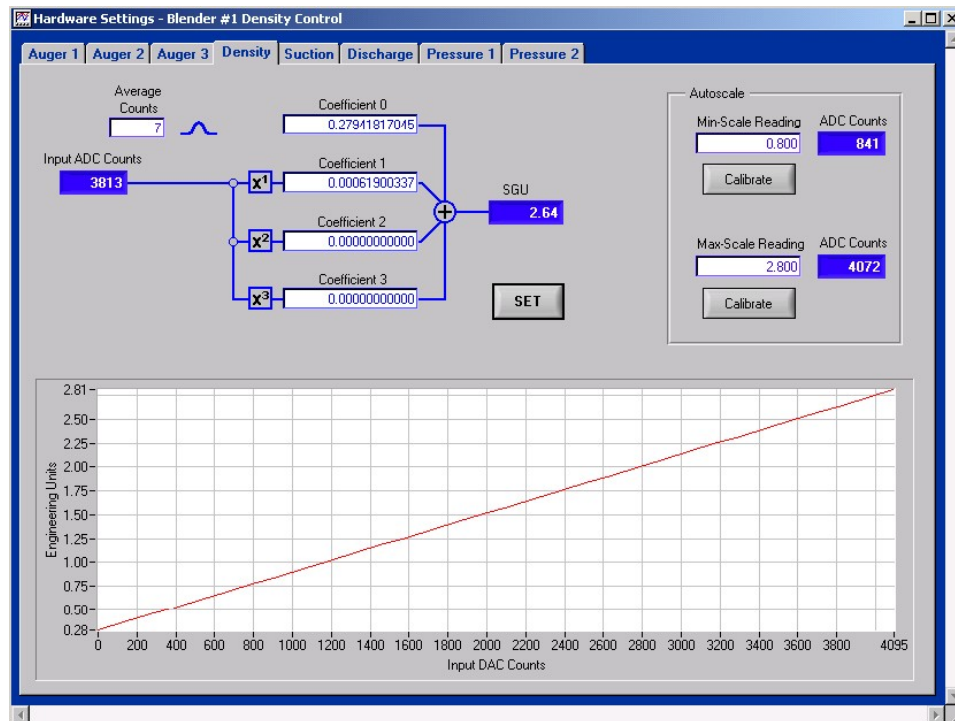


Figure 5.3c: Hardware Setup – Density Tab

5.6 Operations

Once the stages are programmed and all hardware is setup, you should setup the tub level. This involves calibrating the tub level sensor (see **Configuring the Analog Inputs** in section 4.4) and tuning the PID on the tub level control (see **Controller Tuning** in section 3.4).

Note: The AccuFracPC™ software only monitors the tub level and its target set point. This is displayed on the *Blender* windows.

Once everything has been setup, the job can run. While the job is running, it can be monitored or stages can be modified.

5.7 Running a Job

All of the job control functions for the blender can be executed from the *Blender* windows (**Figure 1.1**). To run a job, use the control buttons on the *Blender* windows. A brief explanation of each button is listed below.

Start - In the *GLOBAL* section of *Blender 1* window, the software starts the programmed job on blender 1 and CAS 1. In the *GLOBAL* section of *Blender 2* window, the software starts the programmed job on blender 2 and CAS 2. In *BLENDER 1* section of *Blender 1* window, the software starts the programmed job on blender 1. In *BLENDER 2* section of *Blender 2* window, the software starts the programmed job on blender 2.

Abort - In the *GLOBAL* section of *Blender 1* window, the software stops the programmed job on blender 1 and CAS 1. In the *GLOBAL* section of *Blender 2* window, the software stops the programmed job on blender 2 and CAS 2. In *BLENDER 1* section of *Blender 1* window, the software stops the programmed job on blender 1. In *BLENDER 2* section of *Blender 2* window, the software stops the programmed job on blender 2.

Hold - In *BLENDER 1* section of *Blender 1* window, the software halts the programmed job on blender 1 at the current stage. In *BLENDER 2* section of *Blender 2* window, the software halts the programmed job on blender 2 at the current stage.

Note: Once *Hold* is pressed, the button will change to *Resume*. Press *Resume* to continue the programmed job.

Next - In *BLENDER 1* section of *Blender 1* window, the software moves the job to the next programmed stage on blender 1. In *BLENDER 2* section of *Blender 2* window, the software moves the job to the next programmed stage on blender 2.

Figure 5.4 shows how the hold function affects a ramp. Stage two is a ramp from 1.2 to 1.6 SGU. At a control volume of 50 units, **Hold** is pressed. While the stage is held, the end of the stage and end of job are continuously pushed back. The stage is resumed at 100 units and the job continues, as it would have normally. Notice that the hold function modifies the actual programmed value for the length of the stage. Stage 2 was originally programmed for a volume of 50 units; but when the job is over, stage two is programmed for 100 units. A step function is handled the same as a ramp.

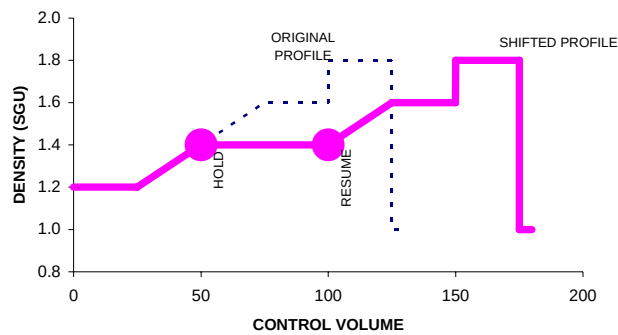


Figure 5.4: Effect of Hold on Job Schedule

In the example illustrated in **Figure 5.5**, stage 2 was originally programmed with a length of 100 units. The **Next Stage** button is pushed halfway through the stage. The volume for stage two is changed to 50 units and stage three is immediately executed. Also, the end of job value is changed from 175 units to 125 units.

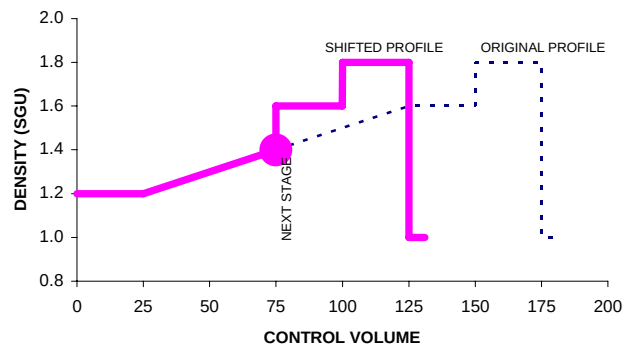


Figure 5.5: Effect of Next Stage on Job Schedule

5.8 Modifying a Running Job

Changes can be made to a job that is currently executing by editing the individual stage values. If changes are made to stages that have not yet run, they will take effect when the stage does run. If the length of a stage is changed, it will affect the end of job value. Changes to the current stage will take place immediately. If a ramp stage is changed in the middle, the target will immediately go to where it would have been had the stage been programmed that way originally.

In the example illustrated in **Figure 5.6**, stage two was originally a ramp with a volume of 100 units. At a control volume of 75 units, the length was extended to 200 units. The target value immediately jumps to 1.3 (which corresponds to the required target based on a stage programmed for 200 units). Changing the beginning and ending density for the stage has a similar effect.

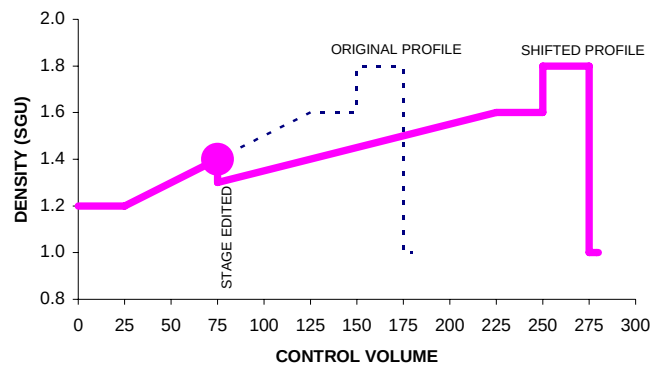


Figure 5.6: Effect of Schedule Change During a Job



Figure 5.7: Override Target Density

Another enhanced feature of the AccuFracPC™ software is the ability to override the target density in PPA or SGU of the current stage or of the whole job while it is running. To override target density, press **OVERRIDE** in the Blender Density section of the *Blender* windows. The **Override Target Density** box (Figure 5.7) appears. Enter a new target and select *This Stage Only* or *Rest of Job*. Press **Override** to send to blender 1 or 2, depending on which blender window the button was pressed. Otherwise, press **Cancel**.

Note: The target will be in the current unit. If the *Display Densities in SGU* box is checked, target is in SGU; otherwise, it is PPA.

Chapter 6:

Blender Chemical Controller

6.0 Overview

The second half of the blender is the blender chemical control component. The chemical controller is programmed in parts added per 1000 gallons of the control rate. The control rate can be any rate, but is typically the blender suction rate. Most of the major functions of the Blender Chemical Controller are accessed and monitored from the *Blender* windows.

The Blender Chemical Controller is responsible for controlling six chemicals (four liquids and two dry). These chemicals are added to the tub before the slurry mixture is discharged from the blender. The purpose of the chemicals is to make the fracturing process more efficient. One common chemical is gel, which suspends the proppant added in the slurry mixture. This suspension creates a pathway for the intended product (oil, gas, etc.) to move towards the surface. Other chemicals (1) break down the slurry to water, (2) reduce the friction as the slurry is being pumped through pipes, and (3) reduce the surface tension of the slurry.

6.1 Setting Up a Job

A chemical job can be divided in as many as 50 segments called stages. The stages are programmed into the controller on the Job Setup Blender Chemicals window and are defined by two properties:

- a. **Volume of Stage** - the length of the stage in total control volume. For example, if stage three is programmed for 100 barrels, and the stage began at 250 barrels, it will end at 350 barrels. The time required to complete each stage depends on the control flow rate.
- b. **Loading** - the target rate for the stage. The value is entered in units per 1000 gallons of control flow (suction). For example, if the suction rate is 50 barrels per minute (BPM) and loading is 1, the target flow rate for a liquid chemical is 2.1 gallons per minute.

For liquid chemicals,

$$\begin{aligned}\text{Target Rate} &= (\text{suction rate}) \times (\text{loading}/1000) \\ &= (50 \text{ bbl/min}) \times (42 \text{ gal/bbl}) \times (1 \text{ gal}/1000 \text{ gal}) \\ &= 2.1 \text{ gal/min}\end{aligned}$$

If the suction rate and the loading are the same for a dry chemical, the target flow rate for a dry chemical is 2.1 pounds per minute

For dry chemicals,

$$\begin{aligned}\text{Target Rate} &= (\text{s. rate}) \times (\text{load}/1000) \\ &= (50 \text{ bbl/min}) \times (42 \text{ gal/bbl}) \times (1 \text{ lbs}/1000 \text{ gal}) \\ &= 2.1 \text{ lbs/min}\end{aligned}$$

To access the job setup window, click  in the Blender 1 - Chemical section on **Blender 1** window or in the Blender 2 - Chemical section on **Blender 2** window.

Note: Both Blender 1 and Blender 2 share the **Blender Chemical Job Setup** window. Thus, only one job setup window is shown at a time. The window title displays the active blender.

For each stage of each chemical tab, the operator enters the volume in barrels and loading. For liquid chemicals, loading is in gallons of a chemical per 1000 gallons total volume. For dry chemicals, loading is in pounds of a chemical per 1000 gallons total volume.

Note: Volumes for the 6 chemicals can be set simultaneously by using the **Set All Volumes** button. Click the **Set All Volumes** button after entering volume settings for Chemical 1. The AccuFracPC™ software will duplicate the Chemical 1 volume settings for Chemical 2 through 6.

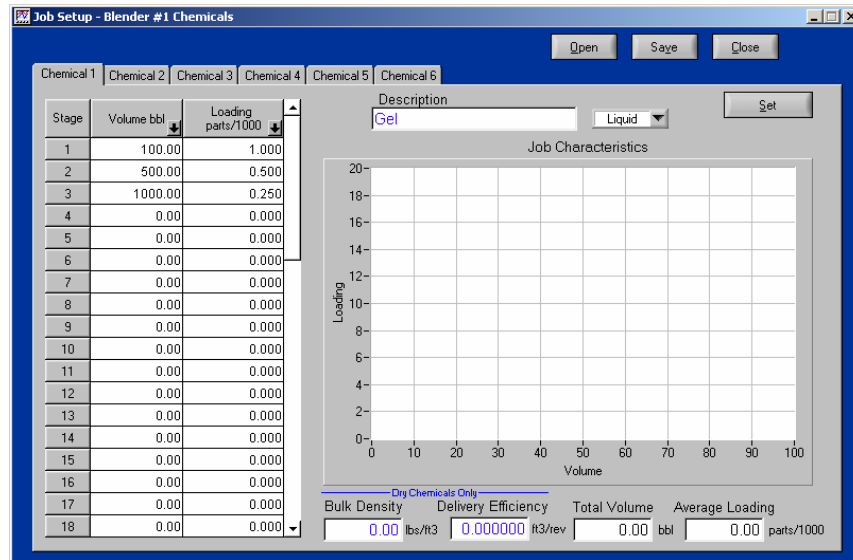


Figure 6.1: Blender Chemical Job Setup

You can enter a name for each chemical in the *Description* field. The chemical can be *Disabled* or setup as a *Liquid* or *Dry* chemical. When *Dry* is selected for a chemical, the *Bulk Density* and the *Delivery Efficiency* of the dry chemical must be entered to obtain the rate in terms of pounds per minute. The *Total Volume* field displays the summation of the volume of the stages for a chemical. The *Average Loading* field shows the average loading of a chemical.

Average Loading is calculated as follows: (Refer also to **Figure 6.1**):

$$\begin{aligned}\text{Average Loading} &= ((100 \times 1) + (500 \times 0.5) + (1000 \times 0.25)) / (100 + 500 + 1000) \\ &= 0.375 \text{ parts/1000 round off to } 0.38 \text{ parts/1000}\end{aligned}$$

After all parameters have been entered, press **Set** to send to the equipment, overriding the current job.

Note: A confirmation message must appear in order for the equipment to accept the settings.

You can save the current job to a file, or open a previous job. You must press **Set** to send the previous job to the equipment.

6.2 Setting Up the Hardware

The blender chemical controller allows configuration of the input frequencies, average counts, PID controller variables, and calibration coefficients. These values are changed in the **Hardware Settings** window. **Figures 6.2a and b** show the hardware settings for the blender chemical. To access the *Hardware Settings* window from the *Blender* windows, click  in the *Blender Chemical* section.

Note: Both Blender 1 Chemical Control and Blender 2 Chemical Control share the *Hardware Setup* window. Thus, only one *Hardware Setup* window is shown at a time. The window title displays the active blender.

Table 6.1 shows the input/output channels being used on the blender chemical controller.

Table 6.1: Input/Output Used of Blender Chemical Controller			
Component	Frequency Input	Analog Input	Analog Output
Chemical 1	1	–	1
Chemical 2	2	–	2
Chemical 3	3	–	3
Chemical 4	4	–	4
Chemical 5	5	–	5
Chemical 6	6	–	7
Analog Suction	–	6	–

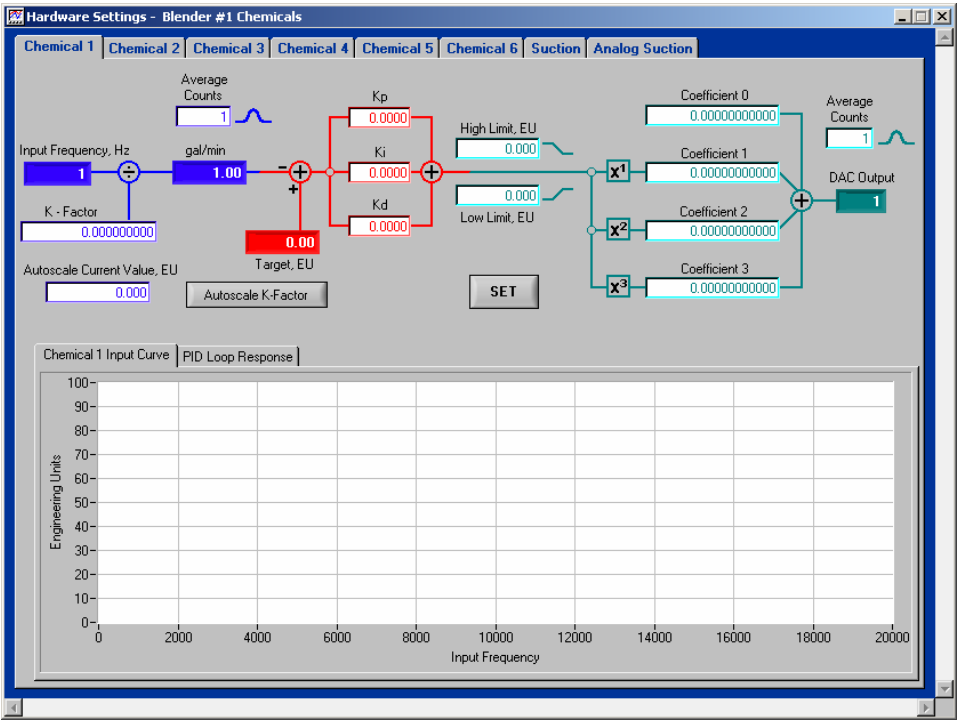


Figure 6.2a: Blender Chemical Hardware Setup - Chemicals

6.3 Chemicals

Each chemical has a digital input associated with it. The state of the input determines whether the chemical is in automatic or manual mode. Normally, the switches are on the blender unit panel. When the switch for a particular chemical is in manual mode, the Blender Chemical Controller does not try to control it. We will discuss setting up Chemical 1. The rest of the chemicals are setup in the same manner.

The Frequency Input channel of the chemical must be setup in order to read its flow rate. Please refer to *Configuring the Frequency Inputs* in Section 4.3.

Note: The *Autoscale Current Value* field is in gallons per minute.

The *Current Value* shows the flowrate of chemical 1 in gallons per minute (GPM). The *Chemical 1 Input Curve* tab displays graphically the characteristics of the frequency input channel. The *Target* field displays the expected flow rate in GPM of chemical 1 for the current stage when a job is running.

The *Low Limit* setting is the threshold value for the minimum engineering unit (EU) setting. The *High Limit* is the threshold value for the maximum EU setting. Both limits are in gallons per minute (GPM).

Note: The chemicals will flow at the low limit when the target is lower than the low limit set. The chemicals will flow at the high limit when the target is greater than the high limit set.

The coefficients apply to the analog output of chemical 1. The *Chemical 1 Output Curve* tab shows graphically the characteristics of the analog output.

Note: All coefficients, except *Coefficient 1*, are zeros. *Coefficient 1* must be 40.95. This tells the controller to output its full range.

The *Average Counts* field next to the coefficients tells the process how many readings are used to acquire an average value. A value of 5 is sufficient.

Note: Increasing *Average Counts* will reduce the effect of noise on the value. A large *Average Counts* will result in a slowed system response.

The **DAC Output** field is for diagnostic purposes. It varies from 0 to 4095. It tells the operator how hard the controller is working to stroke the chemical 1 pump.

Once the stages for chemical 1 and its hardware are setup, you should do a test run in order to tune chemical 1. The operator must enter Kp, Ki, and Kd values in order to make the **Current Value** match the **Target**. The operator can use the **PID Loop Response** graph to track the measured and target values while tuning. Go to Section 3 for PID overview and tuning.

6.4 Analog Suction

Analog suction uses an analog input channel on the blender chemical controller. The **Current Value** displays in barrels per minute (BPM)

Note: *Min-Scale Reading* and *Max-Scale Reading* must be entered in BPM.

To configure the analog input channels, see **Configuring the Analog Inputs** in Section 4.3.

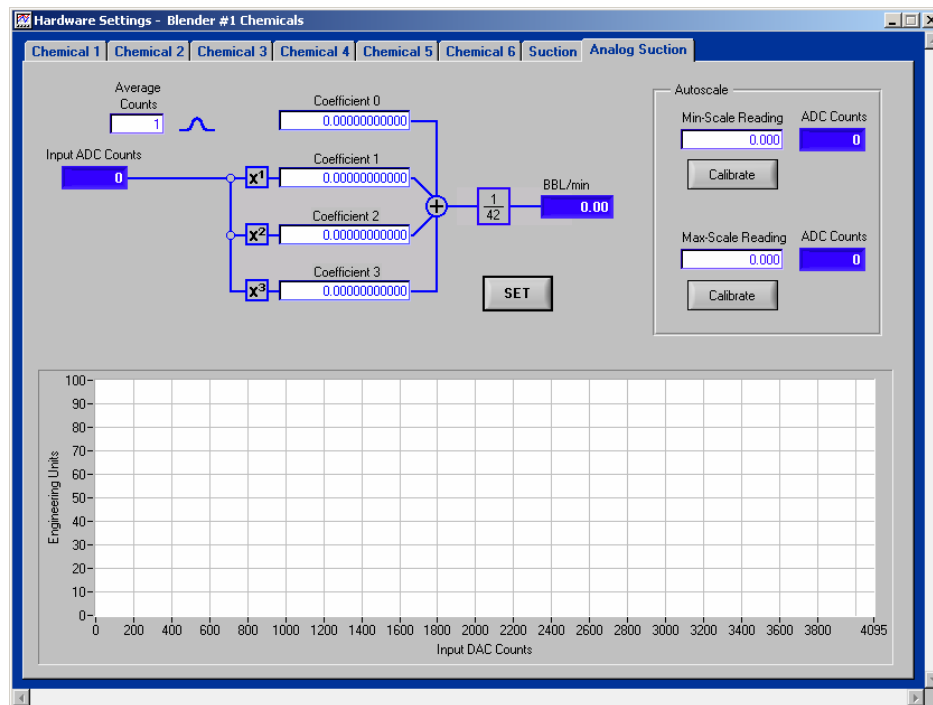


Figure 6.2b: Blender Chemical Hardware Setup - Chemicals

6.5 Operations

Once the stages are programmed and the hardware is setup for all the chemicals, the job can run. While the job is running, it can be monitored or stages can be modified.

6.6 Running and Modifying a Running Job

All of the job control functions can be executed from the System windows or the blender detail window. For a detailed description of running a job, refer to Chapter 5: *Blender Density Controller* in this manual.

Changes can be made to a job that is currently executing by editing individual stage values. If changes are made to stages that have not yet run, they will take effect when the stage does run. If the length of a stage is changed, it will affect the end of the job value. Changes to the current stage will take place immediately. If a ramp stage is changed in the middle of a running job, the target will immediately go to where it would have been had the stage been programmed that way originally. To make changes to chemicals during a job, refer to **Setting Up a Job** in Section 6.1.

Another enhanced feature of the AccuFracPC™ software is the ability to override the target concentration (loading) of the chemicals for the current stage or for the rest of the job while it is running. To override the target concentration, press **Override** in the Blender Chemical section of the *Blender* windows. The Override Target Concentration box will display (Refer to **Figure 6.3**). Select a chemical to change from the list on the left side of the box. Enter a new target and select *This Stage Only* or *Rest of Job*. Press **Override** to send to the blender or **Cancel** to end without sending changes.

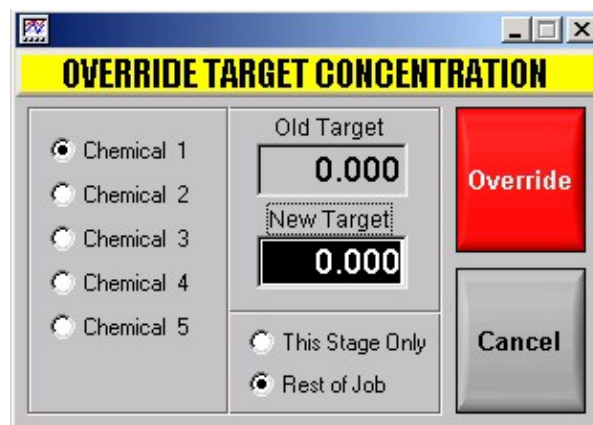


Figure 6.3: Override Target Concentration - Blender Chemical

Note: Target is entered in gallons per 1000 gallons of suction for liquid chemicals and pounds per 1000 gallons of suction for dry chemicals.

Chapter 7:

Chemical Additive System Controller

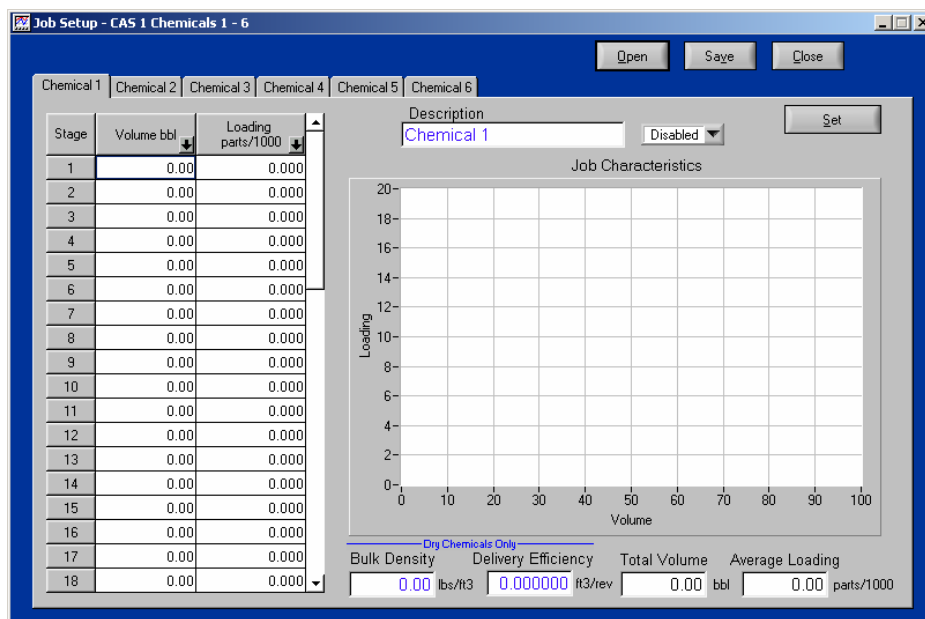
7.0 Overview

Most of the major functions of the Chemical Additive System (CAS) are accessed and monitored from the **Blender** windows and the CAS window. The AccufracPC™ can be connected to a CAS unit that has up to twelve chemicals. The CAS unit described here contains only six chemicals. The CAS unit described here contains only six chemicals.

7.1 Setting Up a Job

Setting up a job on a CAS Unit is exactly the same as the **Blender Chemical Controller**. Refer to Section 6.1 for more details.

To access the job setup window, click  in the **CAS 1** section on the **Blender 1** window or in the **CAS 2** section on the **Blender 2** window.



Stage	Volume bbl	Loading parts/1000
1	0.00	0.000
2	0.00	0.000
3	0.00	0.000
4	0.00	0.000
5	0.00	0.000
6	0.00	0.000
7	0.00	0.000
8	0.00	0.000
9	0.00	0.000
10	0.00	0.000
11	0.00	0.000
12	0.00	0.000
13	0.00	0.000
14	0.00	0.000
15	0.00	0.000
16	0.00	0.000
17	0.00	0.000
18	0.00	0.000

Job Characteristics

Graph: Loading (0-20) vs Volume (0-100)

Summary Statistics:

Bulk Density	Delivery Efficiency	Total Volume	Average Loading
0.00 lbs/ft3	0.000000 ft3/rev	0.00 bbl	0.00 parts/1000

Figure 7.1: CAS System Job Setup

For each stage of each chemical tab, the operator enters the volume in barrels and loading. For liquid chemicals, loading is in gallons of a chemical per 1000 gallons suction total volume. For dry chemicals, loading is in pounds of chemical per 1000 gallons suction total volume.

Note: Volume for Chemicals 1 through 6 can be set simultaneously by using the **Set All Volumes** button. Click the **Set All Volumes** button after entering volume settings for Chemical 1. The AccuFracPC™ software will duplicate the Chemical 1 volume settings for Chemicals 2 through 6. You will receive a confirmation message after the equipment accepts the parameters.

7.2 Setting Up the Hardware

The CAS System controller can control up to five chemicals. The CAS controller allows configuration of the input frequencies, average counts, PID controller variables, and calibration coefficients. These values are changed in the *Hardware Settings* window. **Figure 7.2** shows the *Hardware Settings* window for the CAS System. It can be accessed from the *Blender* windows by clicking  in the *CAS* section.

Note: Both CAS 1 and 2 share the *Hardware Setup* window. Thus, only one *Hardware Setup* window is shown at a time. Its title displays the active CAS system.

Table 7.1 shows the input/output channels used on the CAS controller.

Table 7.1: Input/Output Used of CAS Controller			
Component	Frequency Input	Analog Input	Analog Output
Chemical 1	1	–	1
Chemical 2	2	–	2
Chemical 3	3	–	3
Chemical 4	4	–	4
Chemical 5	5	–	5
Chemical 6 / Suction	6	–	–
Analog Suction	–	6	–

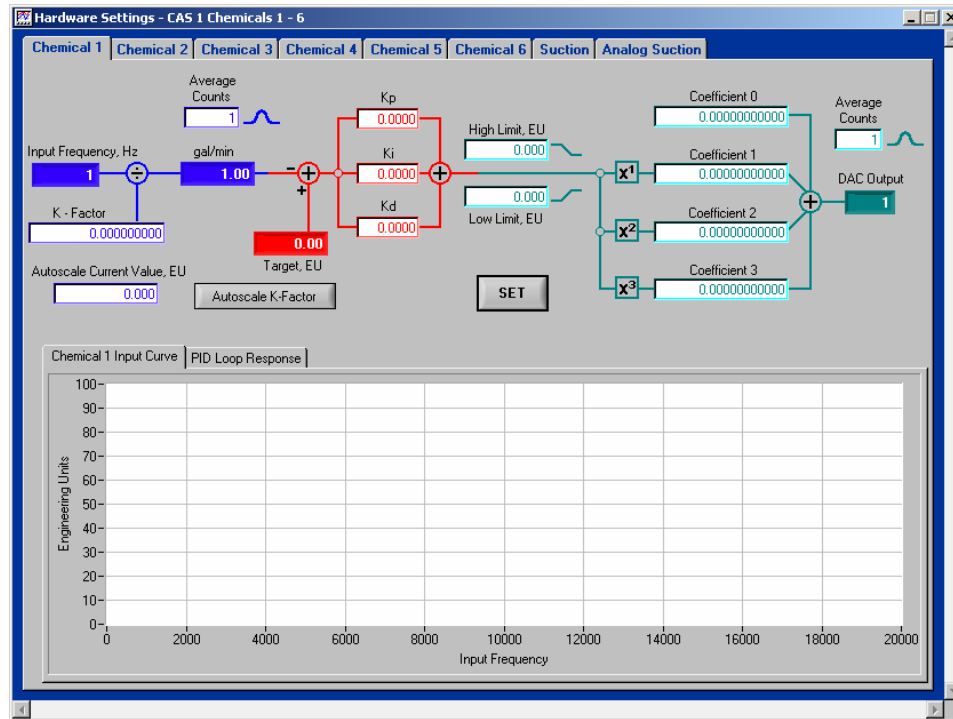


Figure 7.2: CAS Hardware Setup Window

Chemicals

The procedure for setting up the hardware settings for each chemical is similar to the procedure provided in Section 6.3.

Suction

The procedure for setting up the CAS suction is similar to the procedure provided in *Section 5.4: Suction and Discharge*.

7.3 Operations

After the stages are programmed and all the hardware is setup, you can setup the tub level. This involves calibrating the tub level sensor (see **Configuring the Analog Inputs** in Section 4.4) and tuning the PID on the tub level control (see **Controller Tuning** in Section 3.4).

Note: The AccuFracPC™ software does not monitor or control the tub level and its target set point. This can only be done on the unit.

Once everything has been setup, the job can run. While the job is running, it can be monitored or stages can be modified.

7.4 Running a Job

All of the job control functions for the CAS can be executed from the *Blender* windows (**Figure 1.1** and **1.2**). To run a job, use the control buttons on the *Blender* windows. A brief explanation of each button is listed below.

- Start** - In *CAS 1* section of *Blender 1* window, the software starts the programmed job on CAS 1. In *CAS 2* section of *Blender 2* window, the software starts the programmed job on CAS 2.
- Abort** - In *CAS 1* section of *Blender 1* window, the software stops the programmed job on CAS 1. In *CAS 2* section of *Blender 2* window, the software stops the programmed job on CAS 2.
- Hold** - In *CAS 1* section of *Blender 1* window, the software halts the programmed job on CAS 1 at the current stage. In *CAS 2* section of *Blender 2* window, the software halts the programmed job on CAS 2 at the current stage.

Note: Once *Hold* is pressed, the button will change to *Resume*. Press *Resume* to continue the programmed job.

In the *Hold* state, the end volume of the current stage and the end volume of the job for each chemical increases as the suction total increases. Once *Resume* is pressed, the end volume of the current stage and the end volume of the job for each chemical stop increasing. The effect is similar to **Figure 5.4**.

- Next** - In *CAS 1* section of *Blender 1* window, the software moves the job to the next programmed stage on CAS 1. In *CAS 2* section of *Blender 2* window, the software moves the job to the next programmed stage on CAS 2.

Next stage shortens the current stage total and the total volume of the job for each chemical. The effect is similar to **Figure 5.5**.

7.5 Modifying a Running Job

Changes can be made to a job that is currently executing by editing individual stage values. If changes are made to stages that have not yet run, they will take effect when the stage does run. If the length of a stage is changed, it will affect the end of the job value. Changes to the current stage will take place immediately. If a ramp stage is changed in the middle of a running job, the target will immediately go to where it would have been had the stage been programmed that way originally. To make changes to chemicals during a job, refer to **Setting Up a Job** in Section 6.1.

Another enhanced feature of the AccuFracPC™ software is the ability to override the target concentration (loading) of the chemicals for the current stage or of the whole job while it is running. To override the target concentration, press  in the *CAS* section of the *Blender*

windows. The Override Target Concentration box will display (Refer to **Figure 7.3**). Select which chemical you want to change. Select a chemical to change from the list on the left side of the box. Enter a new target and select *This Stage Only* or *Rest of Job*. Press **Override** to send to CAS 1 or 2 or **Cancel** to end without sending changes.

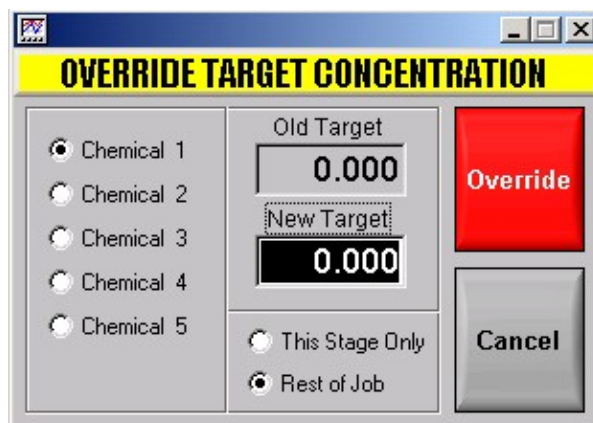


Figure 7.3: Override Target Concentration - CAS

Note: Like the Blender Chemical Controller, the target is in gallons per 1000 gallons of suction for liquid chemical and in pounds per 1000 gallons of suction for dry chemical.

Chapter 8:

AccuFracPCTM Details

8.0 Overview

When all of the equipment is connected properly and communications are established, the software receives data from the six pieces of equipment and up to four additional inputs. The data can be manipulated, monitored, or recorded per the operator's specification. **Table 8.1a** shows the data coming in from one blender; **Table 8.1b** shows data coming in from one CAS; **Table 8.1c** shows data coming in from one DAS and the 6 calculated values; and **Table 8.1d** shows up to four additional comport inputs. These inputs are ASCII data streams.

Table 8.1a: Available Source Data			
Blender			
Chemical Controller		Density Controller	
Suction Rate ACC	Speed Chem6	Stage ADC	Pressure 1 ADC
Suction Total ACC	Target Chem1	% Complete ADC	Pressure 2 ADC
% Complete ACC	Target Chem2	Suction Rate ADC	Measured Tub Level
Stage Chem1	Target Chem3	Suction Total ADC	Target Tub Level
Stage Chem2	Target Chem4	Discharge Rate ADC	Stage % Complete
Stage Chem3	Target Chem5	Discharge Total ADC	Tub Auto/Manual
Stage Chem4	Target Chem6	All Sand Rate	Proppant SGU
Stage Chem5	Conc Chem1	All Sand Total	Fluid SGU
Stage Chem6	Conc Chem2	Measured Density	Current Stage Volume
DAC Chem1	Conc Chem3	Target Density	Programmed Stages
DAC Chem2	Conc Chem4	Ratiometric Density	
DAC Chem3	Conc Chem5	Target Sand Total	
DAC Chem4	Conc Chem6	% Auger1	
DAC Chem5	Target Conc Ch1	% Auger2	
DAC Chem6	Target Conc Ch2	% Auger3	
Total Chem1	Target Conc Ch3	Speed Auger1	
Total Chem2	Target Conc Ch4	Speed Auger2	
Total Chem3	Target Conc Ch5	Speed Auger3	
Total Chem4	Target Conc Ch6	Sand Rate Auger1	
Total Chem5	AIN1 ACC	Sand Rate Auger2	
Total Chem6	AIN2 ACC	Sand Rate Auger3	
Rate Chem1	AIN3 ACC	Sand Total Auger1	
Rate Chem2	AIN4 ACC	Sand Total Auger2	
Rate Chem3	AIN5 ACC	Sand Total Auger3	
Rate Chem4	AIN6 ACC	Target RPM Auger1	
Rate Chem5	AIN7 ACC	Target RPM Auger2	
Rate Chem6	AIN8 ACC	Target RPM Auger3	
Speed Chem1		Target Sand Auger1	
Speed Chem2		Target Sand Auger2	
Speed Chem3		Target Sand Auger3	
Speed Chem4		End of Stage ADC	
Speed Chem5		End of Job ADC	

Table 8.1b: Available Source Data			
CAS			
Suction Rate	DAC Chem10	Speed Chem5	Conc Chem12
Suction Total	DAC Chem11	Speed Chem6	Target Conc Ch1
Base Rate 2	DAC Chem12	Speed Chem7	Target Conc Ch2
Base Total 2	Total Chem1	Speed Chem8	Target Conc Ch3
% Complete	Total Chem2	Speed Chem9	Target Conc Ch4
Suction Rate	Total Chem3	Speed Chem10	Target Conc Ch5
Suction Total	Total Chem4	Speed Chem11	Target Conc Ch6
Base Rate 2	Total Chem5	Speed Chem12	Target Conc Ch7
Base Total 2	Total Chem6	Target Chem1	Target Conc Ch8
% Complete	Total Chem7	Target Chem2	Target Conc Ch9
Stage Chem1	Total Chem8	Target Chem3	Target Conc Ch10
Stage Chem2	Total Chem9	Target Chem4	Target Conc Ch11
Stage Chem3	Total Chem10	Target Chem5	Target Conc Ch12
Stage Chem4	Total Chem11	Target Chem6	AIN1
Stage Chem5	Total Chem12	Target Chem7	AIN2
Stage Chem6	Rate Chem1	Target Chem8	AIN3
Stage Chem7	Rate Chem2	Target Chem9	AIN4
Stage Chem8	Rate Chem3	Target Chem10	AIN5
Stage Chem9	Rate Chem4	Target Chem11	AIN6
Stage Chem10	Rate Chem5	Target Chem12	AIN7
Stage Chem11	Rate Chem6	Conc Chem1	AIN8
Stage Chem12	Rate Chem7	Conc Chem2	AIN9
DAC Chem1	Rate Chem8	Conc Chem3	AIN10
DAC Chem2	Rate Chem9	Conc Chem4	AIN11
DAC Chem3	Rate Chem10	Conc Chem5	AIN12
DAC Chem4	Rate Chem11	Conc Chem6	AIN13
DAC Chem5	Rate Chem12	Conc Chem7	AIN14
DAC Chem6	Speed Chem1	Conc Chem8	AIN15
DAC Chem7	Speed Chem2	Conc Chem9	AIN16
DAC Chem8	Speed Chem3	Conc Chem10	
DAC Chem9	Speed Chem4	Conc Chem11	

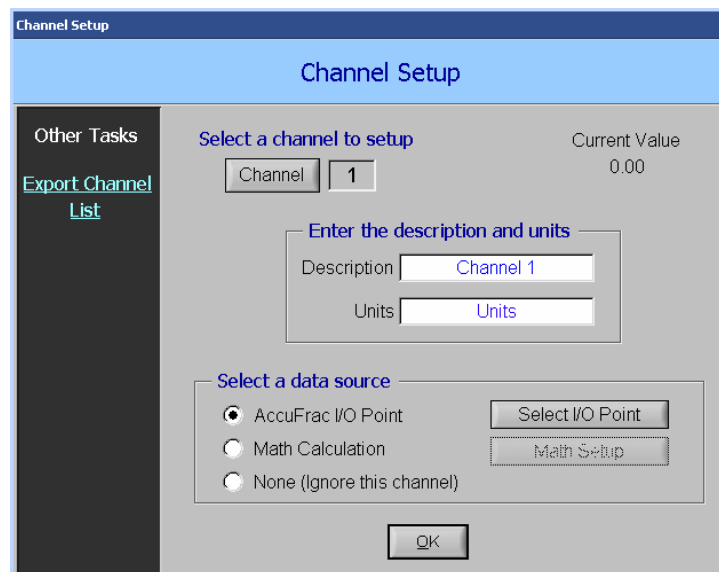
Table 8.1c: Available Source Data	
DAS	Virtual
Channel 1	Countdown Total 1
Channel 2	Countdown Total 2
Channel 3	Blender 1 Prop Total
Channel 4	Blender 2 Prop Total
Channel 5	Inline 1 Prop Total
Channel 6	Inline 2 Prop Total
Channel 7	
Channel 8	
Channel 9	
Channel 10	
Channel 11	
Channel 12	
Inline Density	
Inline Pressure	
Channel 15	
Channel 16	

Table 8.1d: Available Source Data			
Input ASCII Data Stream			
Input 1	Input 2	Input 3	Input 4
Input 1 Data 1	Input 2 Data 1	Input 3 Data 1	Input 4 Data 1
Input 1 Data 2	Input 2 Data 2	Input 3 Data 2	Input 4 Data 2
Input 1 Data 3	Input 2 Data 3	Input 3 Data 3	Input 4 Data 3
...	...	...	...
...	...	...	...
...	...	...	...
Input 1 Data 63	Input 2 Data 63	Input 3 Data 63	Input 4 Data 63
Input 1 Data 64	Input 2 Data 64	Input 3 Data 64	Input 4 Data 64

8.1 Setting Up Channels

From the data in **Table 8.1a, b, c, and d**, you can assign one source data to one channel or you can assign a channel as a math channel. You can setup a maximum of 500 channels in order to monitor, manipulate, and record.

To access the channel setup window, click  and select *Channel Setup*. **Figure 8.1a** appears.



The **Channel Setup** dialog box is shown. It has a title bar labeled "Channel Setup". On the left is a sidebar with "Other Tasks" and a link "Export Channel List". The main area is divided into sections:

- Select a channel to setup:** A "Channel" dropdown menu is set to "1". To the right, "Current Value" is displayed as "0.00".
- Enter the description and units:** A "Description" text box contains "Channel 1" and a "Units" text box contains "Units".
- Select a data source:** Three radio buttons are present: "AccuFrac I/O Point" (selected), "Math Calculation", and "None (Ignore this channel)". To the right are two buttons: "Select I/O Point" and "Math Setup".

An "OK" button is at the bottom center.

Figure 8.1a: Channel Configuration

8.2 Source Data

To assign data to one of the 500 channels, click  and select the desired channel.

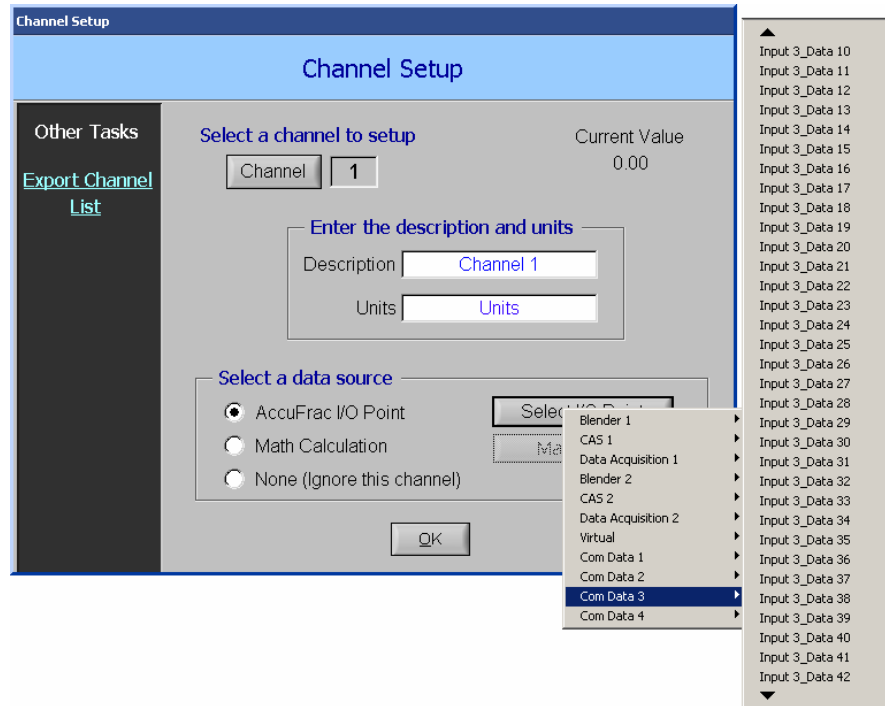


Figure 8.1b: Channel Configuration

Then select the data source as shown in **Figure 8.1b**. The figure shows the description, unit, and current value of the selected channel. You can enter your own description and unit.

Note: Notice ComData 1, 2, and 4 are grayed out. This means that it is not setup as an input or there is no data coming in.

8.3 Math Channels

To assign one of the 500 channels as a math channel, click **Channel** and select the desired channel. Next, check the **Math** box. The **Math Setup** button will be enabled and the **Select Data Source** button will be disabled. After Selecting **Math Setup**, the **Math** window appears (Refer to **Figure 8.2**).

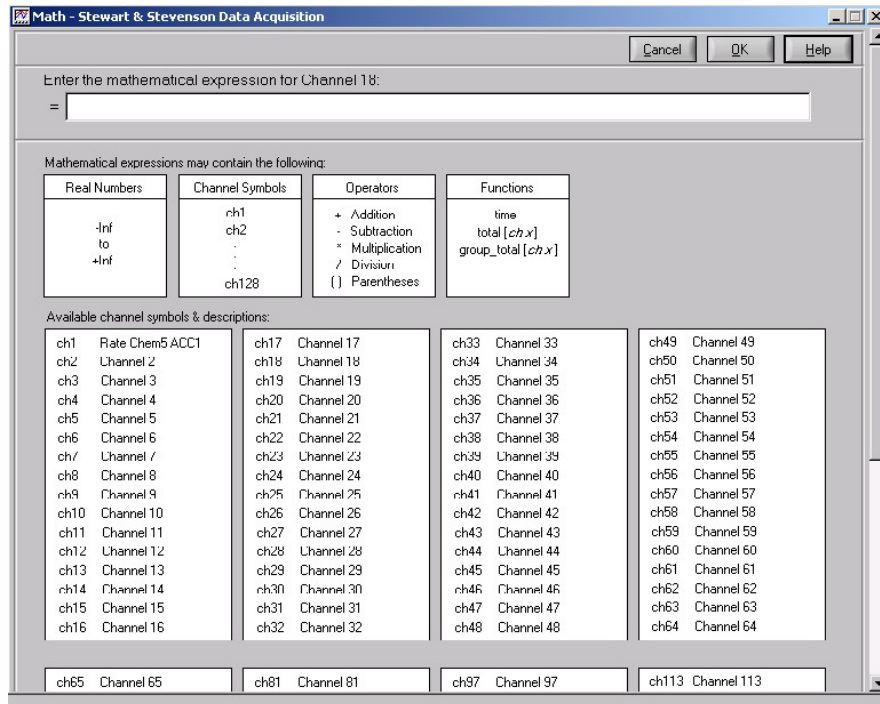


Figure 8.2: Math Setup Window

Enter your mathematical expression and select **OK**.

Note: Use **HELP** to see examples of mathematical expressions. When setting a math channel as a total, divide by 60 in order to calculate minutes.

To save and load the channel setup, refer to Section 2.3 (**Saving and Loading Communication Setup**).

Note: *Load Setting* initializes all totals setup by a math channel to zero.

8.4 File Management

The AccuFracPC™ software allows you to record, play, edit, graph, and delete a file containing these 500 channels. To access the file manage features click  and make your selection.

Pre Recording

Before recording the operator needs to configure which channels are to be recorded by selecting **choose recorded channels** under the file management tab. This will open the *channel recorder setup window*, allowing the operator to add and remove desired channels.

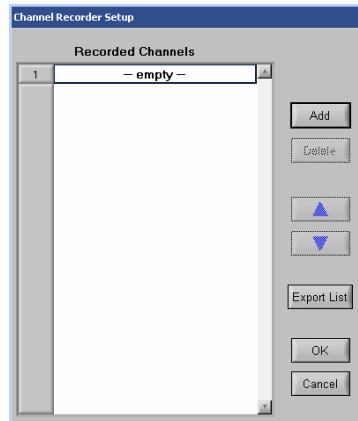


Figure 8.2b: Channel Recorder Setup Window

Recording

When **New** is selected, the software begins recording data for the current job in a new file. Depending on what channels you select the AccuFracPC™ software will record the selected channels at one-second intervals. The system will prompt for a filename. Enter a filename for the recording session. It will be in a comma separated variable file format (*.csv). Then click **OK**.

Note: File type *.csv can be opened with Microsoft Excel.

The **Append** selection allows you to append new data generated by the AccuFracPC™ software to an existing file. The software will prompt you for the file.

While recording, you have the ability to stop or pause a recording session. The software will prompt you before stopping.

Playing

The **Replay** selection allows you to view saved data through the AccuFracPC™ software. The software will display the recorded data on the Monitor Screen. It will prompt you for a file in which to replay. When the software is finished replaying the file, it will notify you that the data display is returning to online (live) data display.

Graphing

The **Graph** provides access to graphs of saved data. The software prompts you for the file in which to graph. The AccuFracPC™ software uses the Monitor window to graph the saved job data.

Deleting

The **Delete** option permanently deletes files from the system. The software will prompt you for the file to delete.

Note: This will permanently delete your file. It will not be in the Recycle Bin.

Editing

The **Edit** selection allows you to edit saved data. The software will prompt you for the file to edit. **Figures 8.3a** and **8.3b** show the **Edit Data** screen.

The **Edit Data** screen graphs the data being edited on the grid above the data display. To edit a data element, double click on the cell containing the data in the lower section of the screen as illustrated.



Figure 8.3a: Edit Data Screen

To trim a data range, first turn on the data cursors by clicking the radio button next to the word **Cursors** located just below the grid. This will display the cursors on the graph as illustrated. Use the cursors to remove data ranges from the data file.

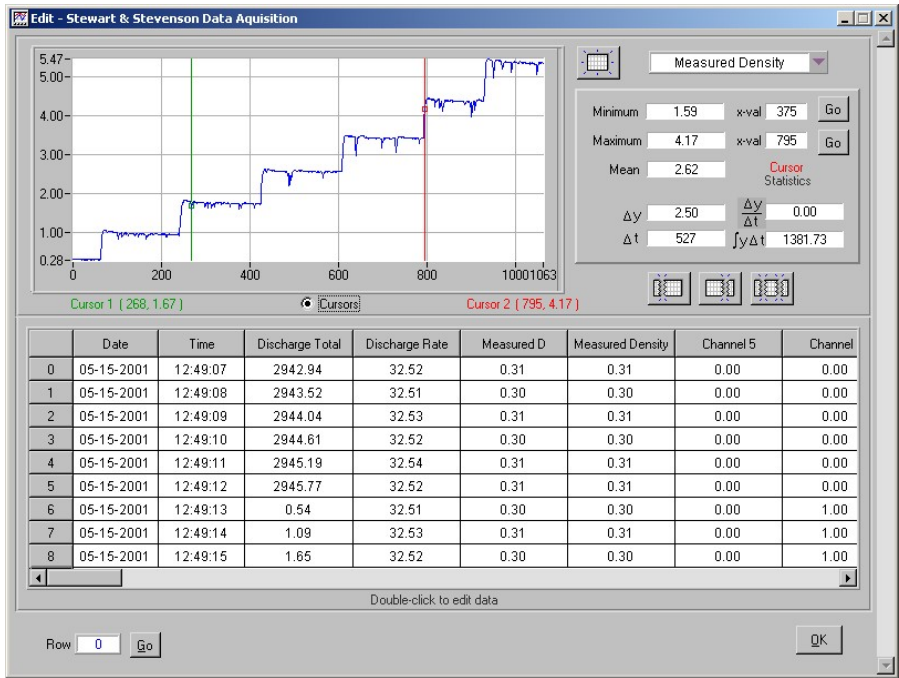


Figure 8.3b: Edit Data Screen (with Cursors turned on)

Using the cursor lines, define a data range to remove. To position the cursor lines, click and drag the lines to the data positions desired. Use the three remove data buttons shown below.



Click the left button to remove the data to the left of the range. Click the middle button to remove the data to the right of the range. Click the right button to remove the data between the green and red cursor lines.

8.5 Setting Up Tags

When recording a file, you want to be able to give it a description in order for you to be able to identify later why it was recorded. You may want to tag it with the customer's name, day of the job, wellhead name, etc. To enter the tag description before a recording session, click . Figure 8.4 appears.

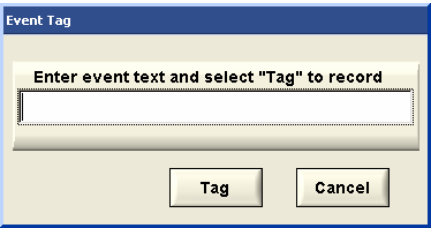


Figure 8.4: Event Tag Window

Enter your description and press the **Tag** button. The description will be recorded in the *.csv file.

8.6 Tabular Reports

Instead of using all 500 channels at a one-second sampling rate of the recorded file, the tabular report feature essentially creates other *.csv files containing only the channels and the sampling rate you pick for analysis. To access this feature, click on . **Figure 8.5** appears. Select your source file, which is usually your original recorded file. Once the source file is opened, the **Available Data** section will be filled. Use the arrows to add or remove available data in your tabular report. Next, select your sampling rate. Once done, select **Generate Report**. The software will prompt you for a filename, and will save your report in *.csv format.

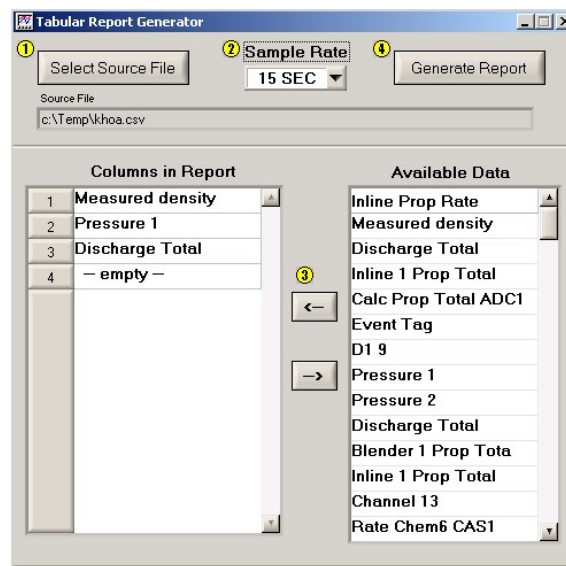


Figure 8.5: Tabular Report Setup

8.7 Printing

The AccuFracPC™ software creates two printing options. You can print from a file or you can do a captured print of the **Monitor** window or the **FracView** window. To select the print option, click  and make your selection.

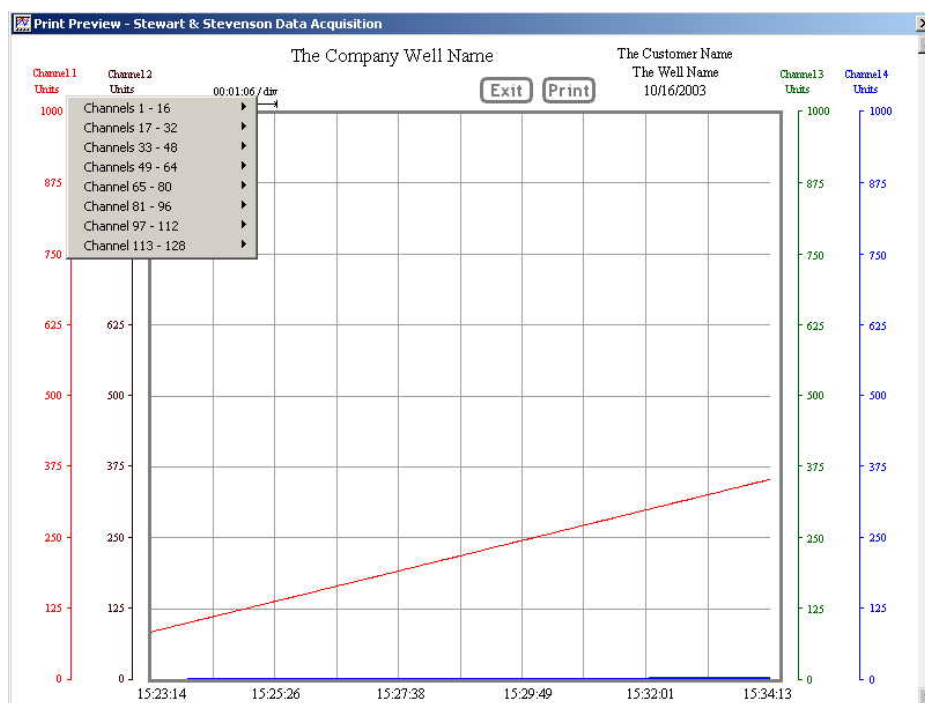


Figure 8.6: Print From a File

When the operator selects print from a file, the software prompts him for a file. After choosing the file, **Figure 8.6** appears. The graph contains four plots. The operator can select the source data by selecting the channel description at the top of the scale and a pull-down menu appears. Make the selection and the graph updates automatically. The operator enters the title, customer name, well name, and date by selecting it. Another neat feature of this graphing function is the ability to change the high and low limit on the scale of a particular channel and the graph updates accordingly. Simply double click on the high or low number and make the change. Once the operator is satisfied with how the graph looks, select **Print** to send it to the printer.

Figure 8.7: Print the Current Window

When the print current window is selected, **Figure 8.7** appears. The operator enters the title, customer name, well name, and date. Depending on which window (FracView or Monitor) the selection was made, the software will print the appropriate window when **Print** is selected.

Chapter 9:

The Drag and Drop System

9.0 Overview

The drag and drop system enhances the functionality, effectiveness, and value of the AccuFracPC™ software. Multiple-monitor support and flexibility have been increased by the addition of four user-configurable screens, which can be displayed concurrently, in addition to, or instead of, the standard AccuFracPC™ interface.

While four custom screens may be displayed at any one time, the number of different customized screens (applicable to different jobs, processes, clients, etc.) that can be saved to disk and later recalled is limited only by storage space.

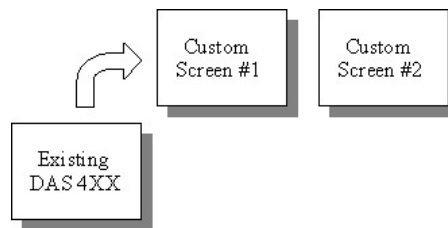


Figure 9.1: Multiple-Monitor Support

The drag and drop module is a peripheral application linked to the AccuFracPC™ via data pipeline. The AccuFracPC™ retains all of its original functionality while exporting real time or recorded data to the customized screens. The custom screens may be used for display, reporting, or analysis.

Whenever real time data is displayed on AccuFracPC™, it will also be displayed on the drag and drop system. If a recorded file is replayed from disk, the data will also replay on the drag and drop screens. If a recorded file is graphed, any graphs on the custom screens will also receive the data.

9.1 Windows and Controls

Windows are the containers onto which controls are placed. Any number of unique processes or report-specific windows can be designed. The collection of windows resides on the hard drive in the form of binary .win files. All window settings such as size, location, background color, and title bar text, as well as resident controls and their settings, are recorded when a .win file is saved and restored when a .win file is opened. When AccuFracPC™ starts, the last two custom screens used (the last two .win files used) open automatically, with their settings restored.

Window or .win files are not copy or password protected and can be shared, distributed, emailed, or otherwise deployed like any other type of electronic document.

Controls are the building blocks of the drag and drop system. The different controls available are illustrated in **Figures 9.2** through **9.12** below.

Table 9.1: Windows, Controls, and Gauges	
Numeric Figure 9.2: Numeric Control	Text Figure 9.3: Text Control
Picture Button Figure 9.4: Picture Button Control	Command Button Figure 9.5: Command Button Control
Tank Slide Thermometer Figure 9.6: Bar Graph Controls	
Gauge Meter Figure 9.7: Gauge Controls	
Decoration 1 Decoration 2 Decoration 3 Decoration 4 Figure 9.8: Decoration Controls	
Graph Figure 9.9: Graph Control	Strip Chart Figure 9.10: Strip Chart Control
LED Figure 9.11: LED Control	Bitmap Figure 9.12: Bitmap Control

9.2 Window Main Menu

Each drag and drop window shares the following main menu items: **File**, **Tools**, **Window**, and **Help**.

The **File** menu enables you to open a saved window, create a new window, save the current window, or send the contents of the current window to a printer. Printing a window that has been designed in a report format,

and loaded with data, is the primary means of report generation with AccuFracPC™.

When a window is printed, only the client area of the window is printed. The frame around the window, the title bar, and the menu bar are not included in the client area.

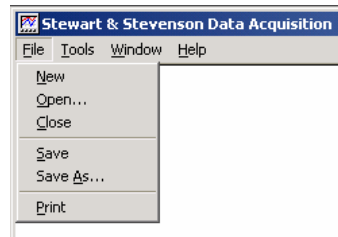


Figure 9.13: The Window File Menu

The **Tools** menu currently has just one tool, labeled **Customize**. Selecting this tool toggles the drag and drop system from Run mode to Design mode. Selecting **Tools > Customize** also opens the Controls Palette. Refer to Section 9.1 for more information on the Controls Palette.

The **Window** menu allows you to switch the uppermost application window between the standard AccuFracPC™ display and the four customizable screens.

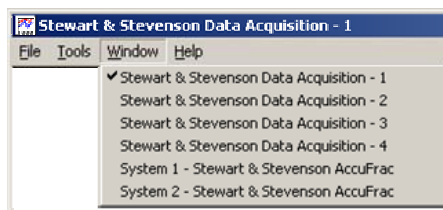


Figure 9.14: The Window Window Menu

The **Help** menu contains a selection that opens a Help About window containing contact information.

9.3 Controls Palette

Selecting **Tools > Customize** toggles the drag and drop system from Run mode to Design mode, and also opens the Controls Palette. While in design mode, the custom screens do not refresh with new data, although the rest of the AccuFracPC™ application continues to operate as normal. The custom screens may be created or modified in design mode.

The Controls Palette is a collection of all the controls that may be used to create a custom window. Windows are designed by "dragging" and "dropping" controls from the controls palette onto the target window.

After a control has been dropped onto a custom window, all of its properties, such as size, location, color, label, font, etc., can be modified, as described in Section 9.4.

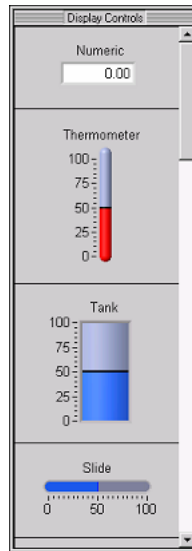


Figure 9.15: Controls Palette

Left clicking a control on the controls palette, without releasing the mouse button, causes the cursor to change from the default pointer to the control cursor . The selected control's background will highlight as shown in **Figure 9.16**.

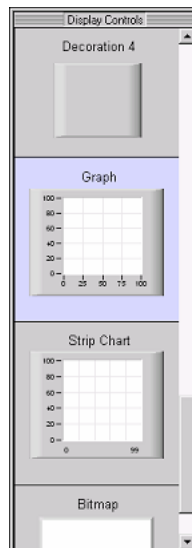


Figure 9.16: Selected Control with Highlight

While holding the left mouse button, move the cursor over the target window, and then release the button. A copy of the control will appear on the target window.

To return to Run mode, select **Tools > Customize**. The controls palette will close and the custom windows will lock.

9.4 Control Properties

While in design mode, left clicking the edge of a control will change the cursor into a sizing arrow (Refer to **Figure 9.17**). While the mouse button is held down, you can change the size of the control by dragging the cursor.



Figure 9.17: Sizing Cursors

While in design mode, left click the middle of a control to change the cursor into a hand symbol (Refer to **Figure 9.18**). While the mouse button is held down, you can move the control around the window to the desired location.



Figure 9.18: The Hand Cursor

There are a number of control properties in addition to size and position that you can select at design time by right clicking on a control. Properties vary for each type of control, and are listed below.

Right click a numeric control to display the properties menu shown in **Figure 9.19**.

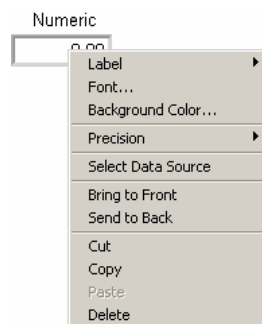


Figure 9.19: Numeric Control Menu

Label refers to the text that appears above the control. In this case, the label contains the text *Numeric*. You can move a label independently of its owner control by dragging with the mouse. A label's text, font, and color can be specified, and whether the label has a raised appearance. This is generally true for all controls with labels.

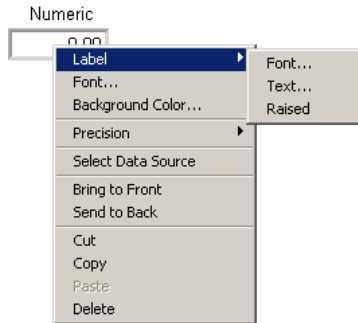


Figure 9.20: Label Menu

Note that in addition to the label font, the font of the control itself can also be selected. **Background Color** allows you to select the color inside the Numeric Control box.

The **Precision** menu item allows you to select the number of digits to display after the decimal. This is generally true for all controls displaying numbers.

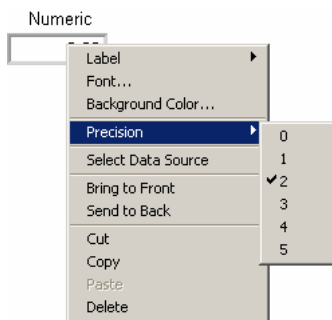


Figure 9.21: Precision Menu

The **Channel** menu item allows you to select an AccuFracPC™ channel. Data from the selected channel is displayed in the control box. This is true for all controls displaying channel data.

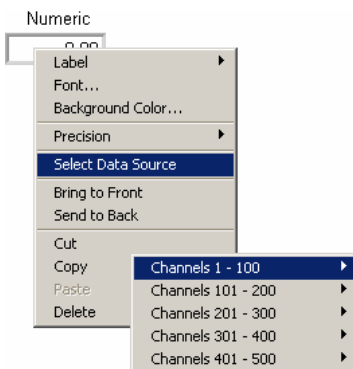


Figure 9.22: Channel Menu

Bring to Front and **Send to Back** allow you to select which controls will appear on top when controls overlap. This is especially useful when using decoration or bitmap controls. This property is settable for all types of controls.

Cut, **Copy**, **Paste**, and **Delete** allow controls to be copied and deleted. This can be useful for creating groups of controls with similar properties.

While in run mode, most of the control settings are locked. Right clicking on a numeric control during run mode causes a smaller properties menu to appear.

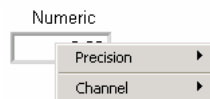


Figure 9.23: Numeric Properties Available During Run Mode

Text control properties settable during design mode are shown in **Figure 9.24**.

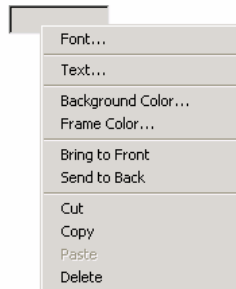


Figure 9.24: Text Control Properties

The **Text** menu allows you to enter the text. Selecting **Background Color** or **Frame Color** displays the Color Selection Preview window (shown in **Figure 9.25** with a bar graph control). Left clicking the color box on the bottom left of the Preview window displays the color picker (Refer to **Figure 9.26**). The color picker allows you to select the color of the text's background or the color of the frame around the text.

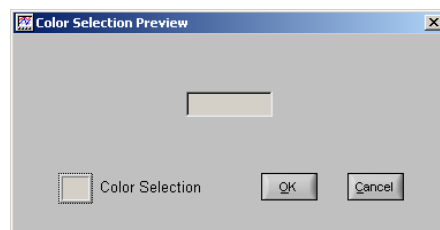


Figure 9.25: Color Selection Preview Window



Figure 9.26: Color Picker

During Run mode, the only property settable for a text control is the text.

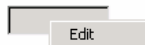


Figure 9.27: Run Mode Properties Menu for Text Controls

Picture button controls have the properties shown in **Figure 9.28** during design mode.

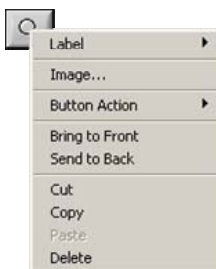


Figure 9.28: Picture Button Properties Menu

Image allows you to select a bitmap image to appear as the picture on the button, shown in **Figure 9.28** as a magnifying glass.

Target Window allows you to select the window to open when the button is pressed (Refer to **Figure 9.29**).

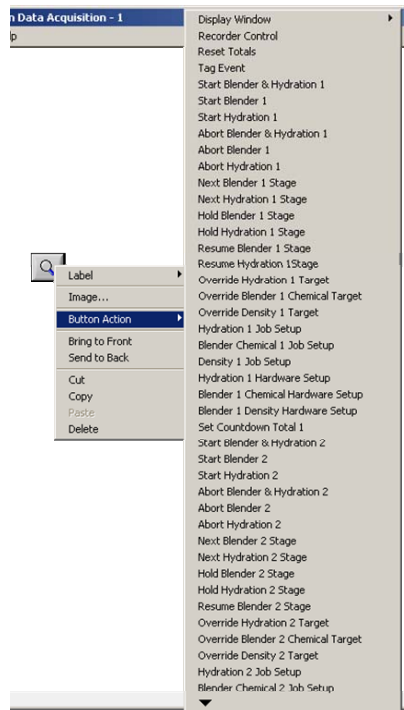


Figure 9.29: Button Action Menu

The only action available to picture and command buttons in AccuFracPC™ is to open a target window.

Command button properties are similar to picture buttons; with the exception that the button's text is selected instead of an image. There are no properties settable for picture buttons and command buttons during Run mode.

Bar graph controls have the design mode properties shown in **Figure 9.30**.

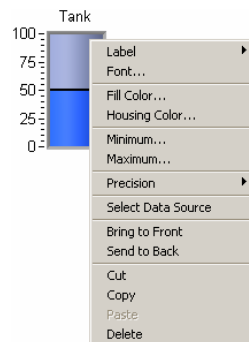


Figure 9.30: Bar Graph Control Properties

Fill Color refers to the color below the current value of the control, or the color of the liquid in the tank shown above. **Housing Color** is the color above the current value, or the color of the empty portion of the tank shown above.

Minimum and **Maximum** refer to the lowest and highest values displayed on the bar graph.

Bar graph properties settable during Run mode are shown in **Figure 9.31**.

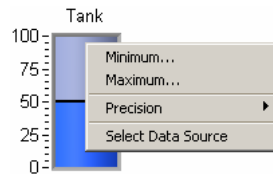


Figure 9.31: Bar Graph Run Mode Properties

Gauge control properties available during Design and Run modes are similar to the bar graph properties, with the exception that **Needle Color** and **Background Color** replace **Fill Color** and **Housing Color**.

Decoration controls are useful for grouping together controls that have a logical association with one another. The Design mode properties available to decoration controls, shown in **Figure 9.32**, require no further explanation. There are no Run mode properties available for decoration controls.

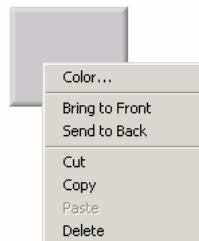


Figure 9.32: Decoration Control Properties

Graph controls have the Design mode properties shown in **Figure 9.33**.

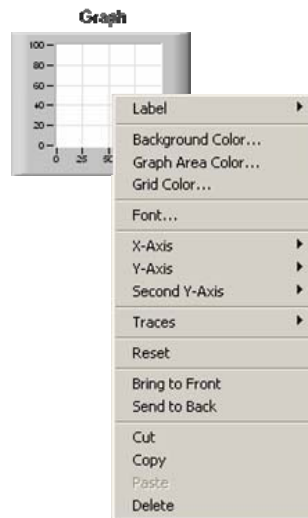


Figure 9.33: Graph Control Properties

The **Background Color** is that part of the graph shown above colored gray. **Graph Area Color** and **Grid Color** require no further explanation.

The x-axis has the properties shown in **Figure 9.34** below.

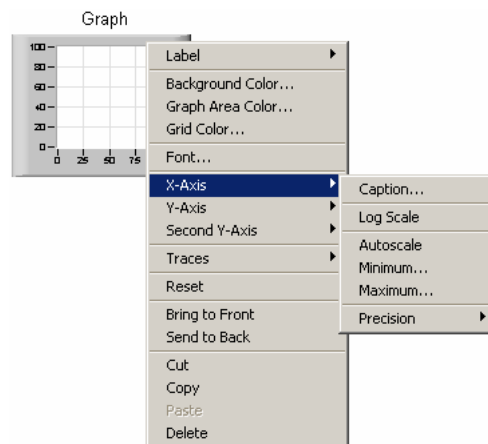


Figure 9.34: X-Axis Properties

Caption allows you to select text to be displayed under the x-axis.

Log Scale toggles the x-axis scale from linear to logarithmic.

Autoscale toggles the x-axis minimum and maximum values from manual to automatic. If either a **Minimum** or **Maximum** value is entered, **Autoscale** will be deselected.

The **Y-Axis** properties are identical to those of the x-axis.

A graph control can have up to four different simultaneous **Traces** or plots. The **Traces** menu item allows you to select the source data channel and color for each of the four available traces.

During Run mode the graph menu contains the properties shown in **Figure 9.35**.

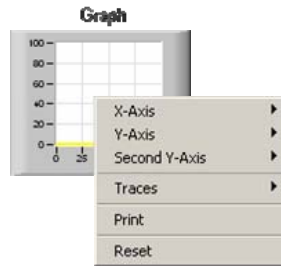


Figure 9.35: Run Mode Graph Properties

During Run mode, there are two additional x-axis properties available. These are **Use Time for X-Axis** and **X-Axis Channel**. If a data channel is selected for the x-axis, **Use Time for X-Axis** will be automatically deselected.

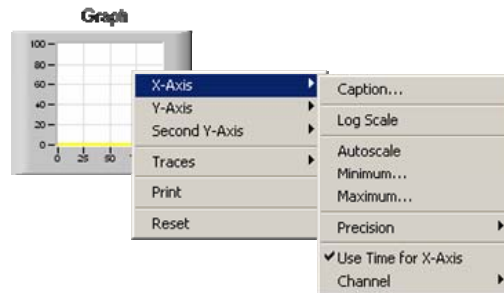


Figure 9.36: Run Mode X-Axis Properties

Strip charts differ from graphs in that they scroll a fixed number data points across the chart area. Whereas graphs are the primary trending controls in AccuFracPC™, strip charts are useful for displaying short-term trends as opposed to long-term historical data. Strip chart controls have the Design mode properties shown in **Figure 9.37**.

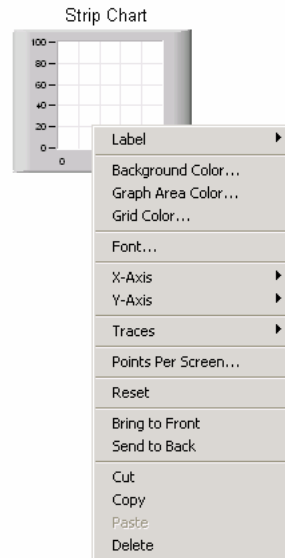


Figure 9.37: Strip Chart Properties

The x-axis of a strip chart represents time in seconds. There is only one property settable for a strip chart x-axis, its **Caption**. For the y-axis, **Caption**, **Minimum**, **Maximum**, and **Precision** may be set.

Points Per Screen refers to the number of data points displayed on one screen. A strip chart with a small number of points per screen will scroll faster than a chart with a large number of points per screen.

During Run mode the settable strip chart properties are those shown in **Figure 9.38**.

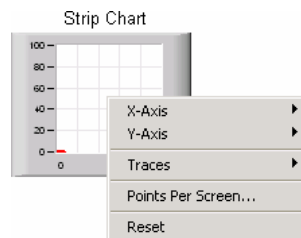


Figure 9.38: Run Mode Strip Chart Properties

LED controls can be one of three different indicator types. They can show that the AccuFracPC™ is online (AccuFrac data is live), or that AccuFrac recording is in progress, but the main use of the LED control is as an alarm indicator. The properties for the LED control are shown in **Figure 9.39**.

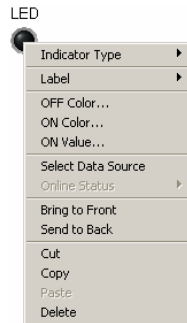


Figure 9.39: LED Control Properties

Indicator Type allows you to select **Alarm**, **Recording In Progress**, or **Online Status**. The OFF Color will be displayed whenever the value of the control is less than the ON Value. The ON Color will be displayed whenever the value of the control is equal to or greater than the ON Value. This provides an LED over range alarm. By reversing the on and off colors, it is also possible to have an LED under range alarm for signals that are too low.

While in Run mode the settable properties are those shown in **Figure 9.40**.

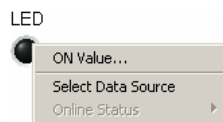


Figure 9.40: LED Run Mode Properties

Bitmap controls allow you to place digital images onto the customized screens. These can be useful for displaying company logos or pictures of the equipment being monitored. The bitmap Design mode properties are shown in **Figure 9.41**. Image files must be copied to and loaded from the AccuFracPC™ application directory. There are no settable bitmap Run mode properties.

More uses for the bitmap control can be found in Section 9.6.

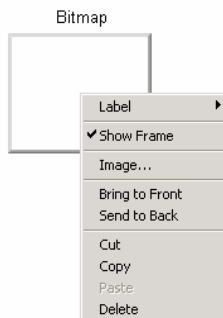


Figure 9.41: Bitmap Control Properties

9.5 Window Properties

Right clicking a window's background area during Design mode allows the selection of the properties shown in **Figure 9.42**. **Color** allows you to select the background color of the window, and **Title** allows you to select the text used in the window title bar.

There are no Run mode settable window properties.

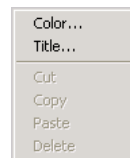


Figure 9.42: *Window Properties*

9.6 Window Design Strategies, Tips, and Tricks

General Guidelines

Limit the number of predominant colors on a window to three or four. Too many colors can make a window appear cluttered and make the window hard to read.

Limit the number of different fonts and font sizes on a window to three or four. Too many fonts and sizes can make a window appear unorganized and cluttered.

Light-colored backgrounds are less reflective and produce less glare than darker colored backgrounds.

Use **Copy** and **Paste** to create collections of controls that are similar in appearance.

Use decorations to group controls that have logical associations with one another together on the screen.

Groups or lists of 7 or fewer controls or items are easier to use than long lists or lots of controls.

Important or critical data should be larger or otherwise more prominent than less important or non-critical data.

Windows for Data Acquisition and Process Monitoring

Images of the equipment being monitored imported with the bitmap control make for easy to read, visually effective windows.



Figure 9.43: Equipment with Numeric Controls

Use the transparent color. The color picker has a selection labeled "T" for transparent. Refer to **Figure 9.45** for an example of transparent color.

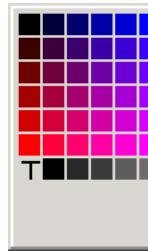


Figure 9.44: Transparent Selection on Color Picker

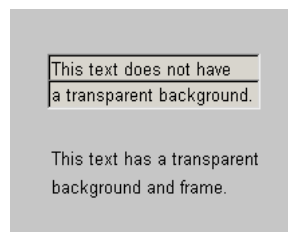


Figure 9.45: Transparent Text Control

Use the transparent color and bitmap controls to create custom controls. **Figure 9.46** shows a default gauge and a custom gauge.

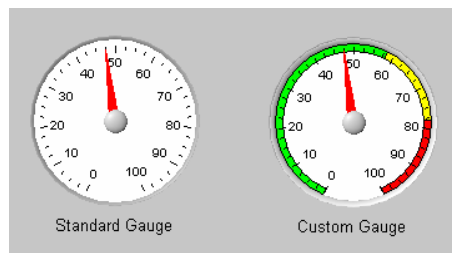


Figure 9.46: Default Gauge and Custom Gauge

The steps followed in making the custom gauge shown above are as follows:

1. Create a gauge on a window.
2. Use the Print Screen button to copy the window contents to the clipboard.
3. Using a bitmap editor like Microsoft ® Paint, paste the clipboard contents to a bitmap.
4. Erase (paint white) the bitmap gauge's numbers, needle, and hash marks. You should now have a white circle of the right size on a gray background.
5. Using the editing tools, draw two concentric black circles just inside the white area.
6. Paint green, yellow, and red between the circles and delete the unwanted parts as appropriate. You should now have something resembling **Figure 9.47**.
7. Crop the image, save, and import into a bitmap control.
8. Align the bitmap over the gauge, set the gauge's background color to transparent, and **Send to Front** the gauge.

The custom gauge can now be reused repeatedly.

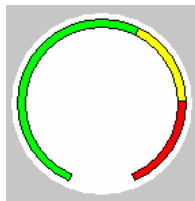


Figure 9.47: Bitmap Background for Custom Gauge

A bitmap background can also be used to contain many controls at the same time, allowing the creation of virtual instruments, panels, and machines. For example, an image of an actual display panel with an assortment of panel meters and gauges can be captured with a digital camera. The image can be imported to a bitmap control, and numeric and gauge controls placed over the appropriate locations, producing a very realistic and professional-looking display.

For another example, a company logo can be placed behind a graph with a transparent graph area.

The whole window background can be a totally customized, hand-drawn bitmap.

Windows for Reporting and Data Analysis

Windows created for generating printed reports should look different than windows created for real time process monitoring.

Different windows should be created solely for reporting purposes. Use the **Save As** Windows menu item to create different windows for printing in color and for printing in black and white.

Create report templates that can easily be reused.

Report generation generally requires only graph and text controls. Use one main graph per report with text fields (such as Name, Date, Notes, Title, etc.) that can quickly be edited.

Printer-friendly windows should contain as few controls with 3-D appearances as possible. Use the transparent color to create flat controls and text.

If a monochrome printer is to be used, use transparent control backgrounds, a white window color, and black text.

Creation of completely customized reports is possible by using a bitmap editor such as Microsoft ® Paint and the bitmap control.

Auger - A rotating helical shaft used for drawing proppant from the hopper into the blender.

Blender Proppant Total - The proppant total calculated by using the densitometer on the blender and the known proppant density.

Damping - Shock Absorbtion.

Inline Density - The density of the slurry flowing in the high pressure pipe to the well. (Used in calculating the Inline & Blender Proppant Totals).

Inline Proppant Total - The proppant total calcualted by using the densitometer near the well head and the known proppant density.

Proppant - Large particles (normally sand) used to keep fractures open.

Quadrature Encoder - A two channel encoder who's outputs are offset by 90 degrees, which indicates the direction as well as the speed of rotation.

Ratiometric Density - A calculated density based on the water and proppant rates.

Slurry - A liquid mixture (usually containing water) of varying subsatances like cement or clay.

Suction Rate - Rate of chemical suction flowing into the mixing tub.

BBL - Barrels (42 Gallons).

CAS - Chemical Additive System.

COM - Communications.

DAC - Digital to Analog Converter.

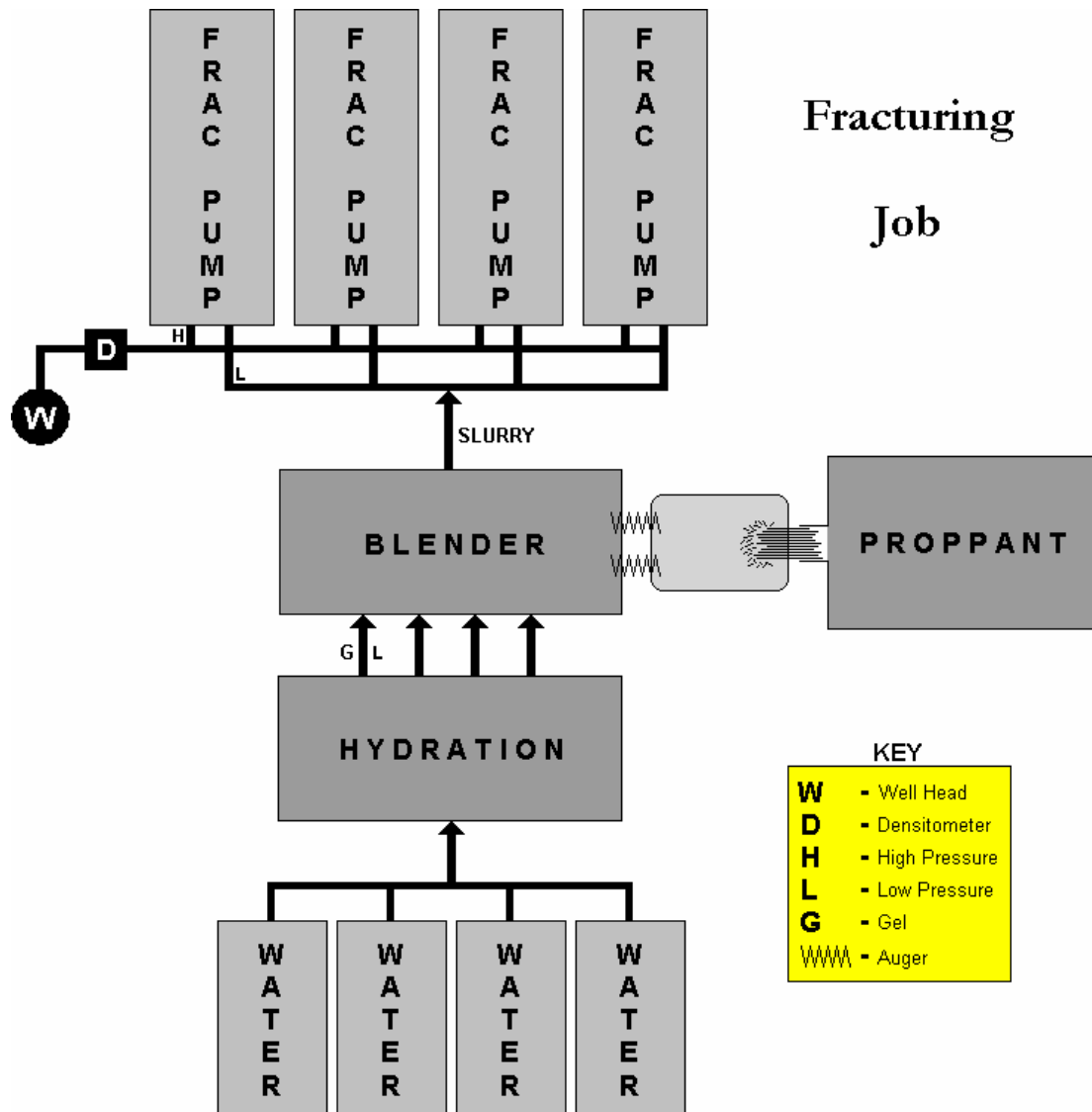
DAS - Data Acquisition System.

LED - Light Emmitting Diode.

PPA - Pounds of Proppant Added per gallon.

REC - Recording.

SGU - Specific Gravity Unit (required to displace on liter of water).



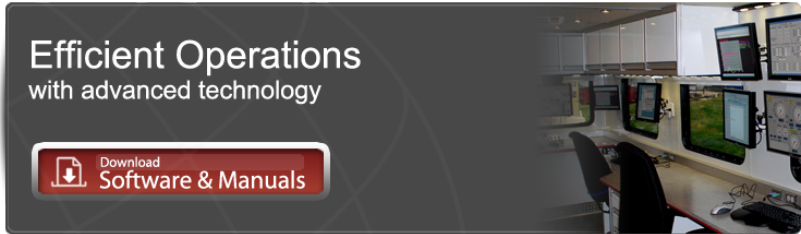


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The Leader in Field Proven Controls

Stewart & Stevenson's data acquisition and control centers provide a centralized command center to control all of the critical well site equipment while monitoring, recording and supervising the fracturing treatment. Data vans reduce the number of equipment operators required to complete the treatment while greatly improving job quality through centralized real-time data gathering and presentation.

Stewart & Stevenson's IPC-PC interface provides control of up to 24 fracturing pumps at a single operator workstation. The AccuFrac-PC interface provides control of multiple blenders, hydration units and chemical additive units from the Data Acquisition and Control Center. UPS systems and solid-state CPU components provide reliable operation with backup systems.

Our control systems are available as discrete components, giving our customers the ability to upgrade existing equipment.

- Fracturing Pump Control System: IPC-PC
- Fracturing Blender Control System: AccuFrac
- Chemical Additive and Hydration Units Control System: AccuFrac
- Multiple Blenders, Hydration Units and Chemical Additive Units: AccuFrac-PC

Control Systems & Software Equipment:



AccuFrac™ Systems

Stewart & Stevenson pioneered the development of advanced electronic control systems for well servicing equipment.

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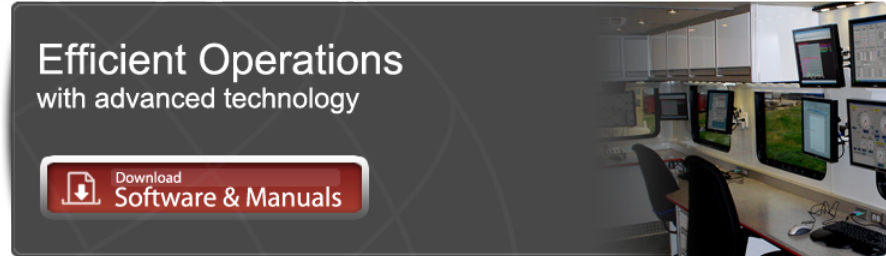
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Stewart & Stevenson's data acquisition and control centers provide a centralized command center to control all of the critical well site equipment while monitoring, recording and supervising the fracturing treatment. Data vans reduce the number of equipment operators required to complete the treatment while greatly improving job quality through centralized real-time data gathering and presentation.

Features/Benefits

Stewart & Stevenson's IPC-PC interface provides control of up to 24 fracturing pumps at a single operator workstation. The AccuFrac-PC interface provides control of multiple blenders, hydration units and chemical additive units from the Data Acquisition and Control Center. UPS systems and solid-state CPU components provide reliable operation with backup systems. Data Acquisition & Control Centers are available in truck, trailer and skid-mounted versions.

Our Control Centers are designed to be "Oilfield Tough," and can be found in some of the world's most extreme environments. Standard units are capable of operating for prolonged periods in climatic conditions with an ambient temperature range of -40°C to + 50°C and are designed for driving over nongrade road surfaces in the rough, windy and dusty environments typically found in the oilfield. Cold weather data vans are available. The sturdy insulated control cabin contains all the control and computer equipment needed to provide a suitable operating environment for company service engineers, operators and customer representatives.

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Stewart & Stevenson's line of drilling, workover and well servicing equipment serves the global oilfield service industry. Quality engineered with the latest advances in oilfield technology, our innovative rigs are at the forefront of making the recovery process safer and more efficient. Manufactured completely in North America since 1987, Stewart & Stevenson rigs meet rigorous industry standards established by the American Petroleum Institute (API) and the International Standards Organization (ISO).

With in-house design, engineering, manufacturing, testing and after-sales capabilities, Stewart & Stevenson serves customers from concept to completion and beyond. Our pioneering technological advancements in rig manufacturing, such as drawworks components and AC/DC control systems, serve oilfield service companies locally and internationally.

Major operators around the globe rely on the superior quality of Stewart & Stevenson rigs. We offer:

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- Workover and well servicing rigs
- Flushby rapid service rigs
- Masts
- Substructures
- Drawworks
- Controls
- Power generation
- Support units
- Aftermarket parts and service
- Complete turnkey packages

In keeping with Stewart & Stevenson's century-old tradition of aftermarket service, we provide rig commissioning, servicing, retrofitting, and parts.



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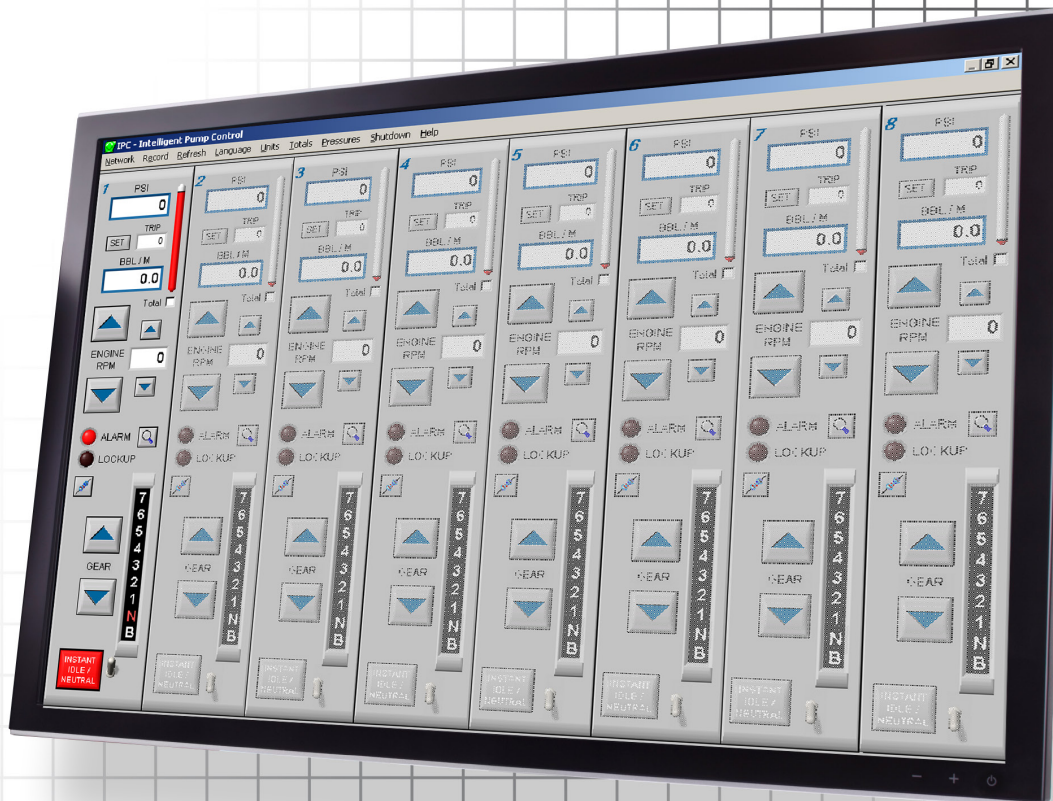
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Stewart & Stevenson IPC-PC

Intelligent Pump Control



User's Guide





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1. Introduction

1.1 Record of Ownership

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CITY: _____ STATE: _____ ZIP CODE: _____

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1.2 Revision Record

Check each revision received and insert the revised and supplementary pages in your manual (if applicable).

REV	REVISION DATE	TECH PUBS WO	PART NUMBER	SALES ORDER NUMBER
0	JUN 2005			
1	MAY 2013	3587510		
2				
3				
4				

1.3 Translation Notice

This manual is written in English. If the equipment owner translates this manual using in-house personnel or a professional service, then the equipment owner acknowledges responsibility for the accuracy of the translated manual. Stewart & Stevenson assumes no responsibility for unit operation errors, damage to or improper use of equipment, improperly trained personnel, improperly maintained equipment, or failure to follow normal safety precautions outlined in this manual or in the vendor literature that may result from inaccuracies in the translated manual.

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1.5 About This Manual

This manual is not a textbook on electronics. Sufficient descriptive material and illustrations are included to enable the operator to understand the basic theory of operation of this equipment. The intent of this manual is to assist trained operators and maintenance personnel in the proper use of the equipment. This guide is not a substitute for properly trained personnel or common sense.

No liability, either express or implied, is given for any information contained herein. This manual is intended **only as a guide**, and not as a substitute for proper training by qualified personnel. Stewart & Stevenson LLC assumes no responsibility for improper use of equipment, improperly trained personnel, improperly maintained equipment, or failure to follow normal safety precautions outlined here or by properly trained personnel.

Use of this guide for any purpose other than for the safe and proper operation and maintenance of the equipment and all of its components constitutes misuse, and is punishable by all applicable laws.

If there is any discrepancy between information contained in this manual and the vendor literature, the vendor literature is assumed correct. Stewart & Stevenson LLC assumes no liability whatsoever for any person who fails to follow the operation and safety procedures of the original equipment manufacturers.

Please read through this guide in its entirety **before** attempting to operate the equipment. Stewart & Stevenson LLC. assumes no liability for failure to do so.

All information in this guide is based on the latest production information available at the time of publication. Direct any questions concerning the contents or format of this guide to:

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Product Information: controls.info@ssss.com



1.6 Conventions Used in This Manual

The IPC-PC Intelligent Pump Control Manual uses the following formats:

- ***Bold and Italicized Text*** indicates a screen name.
- **Bold Text** indicates a button on a screen or dialog box.
- *Italicized Text* indicates a variable that must be entered by the user.
- `Courier Text` indicates commands that must be entered by the user.
- ALL CAPITAL TEXT indicates a file name.

NOTE: Is used to notify personnel of installation, operation, or maintenance information that is important, but not hazard related.



1.7 Manual Danger, Warning, and Caution Statements

Throughout this manual, statements may appear which emphasize important and critical information. These statements will be set off from the rest of the text, and will be formatted and defined as shown.

	Indicates an imminently hazardous situation, which, if not avoided, will result in death or serious injury. This type of statement is limited to only the most extreme situations.
	Indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injury.
	Indicates a potentially hazardous situation, which, if not avoided, could result in minor or moderate injury or serious damage to equipment. It may also be used to alert against unsafe practices.

NOTE: Is used to notify personnel of installation, operation, or maintenance information that is important, but not hazard related.



2. Overview

Stewart & Stevenson's IPC-PC allows fracturing pump operators to monitor and control up to twenty-four frac pumps simultaneously from a single PC interface. Mission critical process data is displayed in an easy to read analog format with data continuously compared against configurable alarm set points. The operator is alerted if any engine, transmission, or pump data from any of the (up to) twenty-four frac pumps is out of range. Real-time data acquired from multiple pumps can be multiplexed into a single data stream for transmission to external data acquisition or analysis packages.

2.1 Who Should Use This Manual?

This manual supplements the existing Intelligent Pump Control (IPC) user documentation and is intended for IPC operators who desire to add PC navigability and functionality with IPC-PC.

2.2 Who Can Use IPC-PC?

IPC-PC may be used with any IPC hardware that has firmware version 2.0 or later. IPC-PC firmware upgrades are available at no cost at:

<http://controls.stewartandstevenson.com/downloads.aspx?s=s>

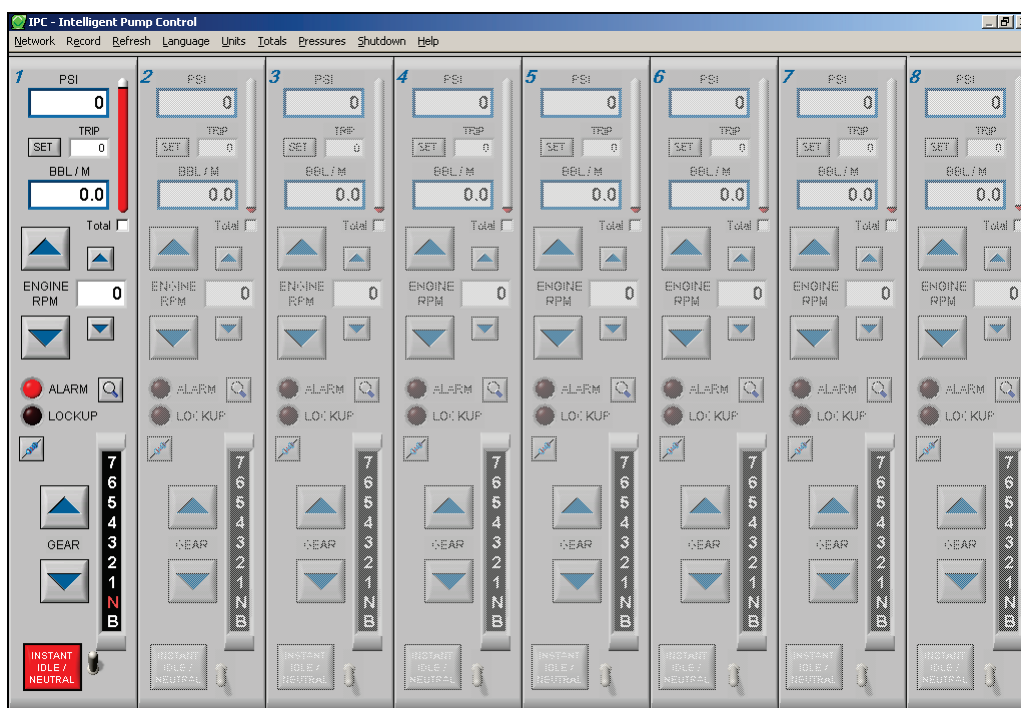


Figure 1, IPC-PC Control Window



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3. Initial Setup

This section covers the details of understanding, establishing, and operating the communications network in IPC-PC. Furthermore, many key components, diagrams, and terms will be sufficiently explained in detail in order to facilitate the user in operating an IPC-PC workstation.

3.1 How IPC-PC Interacts with the IPC Controller Network

A typical Intelligent Pump Control installation is shown below in Figure 2. Multiple Frac Pumps are connected to one IPC-PC workstation.

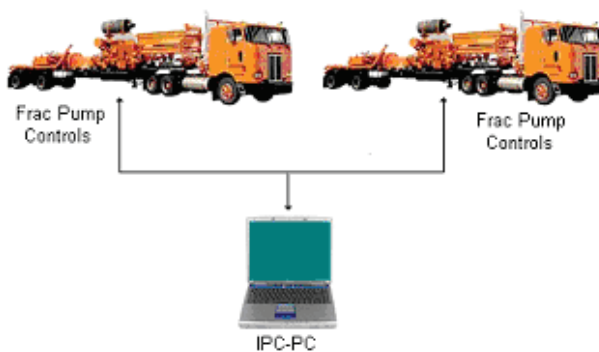


Figure 2, Typical IPC Controller Network

3.2 The COM Port Setup Window

The **COM Port Setup** window is used to select the COM ports on the host computer through which IPC-PC will communicate with IPC. To display the window select **Network** → **COM Port Setup** from the IPC menu as shown in Figure 3.

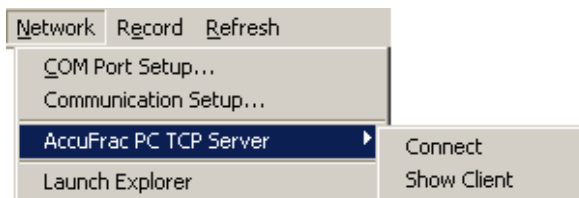


Figure 3, Network Tab



The **COM Port Setup** window contains settings for up to twenty-four input serial ports and one additional port for serial output. Each of the twenty-four input ports can be connected to one IPC frac pump.

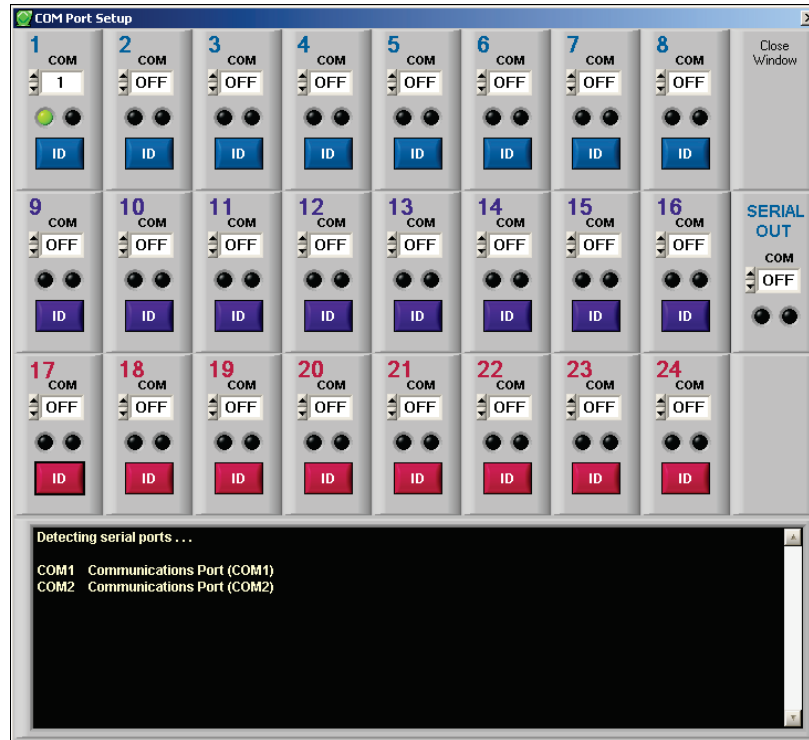


Figure 4, COM Port Setup Window

3.3 The Serial Port Enumerator

The **Serial Port Enumerator** shown in Figure 5 is part of the **COM Port Setup** window. The enumerator lists all COM ports installed on the host computer. The **Serial Port Enumerator** is a simple diagnostic tool that may be useful when configuring the host computer.

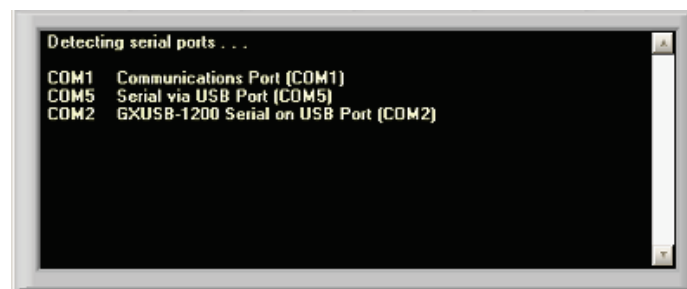


Figure 5, Serial Port Enumerator



3.4 Selecting a COM Port

A COM port must be selected for each frac pump to be controlled by IPC-PC. COM ports 1- 48 may be chosen. After a port is selected IPC-PC immediately attempts to open the port. If the selected port is unavailable or in use by another application, the port will not open. A message will prompt the operator that the selection is invalid.

COM port setup needs to be done only once since the settings are stored and will be recalled when the IPC-PC application runs.

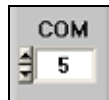


Figure 6, COM Port Selector

3.5 COM Status LEDs

If the selected port is opened successfully, the green **Port Available** LED will illuminate. As data is received from the IPC network the red **Receiving Data** LED will illuminate. It is normal for the **Receiving Data** LED to flash on and off as data is received.

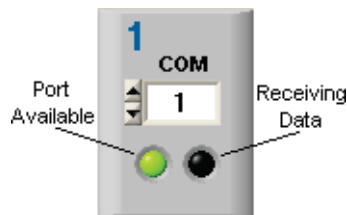


Figure 7, COM Status LED



3.6 Serial Data Output

Selecting a COM port on the serial output selector enables serial output. In this case the rightmost LED indicates **Transmitting Data** instead of **Receiving Data**.



Figure 8, Serial Output Control

The serial output port is configured at 57,600 bits per second, eight data bits, no parity bit, one stop bit, with flow control off.

The serial output data is formatted as comma-delimited ASCII text and consists of a timestamp in the form HH:MM:SS followed by packets of real-time data values for each online pump. Specific details of the data values included in the serial output can be found in Appendix A, *Serial Data Output Values*.



3.7 Communication Setup Window

The **Communication Setup** window allows the operator to fundamentally change how data is transferred across the IPC-PC network. The operator can access this window by selecting the **Network** tab then, **Communication Setup**.

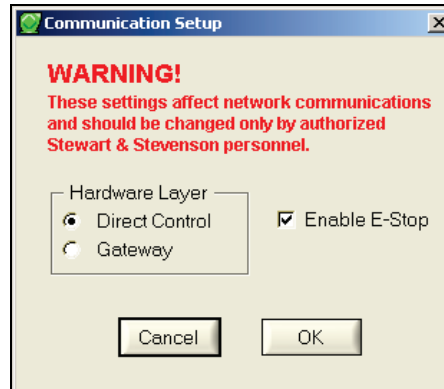


Figure 9, Communication Setup Window

The **Hardware Layer** radio select buttons allows the operator to connect to the Main Control Board (MCB) through the **Gateway** using a RS232 connection, or by **Direct Control** using a RS485 connection.

 CAUTION	The E-Stop button sets the engine to instant idle/neutral. It is <i>NOT</i> an emergency stop button.
---	--

To the right of the Hardware Layer radio select buttons is the **Enable E-Stop** selector, which allows an operator to immediately set the engine to instant idle/neutral by depressing the large mushroom button located inside the data van. No action will occur if the **E-Stop** selector is not enabled.



3.8 AccuFrac PC TCP Server

The **AccuFrac PC TCP Server** tab allows the operator to connect to AccuFrac PC to receive and display *Inline Pressure*. To connect to the server, the operator must select **Change Server Name** on the **AccuFrac PC TCP Client** window, and input the server address into the field shown in Figure 10.

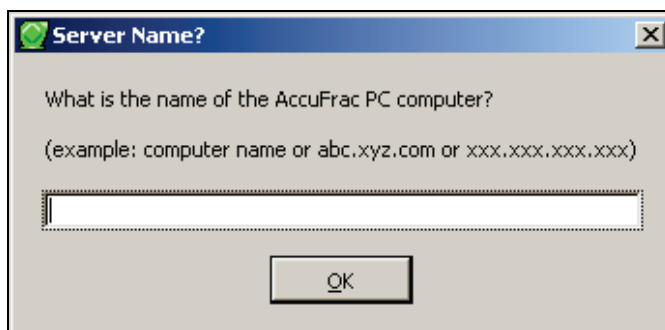


Figure 10, Server Name Window



3.9 Selecting the Engine & Transmission

Configuring the Engine & Transmission is done at the factory. However, if new firmware is loaded on the MCB these settings will have to be configured again.

NOTE: Improper settings can damage the *Engine* and *Transmission* being used. Contact Stewart & Stevenson if you are unsure of these settings.

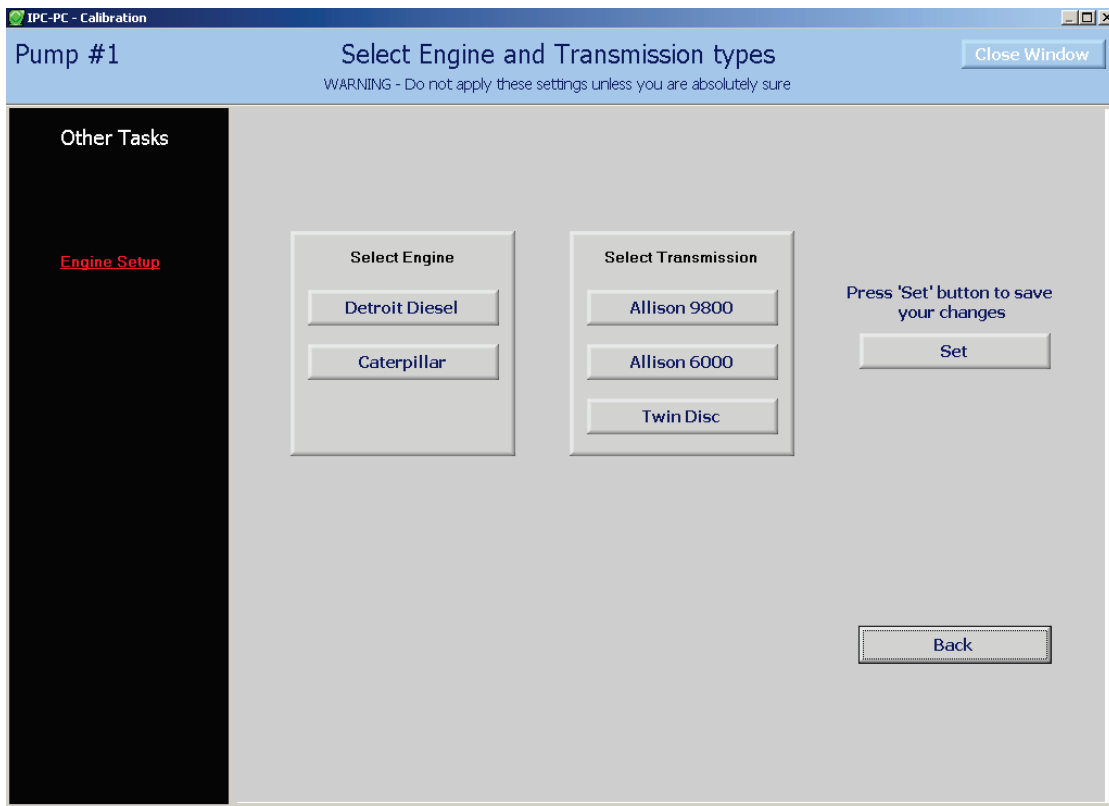


Figure 11, Engine & Transmission Selection Screen



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4. The Multi-Pump Control Window

The **Multi-Pump Control** window allows the operator to control up to twenty-four pumps simultaneously. Individual controls for each pump's engine throttle and transmission gear are provided. Displayed data includes pump discharge pressure, discharge rate, engine rpm, and transmission lockup. All data including those not displayed on the **Multi-Pump Control** window are monitored for alarm conditions. Any data point outside of its normal operating range generates an alarm event and illuminates the alarm indicator.

Any unused pump panel (not connected to an IPC pump) will appear dimmed.

Figure 12 shows one active pump connection, while panels two through eight are dimmed.

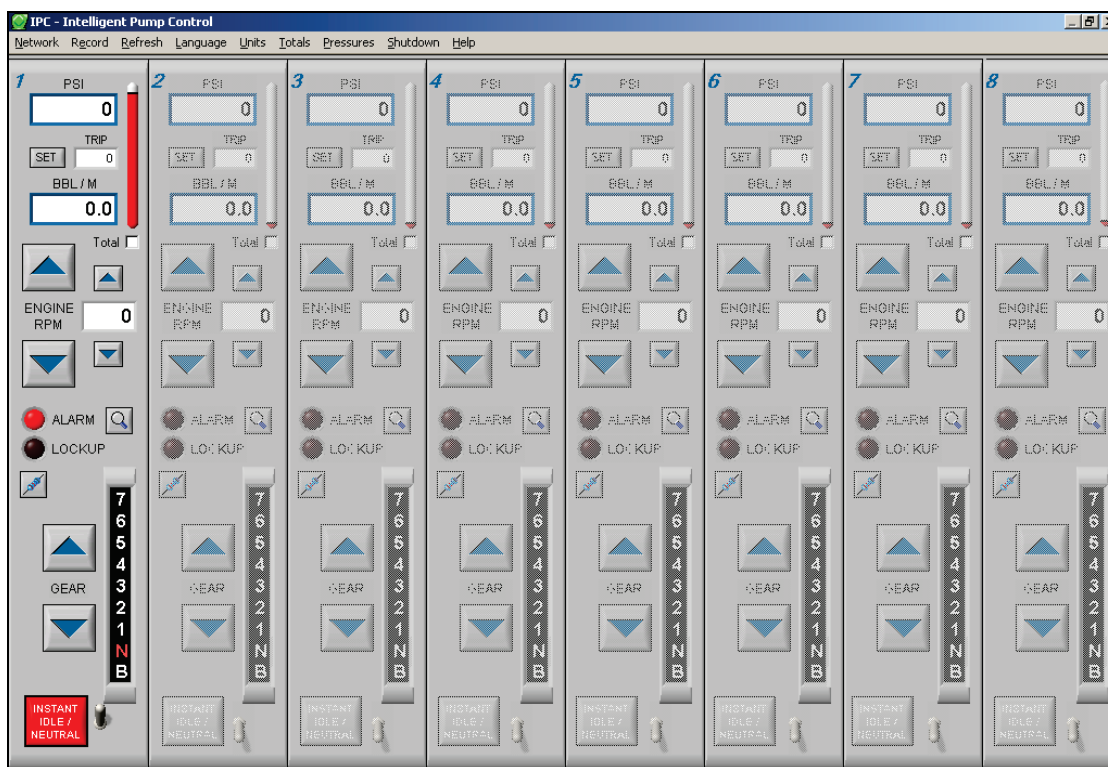


Figure 12, Multi-Pump Control Window



4.1 Engine Throttle Control

The **Engine Throttle Control** is a four-way switch with small and large increment and decrement buttons. Each press of a button causes the corresponding engine's RPMs to increment or decrement by either the small or large throttle steps as configured in IPC. The engine's RPM set point will never exceed the high RPM limit configured in IPC.

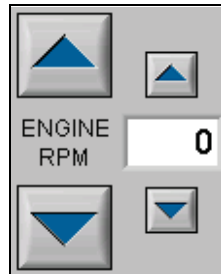


Figure 13, Engine Throttle Control

4.2 Transmission Gear Selector

The **Transmission Gear Selector** is a two-way switch that increments or decrements the selected gear. Each touchscreen button causes the transmission to shift up or down by one gear. The gear that the transmission is *currently in* will be displayed in red, while all other gears appear white. After pressing a gearshift button, a slight delay while the transmission shifts before the indicated gear changes is normal.



Figure 14, Transmission Gear Selector



4.3 *Transmission Lockup LED*

The green **Transmission Lockup** LED will illuminate in green when the transmission is in lockup mode.



Figure 15, Transmission Lockup LED

 CAUTION	Operating the transmission under load for extended periods of time out of lockup (i.e., in torque converter mode) may cause excessive heat build up or damage.
---	---

Lockup is typically achieved at speeds above 1500 RPM.



4.4 Overpressure Trip Set Point

IPC commands the engine to idle and the transmission to go to neutral whenever the discharge pressure exceeds the **Overpressure Trip Set Point**. The **Overpressure Trip Set Point** for each pump is displayed near the top of each pump panel. To enter a new set point, click the **SET** button and a number pad for a new set point will appear shown in Figure 16.

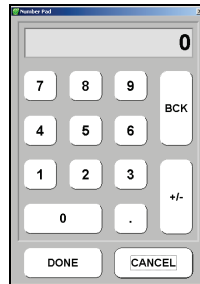


Figure 16, Number Pad

The overpressure bar graph is displayed to the right of the set point. This graph indicates the current discharge pressure of the pump as a percentage of the trip pressure. If the graph moves all the way to the top, the pump will trip.

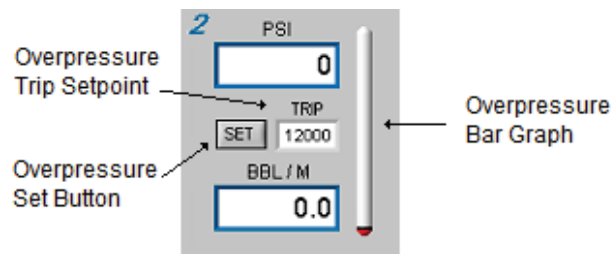


Figure 17, Overpressure Trip Controls



4.5 **Instant Idle/Neutral Button**

An **Instant Idle/Neutral** button is located at the bottom of each pump panel. Pressing the **Instant Idle/Neutral** button causes the corresponding pump's throttle to go to idle and the transmission to go to neutral without affecting any of the other pumps.

The **Instant Idle/Neutral** button must first be enabled by moving the nearby toggle switch to the "Up" position. When enabled, the **Instant Idle/Neutral** button changes from gray to red.

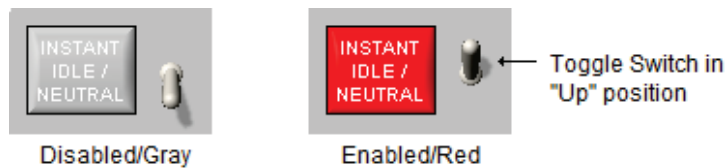


Figure 18, Instant Idle/Neutral Button

4.6 **Alarm LED**

An **Alarm** LED is associated with each pump. The red alarm LED will illuminate if any of the operating parameters are outside of their normal operating ranges as configured in IPC. The **Alarm** LED will also illuminate if a diagnostic fault code is received from the engine's electronic control module (ECM). If an alarm becomes active, as indicated by the **Alarm** LED, the source of the alarm may be located by navigating to the **Diagnostics & Control** window with the **Pump Zoom** Button. The **Pump Zoom** button is described in section 4,7, *Pump Zoom Button*.



Figure 19, Alarm LED



4.7 Pump Zoom Button

Each pump panel contains a **Pump Zoom** button. Clicking the **Pump Zoom** button will display the **Diagnostics & Control** window as described in the next section.



Figure 20, Pump Zoom Button

4.8 Total Radio Button

The **Total Radio** button allows the operator to total the rate, HHP, and volume for all pumps the operator chooses to select. The totals for each pump can be viewed at the bottom of the **Multi-Pump Control** window.



Figure 21, Total Radio Button

4.9 Resistor Button

The **Resistor** button found on each pump panel of the **Multi-Pump Control** window takes the operator to the **Hardware Calibration** window for the corresponding pump selected. The Hardware Calibration Window which will be discussed in Section 6 allows the operator to calibrate various aspects of the engine, transmission, and pump.



Figure 22, Resistor Button



5. The Diagnostics & Control Window

The **Diagnostics & Control** window is an in-depth display of the frac pump's operation shown below in Figure 23.

It is organized into three main sections:

- Engine
- Transmission
- Pump

Each section contains a wealth of diagnostic data that the operator can use to monitor the engine, pump, and transmission.

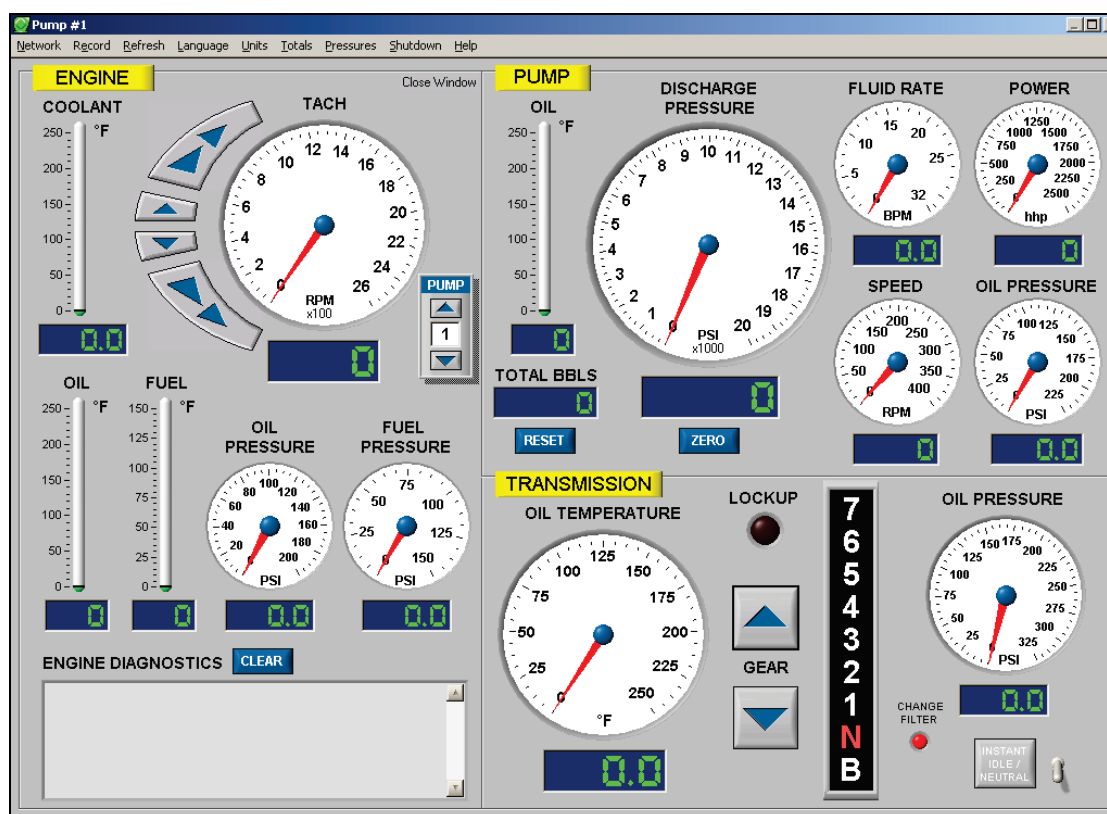


Figure 23, Diagnostics & Control Window



5.1 Engine Diagnostics Display

The **Engine Diagnostics** display translates diagnostic fault codes generated by the engine's ECM. Messages are retained in the scrollable list box until the **CLEAR** button is pressed or the IPC-PC application is shut down.

Broadcast fault codes conforming to either the J1587 or J1939 standard can be displayed on IPC-PC. Currently, IPC and IPC-PC can display fault codes generated by Detroit Diesel ECMs only.

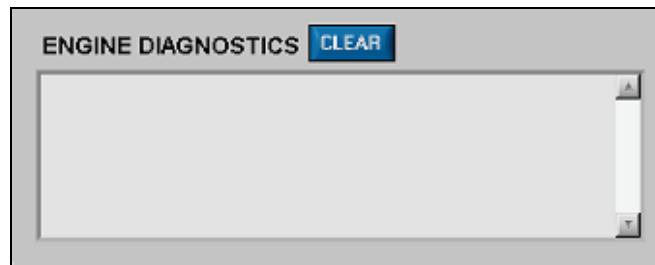


Figure 24, Engine Diagnostic Display

5.2 Throttle Controls & Tachometer

The **Throttle Controls & Tachometer** on the **Diagnostics & Control** window look and operate the same as those on the **Multi-Pump Control** window, with the exception that the throttle control has a slightly different shape.

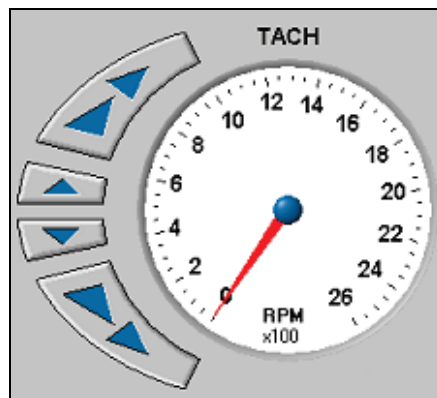


Figure 25, Throttle Controls & Tachometer



5.3 Change Filter & Lockup LEDs

A lockup indicator LED is displayed in the transmission section of the **Diagnostics & Control** window along with an additional LED labeled **CHANGE FILTER**. The red change filter LED illuminates when IPC receives a blocked filter signal from the transmission filter transducer.



Figure 26, Change Filter LED

5.4 Pressure Transducer Calibration

The pump discharge pressure can be calibrated (zeroed) from IPC-PC by clicking the **ZERO** discharge pressure button. This causes the current signal level from the discharge pressure transducer to represent zero within IPC. This is an IPC hardware calibration and will be retained in non-volatile memory.

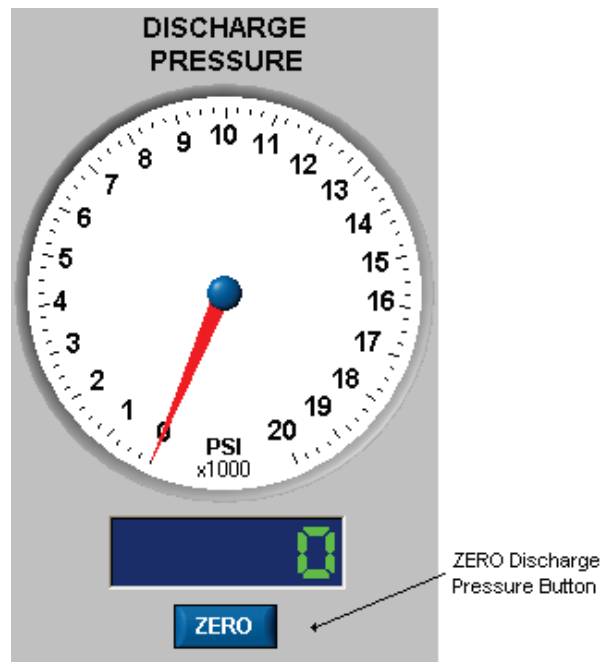


Figure 27, ZERO Discharge Pressure Button



5.5 Slurry Totalizer

IPC maintains a running total of the amount of slurry pumped. This value is displayed on IPC-PC and can be reset by clicking the totalizer **RESET** button.

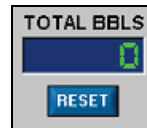


Figure 28, Slurry Totalizer with Reset Button

5.6 The Pump Selector

The **Pump Selector** shown in Figure 29 indicates which pump is currently displayed on the pump diagnostics window. The selector also allows the operator to choose which pump is displayed by clicking the up or down arrows. The currently selected pump is also indicated on the title bar of the **Diagnostics & Control** window.

The pump selector may be dragged with the mouse anywhere within the **Diagnostics & Control** window.

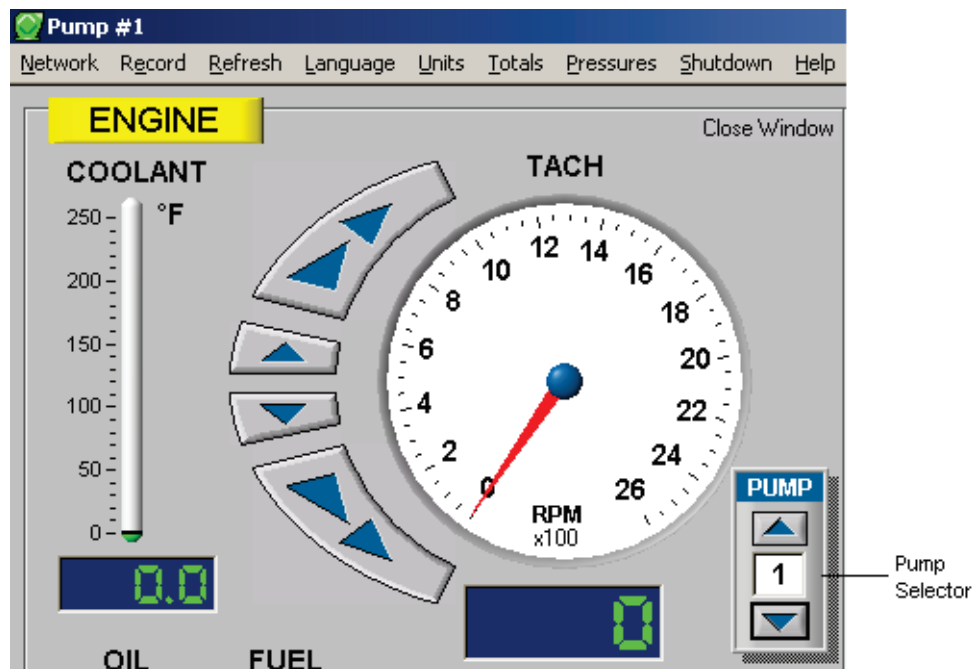


Figure 29, Pump Selector



5.7 Alarm Indicators

The normal operating ranges for all data points are independently configurable from within IPC. Each of the digital numeric fields indicates when its value is not within normal operating range by changing color from green to red. When any digital display is out of range (colored red), or if any engine diagnostic fault codes are displayed, the **Alarm** LED on the multi-pump control window will illuminate.

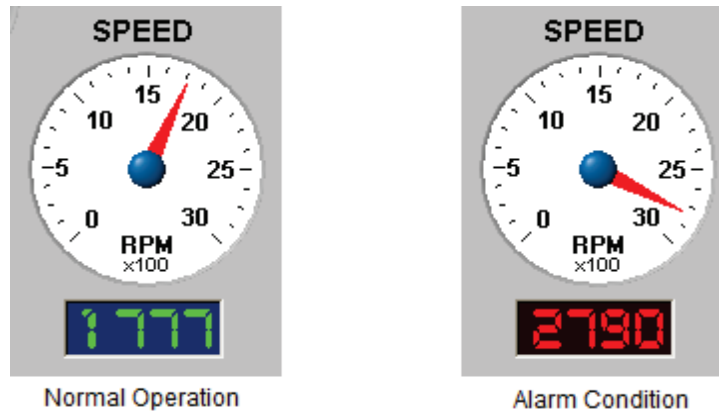


Figure 30, Alarm Indicators



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6. The Hardware Calibration Window

The **Hardware Calibration** window allows the operator to calibrate various aspects of the engine, transmission, and pump. This section will cover different aspects concerning calibration and the steps the operator required to properly modify these settings.

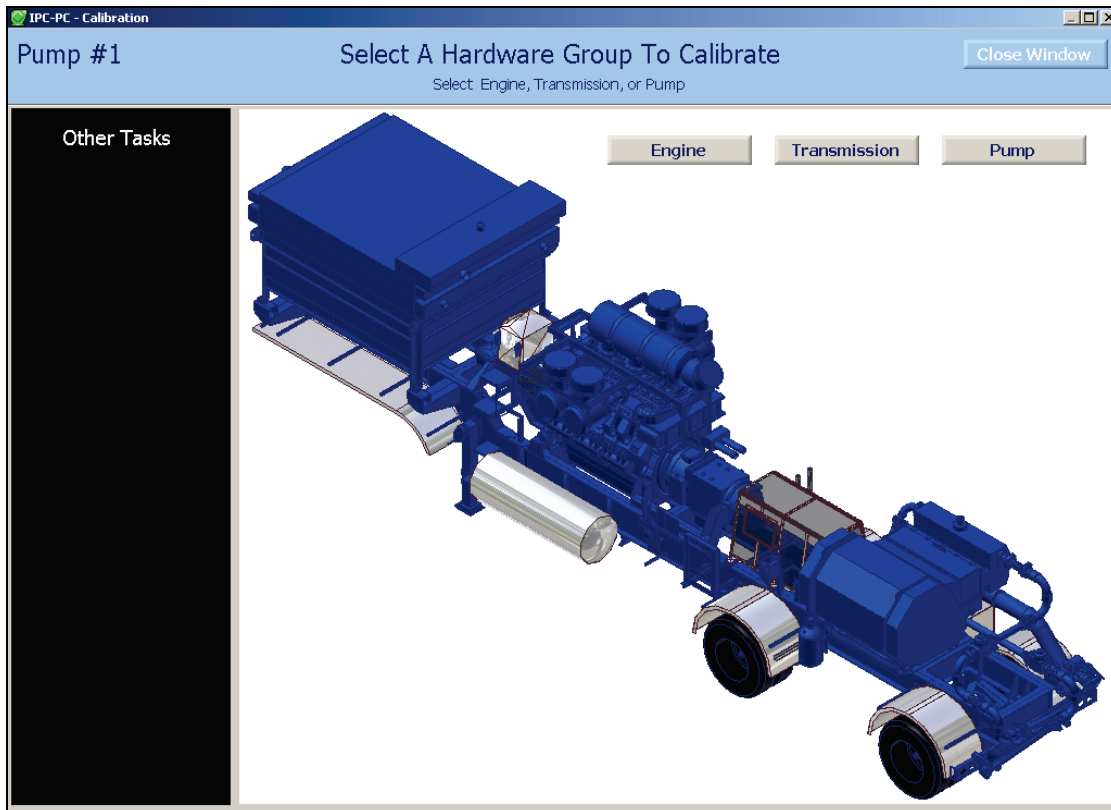


Figure 31, Hardware Calibration Window



6.1 Navigating to the Hardware Calibration Window

The first step in navigating to the **Hardware Calibration** window is clicking the Resistor Button (shown in Figure 22) corresponding to the desired pump located on the **Multi-Pump Control** window. The operator will then be prompted for a password (shown in Figure 32) which can be entered using a digital key pad by depressing the left mouse button over the password field.

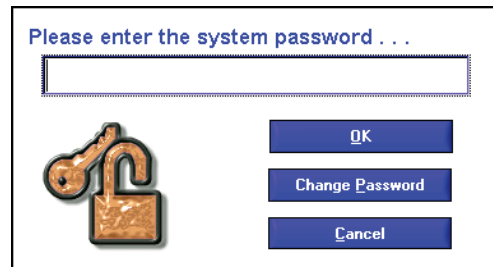


Figure 32, System Password Window



6.2 Throttle Setup

The operator can navigate to the Throttle Setup screen by clicking:

Resistor button → **Engine** tab → **Throttle**.

From here, the operator can modify the *throttle step size*, *scale*, and *RPM range*.

The *Throttle Step Size* changes the RPM increments when depressing the larger and smaller throttle step buttons. They are defaulted at 10 and 100 RPMs.

NOTE: The *offset* and *gain* are calibrated at the factory. Contact Stewart & Stevenson if these settings need to be changed.

After configuring the throttle steps, offset, and gain, it is necessary to calibrate the RPM range. The low limit RPM range is defaulted at 600 RPMs however, it is up to the operators discretion as to what these values should ultimately be set to. It should be noted, that the engine will not fall below its idling speed even with the low limit range set to zero. The same holds true for the high limit range.

NOTE: The operator must click “**set**” to store new values.

Throttle Step Size	Scale	RPM Range
Small 10	Offset 0.000	Low Limit 600
Large 100	Gain 0.000	High Limit 0

Figure 33, Throttle Setup



6.3 Alarm Calibration

When calibrating the alarms, the operator should follow the same procedure as detailed in section 5.2 for configuring the low limit and high limit RPM range. When an alarm is tripped the corresponding display on **Diagnostics & Control** window will turn red and the **Alarm** LED will illuminate.

SPEED RPM Low Limit 0.00 High Limit 0.00 SET	OIL PRESSURE PSI Low Limit 0.00 High Limit 0.00 SET	FUEL PRESSURE PSI Low Limit 0.00 High Limit 0.00 SET
OIL TEMPERATURE °F Low Limit 0.00 High Limit 0.00 SET	FUEL TEMPERATURE °F Low Limit 0.00 High Limit 0.00 SET	WATER TEMPERATURE °F Low Limit 0.00 High Limit 0.00 SET

Figure 34, Engine Alarm Calibration Window



6.4 Transmission Oil Pressure Calibration

Calibrating the **Transmission Oil Pressure** is a six step process:

1. Enter the desired **PSI** into the **Min-Scale Reading** field.
2. Press the Calibrate **Min-Scale Reading** button.
3. Enter the desired **PSI** in the **Max-Scale Reading** field.
4. Press the **Calibrate Max-Scale Reading** button.
5. Press the **Auto-Scale** button.
6. Press the **Set** button to save your changes.

How To Auto-Scale the Analog Input:

With a low signal or simulated input

1. Enter the desired current min-scale reading
2. Press the 'Calibrate Min Scale' button

With a high signal or simulated input

3. Enter the desired current max-scale reading
4. Press the 'Calibrate Max Scale' button
5. Press the 'Auto-Scale' button
6. Press the 'Set' button to save your changes

1. Min-Scale Reading

2. Min ADC Counts

3. Max-Scale Reading

4. Max ADC Counts

5.

Press 'Set' button to save your changes

Average Counts

Increase Average Counts for smoother response

Figure 35, Transmission Oil Pressure Calibration Window

NOTE: There are four other screens (**Transmission Oil Temperature**, **Pump Discharge Pressure**, **Pump Oil Temperature**, and **Pump Oil Pressure**) that have the same layout and procedure as the **Transmission Oil Pressure** screen. Therefore, only the **Transmission Oil Pressure** screen will be covered in detail.

6.5 Transmission Filter Switch Calibration

Average Counts is the only setting available for calibration on the **Transmission Filter Switch** Screen. **Average Counts** is defaulted to five which is the recommended setting for this particular application.



6.6 The Pump Setup Window

The **Pump Setup** window allows the operator to set the pump efficiency factor and the pump gear ratio. The pump gear ratio should be a value that reflects the manufacturer's specifications for the specified pump.

The pump efficiency factor is simply used to correct theoretical displacement and is measured in percentages. Therefore, a rating of "1.00" is equal to one hundred percent efficiency and a rating of "0.50" is equal to fifty percent efficiency. As a pump wears the efficiency tends to decrease and it is up to the operator to compensate for this.

A screenshot of the 'Pump Setup' window. It contains two input fields. The first field is labeled 'Pump Efficiency' and has the value '0.00' entered. Below this field, it says 'Expected Range: 0.80 to 1.00'. The second field is labeled 'Pump Gear Ratio' and has the value '1: 1.00' entered.

Pump Efficiency	Pump Gear Ratio
0.00	1: 1.00

Expected Range: 0.80 to 1.00

Figure 36, Pump Efficiency & Gear Ratio Fields



6.7 Pump Rate Setup Window

A *K-Factor* is used to convert a frequency into an engineering unit. If the operator knows the *K-Factor*, input it directly into the **K-Factor** field.

If the *K-Factor* is unknown the operator can complete the following steps:

1. Enter the desired current value.
2. Click the **Get Frequency** button.
3. Click the **Auto-Scale** button.
4. Press **Set** to store your changes.

Figure 37, Pump Rate Setup Window



6.8 Plunger Setup Window

The **Plunger Setup** window asks the operator for the *number of plungers*, the *plunger size* (diameter), and the *plunger stroke* (length). All of this data except for the *number of plungers* can be derived from the manufacturer's specifications and should be entered in the fields below in Figure 38.

The Plunger Setup Window is a rectangular dialog box with a light gray background. It contains three main sections. The first section, titled "Number of Plungers", features a blue downward-pointing triangle button on the left, a white text box in the center containing the number "3", and a blue upward-pointing triangle button on the right. The second section, titled "Plunger Diameter", has a white text box containing "0.00". The third section, titled "Plunger Stroke", has a white text box containing "0.00".

Number of Plungers	Plunger Diameter	Plunger Stroke
3	0.00	0.00

Figure 38, Plunger Setup Window



7. Taskbar Options

Several options are available from the taskbar to customize the IPC-PC system.

7.1 *Refresh Tab*

The speed at which the IPC-PC windows are updated can be adjusted to reduce CPU utilization when running IPC-PC on lower-performance computers. The default refresh period of one second is recommended for most cases.

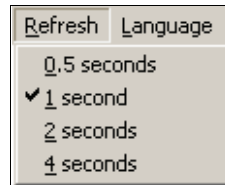


Figure 39, Refresh Tab



7.2 Language Tab

The display language used on the application windows can be selected from the *Language* menu item. Currently the English and Chinese languages are supported.



Figure 40, Language Tab

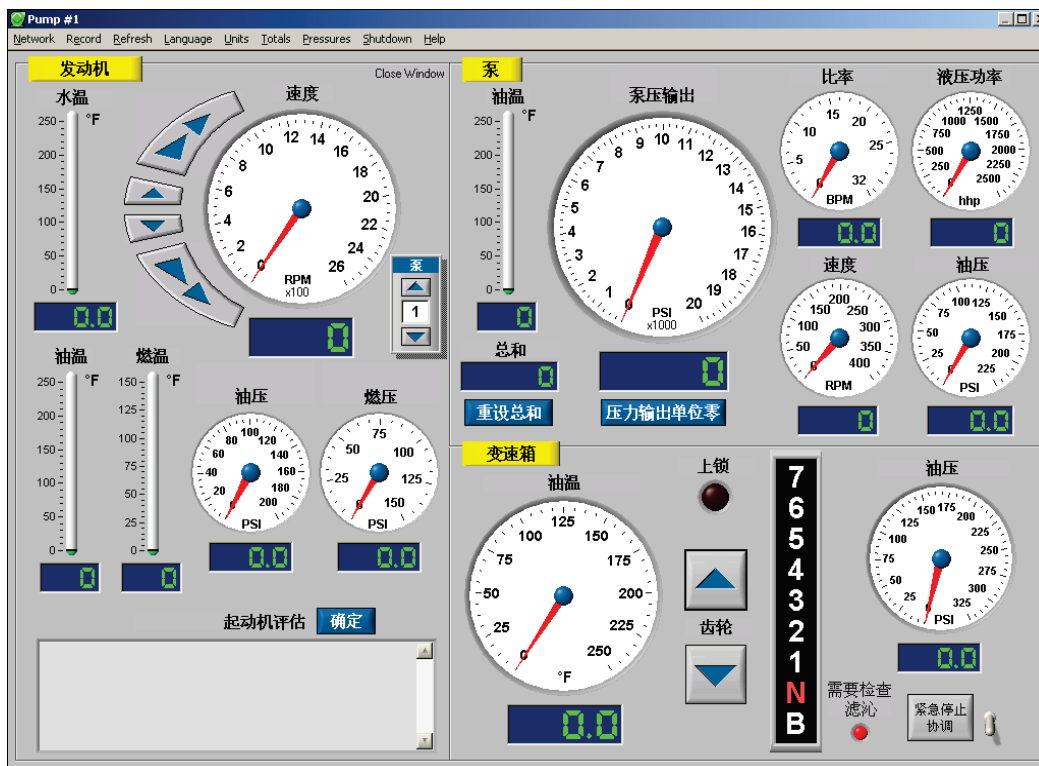


Figure 41, Chinese Display



7.3 Record Tab

The **Record** tab allows the operator to start, stop, and pause data being gathered and recorded by IPC-PC to a CVS file for later analysis. The pump *number*, *date*, and *time* are all recorded in millisecond time intervals.



Figure 42, Record Tab

7.4 Units Tab

The **Units** tab allows the operator to choose whether the Metric System or English System of units is displayed on all gauges.

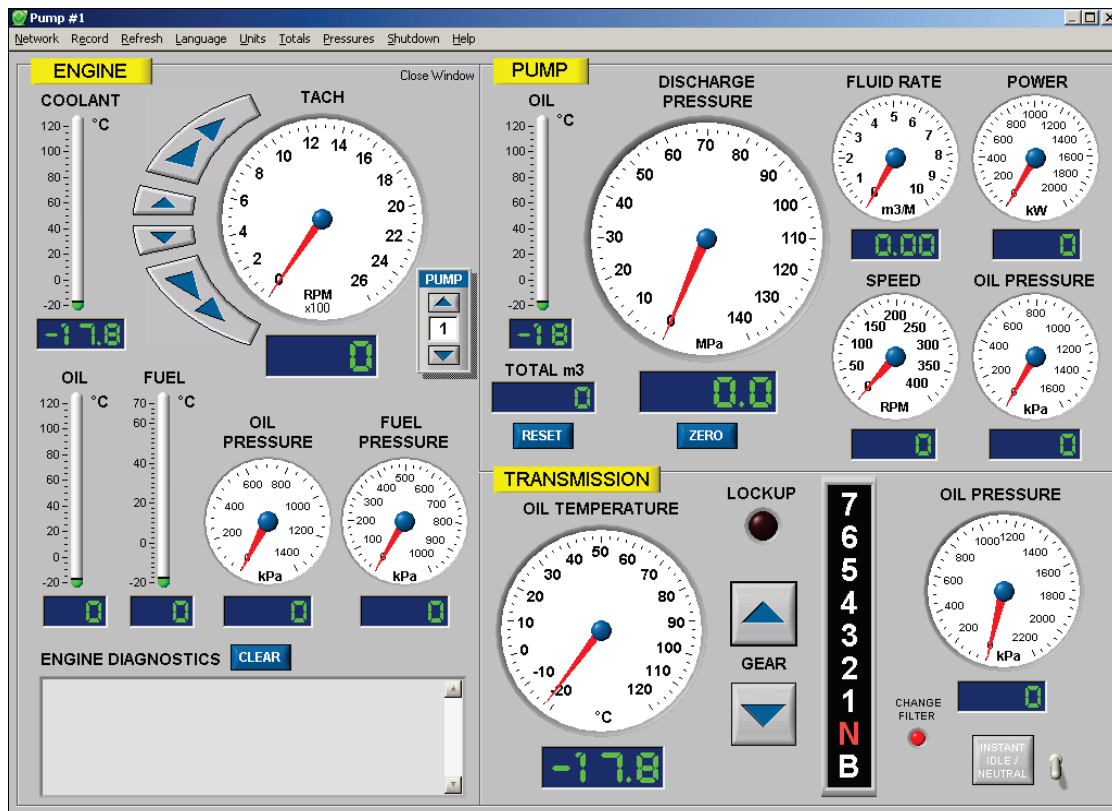


Figure 43, Metric Gauges



7.5 Totals Tab

By selecting **Reset Discharge Totals** under the **Totals** tab the operator has the ability to reset the discharge total on all active pumps to zero.

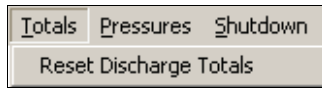


Figure 44, Totals Tab

7.6 Pressures Tab

The **Pressures** tab is similar to the **Totals** tab. It has one drop down sub menu called, **Zero Discharge Pressures**. It allows the operator to zero the discharge pressure on all active pumps.

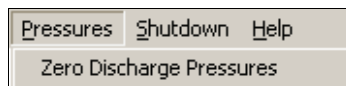


Figure 45, Pressures Tab

7.7 Shutdown Tab

The **Shutdown** tab allows the operator to set all active pumps to idle/neutral.

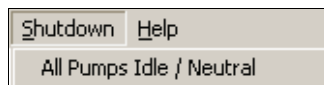


Figure 46, Shutdown Tab



Appendix A: Serial Data Output Values

The serial output data is formatted as comma-delimited ASCII text and consists of a timestamp in the form HH:MM:SS, followed by packets of real-time data for each online pump and ending with a carriage return/line feed. Table 1 is an example of the data output when two pumps are online.

Table 1, Serial Data Output

DESCRIPTION	POSITION	SERIAL OUTPUT DATA	DESCRIPTION	POSITION	SERIAL OUTPUT DATA
TIMESTAMP	1	HH:MM:SS			
PUMP #1 DATA PACKET	2	Engine RPM	PUMP #2 DATA PACKET	19	Engine RPM
	3	Engine Oil Pressure		20	Engine Oil Pressure
	4	Engine Fuel Pressure		21	Engine Fuel Pressure
	5	Engine Oil Temperature		22	Engine Oil Temperature
	6	Engine Fuel Temperature		23	Engine Fuel Temperature
	7	Engine Coolant Temperature		24	Engine Coolant Temperature
	8	Transmission Lockup		25	Transmission Lockup
	9	Transmission Gear		26	Transmission Gear
	10	Transmission Oil Pressure		27	Transmission Oil Pressure
	11	Transmission Oil Temperature		28	Transmission Oil Temperature
	12	Pump Discharge Pressure		29	Pump Discharge Pressure
	13	Pump Hydraulic Power		30	Pump Hydraulic Power
	14	Pump Oil Pressure		31	Pump Oil Pressure
	15	Pump Oil Temperature		32	Pump Oil Temperature
	16	Pump RPM		33	Pump RPM
	17	Pump Rate		34	Pump Rate
	18	Pump Slurry Total		35	Pump Slurry Total
	19	Engine RPM	Terminators	35	CR LF



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Appendix B: IPC-PC Measurement Units

IPC-PC can scale the process data to both the English and Metric measurement systems. This scaling is reflected in the values displayed on the screen as well as the values of the serial output data. Table 2 lists the units of measurement used for each data point.

Table 2, IPC-PC Engineering Units

DATA POINT	ENGLISH	METRIC
Engine Speed	RPM	RPM
Engine Oil Pressure	PSI	kPa
Engine Fuel Pressure	PSI	kPa
Engine Oil Temperature	°F	°C
Engine Fuel Temperature	°F	°C
Engine Coolant Temperature	°F	°C
Transmission Oil Pressure	PSI	kPa
Transmission Oil Temperature	°F	°C
Pump Discharge Pressure	PSI	MPa
Pump Overpressure Set Point	PSI	MPa
Pump Hydraulic Power	hp	kW
Pump Oil Pressure	PSI	kPa
Pump Oil Temperature	°F	°C
Pump Speed	RPM	RPM
Pump Rate	BBL / min	m ³ / min
Pump Slurry Total	BBL	m ³



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IPC™ Pump Controller

Stewart & Stevenson's Intelligent Pump Control System (IPC-PC) is capable of monitoring and controlling of up to 24 fracturing pumps at a single operator workstation, giving you precise, remote control over an entire frac spread. The IPC System allows users to control various functions of the equipment through a touch screen interface. Status lights are used to notify the operator of alarms when a problem exists with the engine, transmission, or the pump. Functions, such as start/shutdown of the engine, increasing/decreasing throttle and gear selection, can be controlled via the touchscreen pump control interface.

The IPC is a microprocessor-based system with a Touchscreen operator interface that can be stored in a weather tight suitcase or counter-mounted inside a Control Center. The display is a touch sensitive 8.5" X 6.25" graphical display. IPC simplifies operations by reducing the amount of electronic components required to control the various functions of fracturing equipment.

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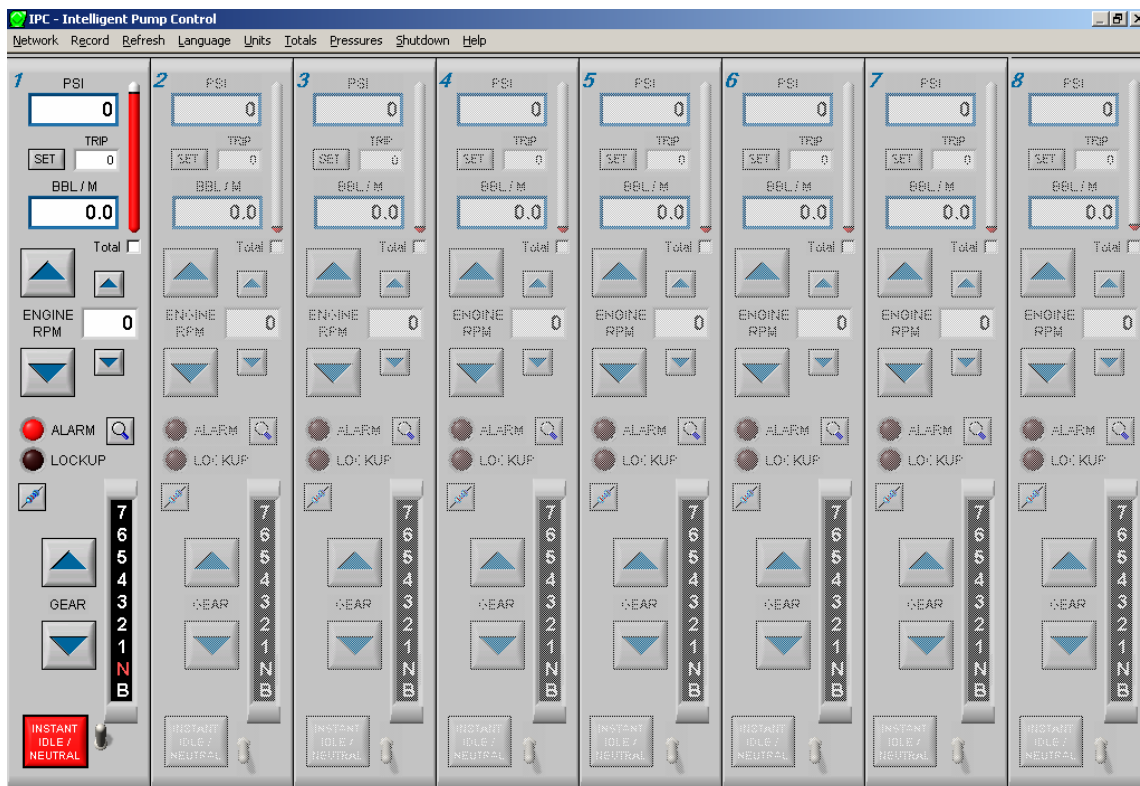
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Control

Operation Manual



OEM

Original Equipment Manufacturer



Stewart & Stevenson Control System Group
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About This Manual

This manual is not a textbook on mechanics, electronics, or hydraulics. Sufficient descriptive material and illustrations are included to enable the operator to understand the basic construction and theory of operation of this equipment. The intent of this manual is to guide the operators and maintenance personnel in the proper use of the equipment. This manual is not a substitute for properly trained personnel or common sense.

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All information in this manual is based on the latest production information available at the time of publication. Direct any questions concerning the contents or format of this manual to:

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Overview

Stewart & Stevenson's IPC-PC allows fracturing pump operators to monitor and control up to twenty-four frac pumps simultaneously from a single PC interface. Mission critical process data is displayed in an easy to read analog format with data continuously compared against configurable alarm set points. The operator is alerted if any engine, transmission, or pump data from any of the (up to) twenty-four frac pumps is out of range. Real-time data acquired from multiple pumps can be multiplexed into a single data stream for transmission to external data acquisition or analysis packages.

1

1.1 Who this Manual is For

This manual supplements the existing Intelligent Pump Control (IPC) user documentation and is intended for IPC operators who desire to add PC navigability and functionality with IPC-PC.

1.2 Who Can Use IPC-PC

IPC-PC may be used with any IPC hardware that has firmware version 2.0 or later. IPC firmware upgrades are available at no cost at:

<http://www.ssss.com/petroleum/download.asp>

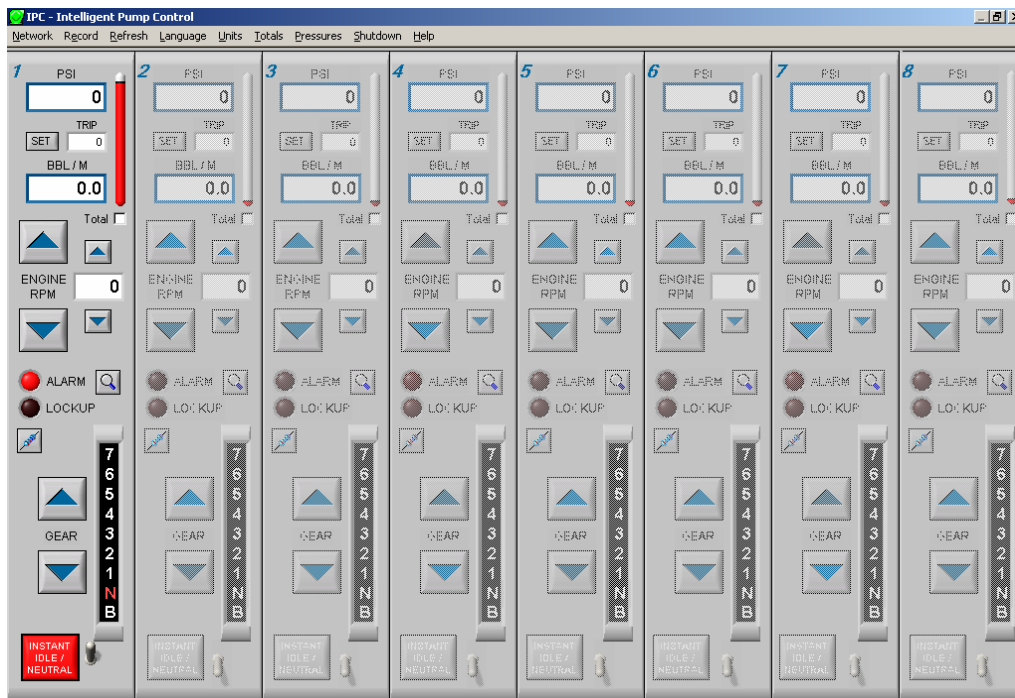


Figure 1-1: IPC-PC Control Window

Initial Setup

2

This chapter covers the details of understanding, establishing, and operating the communications network in IPC-PC. Furthermore, many key components, diagrams, and terms will be sufficiently explained in detail in order to facilitate the user in operating an IPC-PC workstation.

2.1 How IPC-PC Interacts with the IPC Controller Network

A typical Intelligent Pump Control installation is shown below in **Figure 2-1**. Multiple Frac Pumps are connected to one IPC-PC workstation.

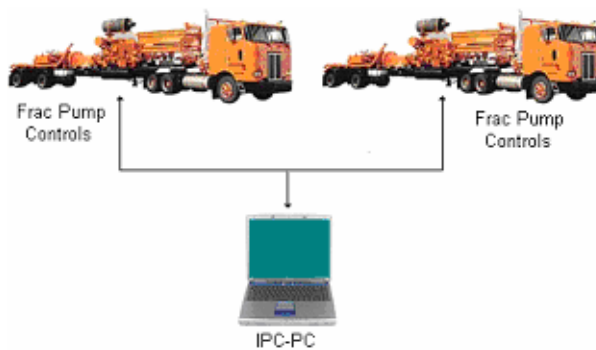


Figure 2-1: Typical IPC Controller Network

2.2 The COM Port Setup Window

The COM Port Setup Window is used to select the COM ports on the host computer through which IPC-PC will communicate with IPC. To display the the window select **Network > COM Port Setup** from the IPC menu as shown in **Figure 2-2**.

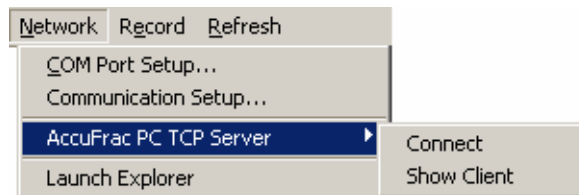


Figure 2-2: Network Tab

The COM Port Setup Window contains settings for up to twenty-four input serial ports and one additional port for serial output. Each of the twenty-four input ports can be connected to one IPC frac pump.

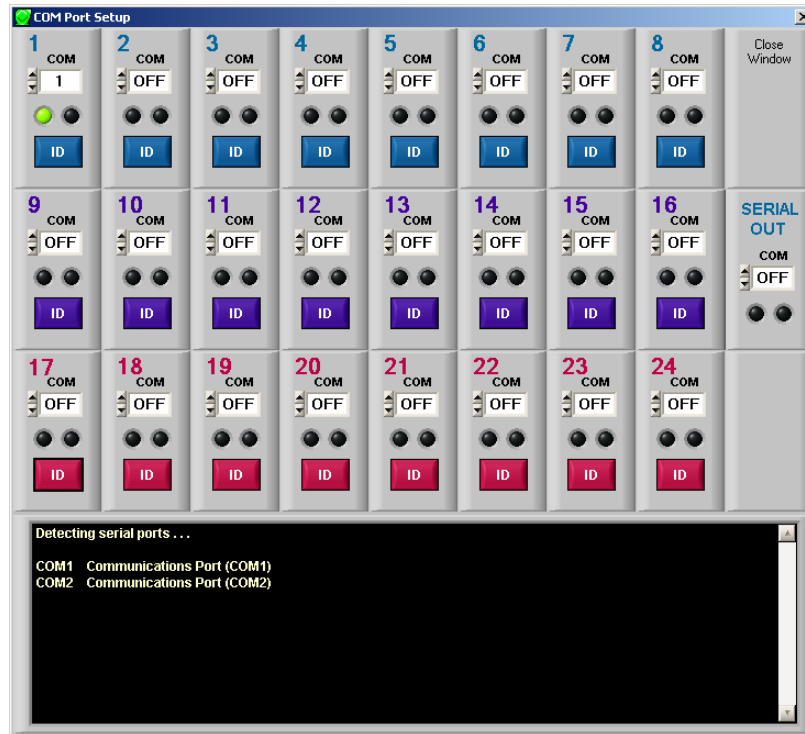


Figure 2-3: COM Port Setup Window

2.3 The Serial Port Enumerator

The Serial Port Enumerator shown in **Figure 2-4** is part of the *COM Port Setup Window*. The enumerator lists all COM ports installed on the host computer. The Serial Port Enumerator is a simple diagnostic tool that may be useful when configuring the host computer.

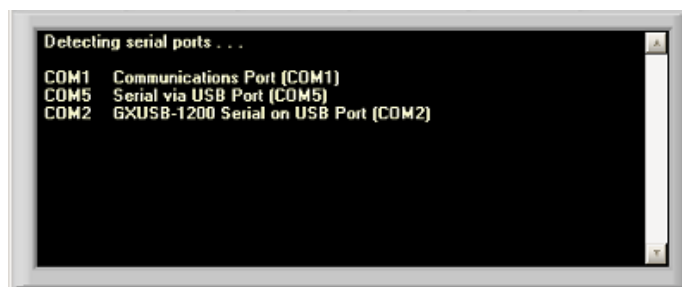


Figure 2-4: Serial Port Enumerator

2.4 Selecting a COM Port

A COM port must be selected for each frac pump to be controlled by IPC-PC. COM ports 1- 48 may be chosen. After a port is selected IPC-PC immediately attempts to open the port. If the selected port is unavailable or in use by another application, the port will not open and a message will prompt the operator that the selection is invalid.

COM port setup needs to be done only once, since the settings are stored and will be recalled whenever the IPC-PC application runs.



Figure 2-5: COM Port Selector

2.5 COM Status LEDs

If the selected port is opened successfully, the green “Port Available” LED will illuminate. As data is received from the IPC network the red “Receiving Data” LED will illuminate. It is normal for the “Receiving Data” LED to flash on and off as data is received.

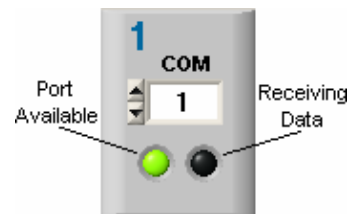


Figure 2-6: COM Status LEDs

2.6 Serial Data Output

Selecting a COM port on the serial output selector enables serial output. In this case the rightmost LED indicates “Transmitting Data” instead of “Receiving Data.”



Figure 2-7:
Serial Output Control

The serial output port is configured at 57,600 bits per second, eight data bits, no parity bit, one stop bit, with flow control off.

The serial output data is formatted as comma-delimited ASCII text and consists of a timestamp in the form HH:MM:SS followed by packets of real-time data values for each online pump. Specific details of the data values included in the serial output can be found in Appendix B, *Serial Data Output Values*.

2.7 Communication Setup Window

The Communication Setup Window allows the operator to fundamentally change how data is transferred across the IPC-PC network. The operator can access this window by selecting the **Network** tab then, **Communication Setup**.

The *Hardware Layer* radio select buttons allows the operator to connect to the Main Control Board (MCB) through the **Gateway** using a RS232 connection, or by **Direct Control** using a RS485 connection.

To the right of the Hardware Layer radio select buttons is the **Enable E-Stop** selector, which allows an operator to immediately set the engine to instant idle / neutral by depressing the large mushroom button located inside the data van. No action will occur if the **E-Stop** selector is not enabled.

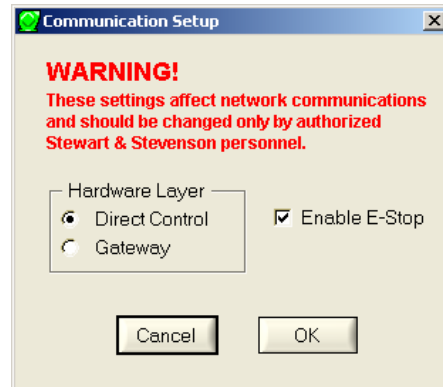


Figure 2-8:
Communication Setup Window

Note: The E-Stop button sets the engine to instant idle/neutral. It is *NOT* an emergency stop button.

2.8 AccuFrac PC TCP Server

The AccuFrac PC TCP Server tab allows the operator to connect to AccuFrac PC in order to receive and display *Inline Pressure*. In order to connect to the server, the operator must select **Change Server Name** on the AccuFrac PC TCP Client window, and input the server address into the field shown in **Figure 2-9**.

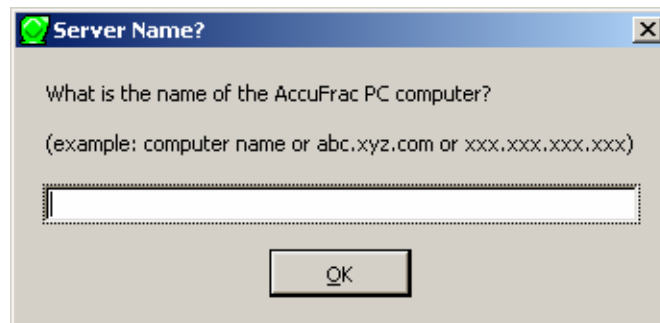


Figure 2-9: Server Name Window

2.9 Selecting the Engine & Transmission

Configuring the Engine & Transmission is done at the factory. However, if new firmware is loaded on the MCB these settings will have to be configured again.

Note: Improper settings can damage the *Engine* and *Transmission* being used. Contact Stewart & Stevenson if you are unsure of these settings.

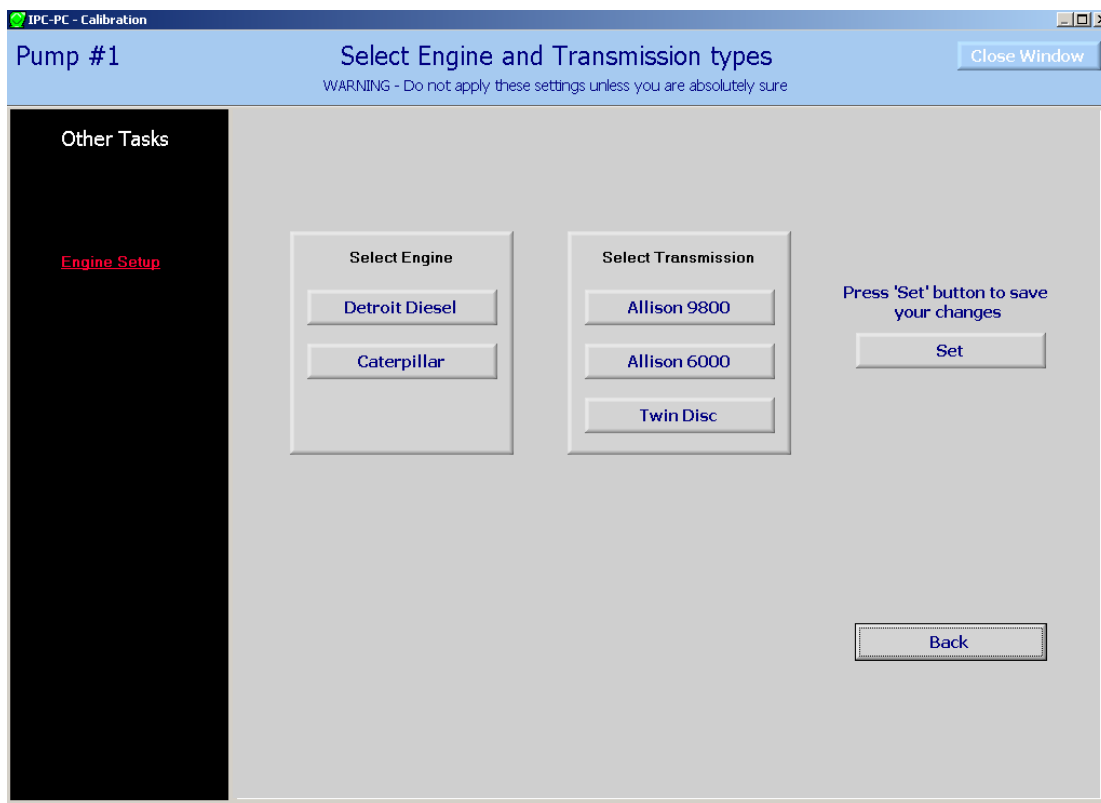


Figure 2-10: Engine & Transmission Selection Screen

The Multi-Pump Control Window

3

The Multi-Pump Control Window allows the operator to control up to twenty-four pumps simultaneously. Individual controls for each pump's engine throttle and transmission gear are provided.

Displayed data includes pump discharge pressure, discharge rate, engine rpm, and transmission lockup. All data including those not displayed on the Multi-Pump Control Window are monitored for alarm conditions. Any data point outside of its normal operating range generates an alarm event and illuminates the alarm indicator.

Any unused pump panel (not connected to an IPC pump) will appear dimmed. **Figure 3-1** shows one active pump connection, while panels two through eight are dimmed.

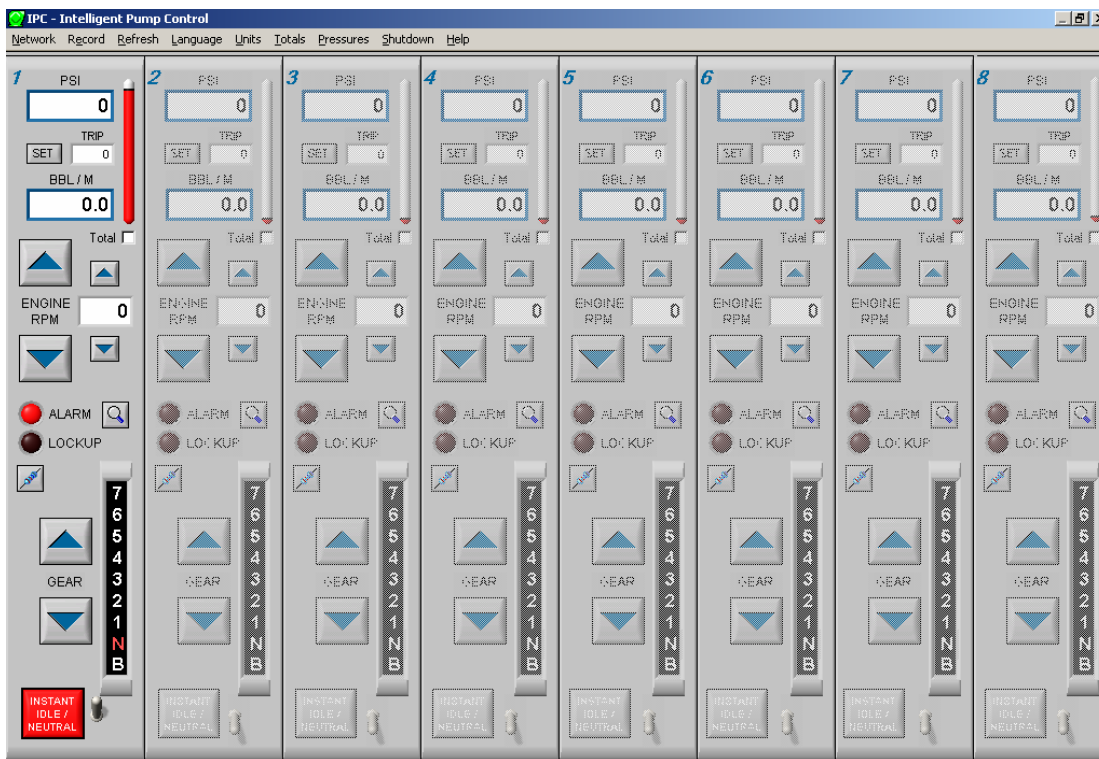


Figure 3-1: Multi-Pump Control Window

3.1 Engine Throttle Control

The Engine Throttle Control is a four-way switch with small and large increment and decrement buttons. Each press of a button causes the corresponding engine's RPMs to increment or decrement by either the small or large throttle steps as configured in IPC. The engine's RPM set point will never exceed the high RPM limit configured in IPC.

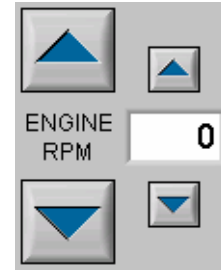


Figure 3-2: Engine Throttle Control

3.2 Transmission Gear Selector



Figure 3-3: Transmission Gear Selector

The Transmission Gear Selector is a two-way switch that increments or decrements the selected gear. Each touchscreen button causes the transmission to shift up or down by one gear. The gear that the transmission is *currently in* will be displayed in red, while all other gears appear white. After pressing a gearshift button, a slight delay while the transmission shifts before the indicated gear changes is normal.

3.3 Transmission Lockup LED

The green Transmission Lockup LED will illuminate in green whenever the transmission is in lockup mode. Operating the transmission under load for extended periods of time out of lockup (i.e., in torque converter mode) may cause excessive heat build up or damage. Lockup is typically achieved at speeds above 1500 RPM.



Figure 3-4: Transmission Lockup LED

3.4 Overpressure Trip Set Point

IPC commands the engine to idle and the transmission to go to neutral whenever the discharge pressure exceeds the Overpressure Trip Set Point. The Overpressure Trip Set Point for each pump is displayed near the top of each pump panel. To enter a new set point, click the SET button and a number pad for a new set point will appear shown in **Figure 3-5**.



Figure 3-5: Number Pad

The overpressure bar graph is displayed to the right of the set point. This graph indicates the current discharge pressure of the pump as a percentage of the trip pressure. If the graph moves all the way to the top, the pump will trip.

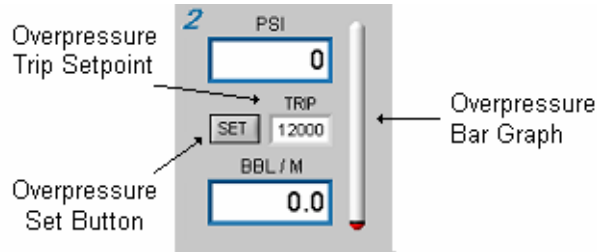


Figure 3-6: Overpressure Trip Controls

3.5 Instant Idle / Neutral Button

An Instant Idle / Neutral button is located at the bottom of each pump panel. Pressing the Instant Idle / Neutral Button causes the corresponding pump's throttle to go to idle and the transmission to go to neutral without affecting any of the other pumps. The Instant Idle / Neutral Button must first be enabled by moving the nearby toggle switches to the "Up" position. When enabled, the Instant Idle / Neutral Button changes from gray to red.

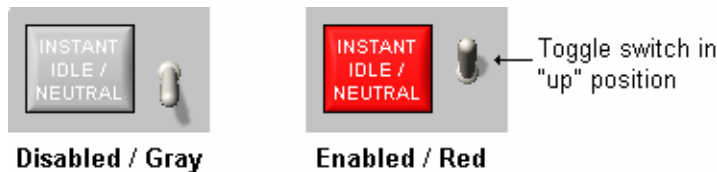


Figure 3-7: Instant Idle / Neutral Button

3.6 Alarm LED

An Alarm LED is associated with each pump. The red alarm LED will illuminate if any of the operating parameters are outside of their normal operating ranges as configured in IPC. The Alarm LED will also illuminate if a diagnostic fault code is received from the engine's electronic control module (ECM). If an alarm becomes active, as indicated by the Alarm LED, the source of the alarm may be located by navigating to the Diagnostics & Control Window with the Pump Zoom Button. The Pump Zoom Button is described in section 14, *Pump Zoom Button*.



Figure 3-8: Alarm LED

3.7 Pump Zoom Button

Each pump panel contains a Pump Zoom Button. Clicking the Pump Zoom Button will display the *Diagnostics & Control Window* as described in the next section.



Figure 3-9: Pump Zoom Button

3.8 Total Radio Button



Figure 3-10: Total Radio Button

The Total Radio Button allows the operator to total the rate, HHP, and volume for all pumps the operator chooses to select. The totals for each pump can be viewed at the bottom of the *Multi-Pump Control Window*.

3.9 Resistor Button

The Resistor Button found on each pump panel of the *Multi-Pump Control Window* takes the operator to the **Hardware Calibration Window** for the corresponding pump selected. The Hardware Calibration Window which will be discussed in Chapter 5 allows the operator to calibrate various aspects of the engine, transmission, and pump.



Figure 3-11: Resistor Button

The Diagnostics & Control Window

The Diagnostics & Control Window is an in-depth display of the frac pump's operation shown below in **Figure 4-1**. It is organized into three main sections: engine, transmission, and pump. Each section contains a wealth of diagnostic data that the operator can use to monitor the engine, pump, and transmission.

4

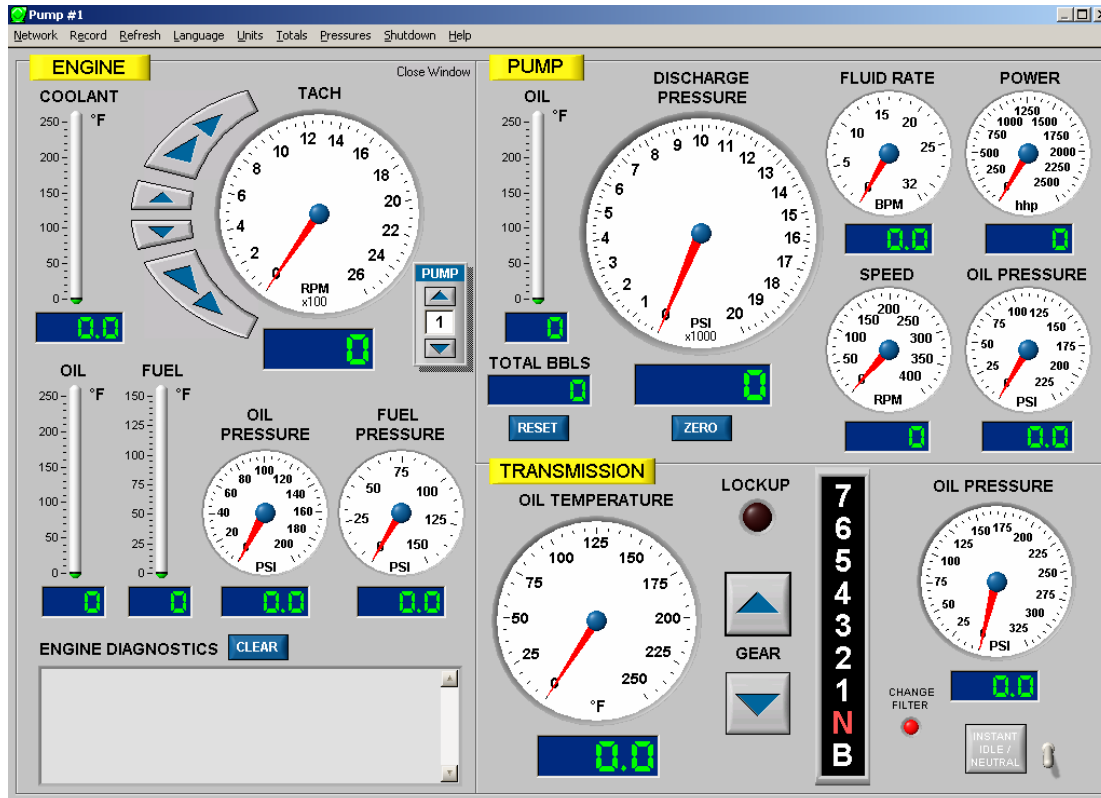


Figure 4-1: Diagnostics & Control Window

4.1 Engine Diagnostics Display

The Engine Diagnostics Display translates diagnostic fault codes generated by the engine's ECM. Messages are retained in the scrollable list box until the CLEAR button is pressed or the IPC-PC application is shut down.

Broadcast fault codes conforming to either the J1587 or J1939 standard can be displayed on IPC-PC. Currently, IPC and IPC-PC can display fault codes generated by Detroit Diesel ECMs only.

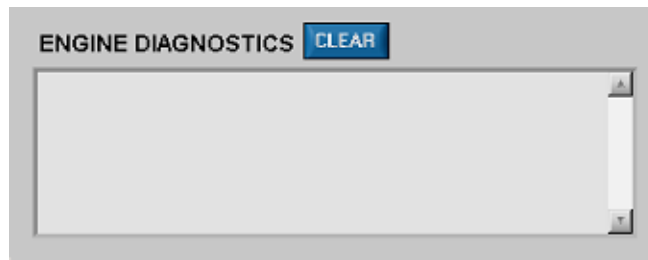


Figure 4-2: Engine Diagnostic Display

4.2 Throttle Controls & Tachometer

The Throttle Controls & Tachometer on the Diagnostics & Control Window look and operate the same as those on the Multi-Pump Control Window, with the exception that the throttle control has a slightly different shape.

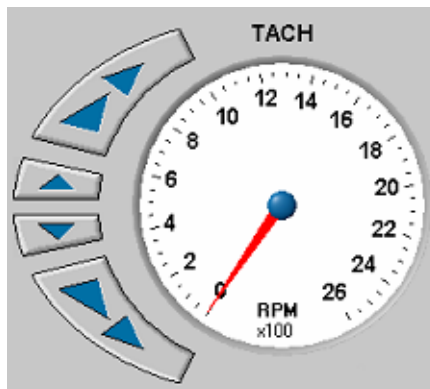


Figure 4-3: Throttle Controls & Tachometer

4.3 Change Filter & Lockup LEDs

A lockup indicator LED is displayed in the transmission section of the Diagnostics & Control Window along with an additional LED labeled “CHANGE FILTER.” The red change filter LED illuminates whenever IPC receives a blocked filter signal from the transmission filter transducer.



Figure 4-4: Change Filter LED

4.4 Pressure Transducer Calibration

The pump discharge pressure can be calibrated (zeroed) from IPC-PC by clicking the ZERO discharge pressure button. This causes the current signal level from the discharge pressure transducer to represent zero within IPC. This is an IPC hardware calibration and will be retained in non-volatile memory.

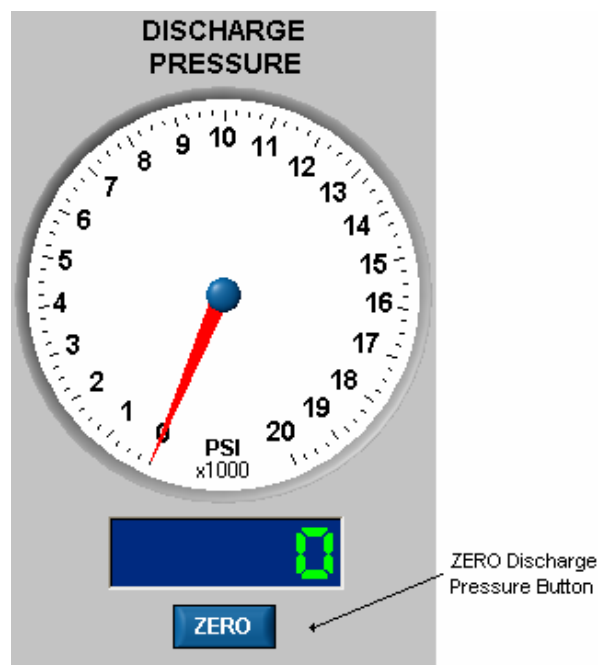


Figure 4-5: ZERO Discharge Pressure Button

4.5 Slurry Totalizer

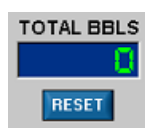


Figure 4-6: Slurry Totalizer with Reset Button

IPC maintains a running total of the amount of slurry pumped. This value is displayed on IPC-PC and can be reset by clicking the totalizer RESET button.

4.6 The Pump Selector

The Pump Selector shown in **Figure 4-7** indicates which pump is currently displayed on the pump diagnostics window. The selector also allows the operator to choose which pump is displayed by clicking the up or down arrows. The currently selected pump is also indicated on the title bar of the Diagnostics & Control Window.

The pump selector may be dragged with the mouse anywhere within the Diagnostics & Control Window.

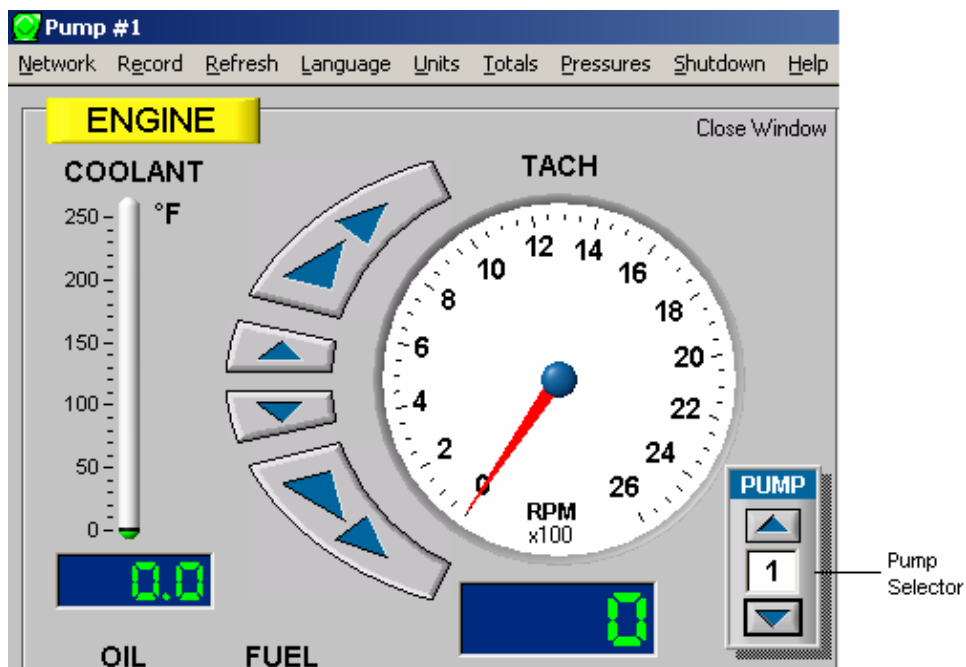


Figure 4-7: Pump Selector

4.7 Alarm Indicators

The normal operating ranges for all data points are independently configurable from within IPC. Each of the digital numeric fields indicates when its value is not within normal operating range by changing color from green to red. Whenever any digital display is out of range (colored red), or if any engine diagnostic fault codes are displayed, the alarm LED on the multi-pump control window will illuminate.

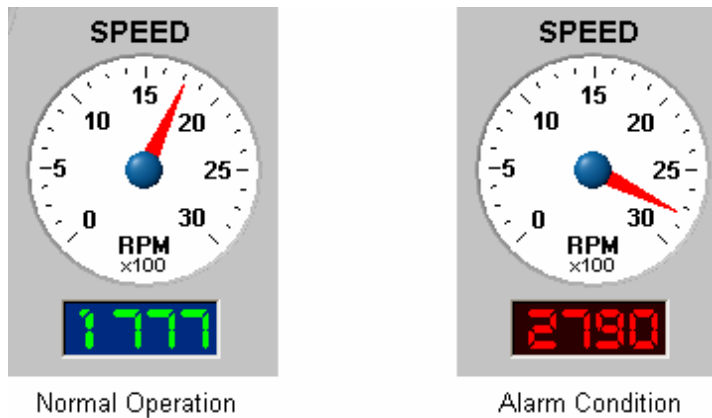


Figure 4-8: Alarm Indicators

The Hardware Calibration Window

The Hardware Calibration Window allows the operator to calibrate various aspects of the engine, transmission, and pump. Chapter 5 will cover different aspects concerning calibration and the steps the operator must do to properly modify these settings.

5

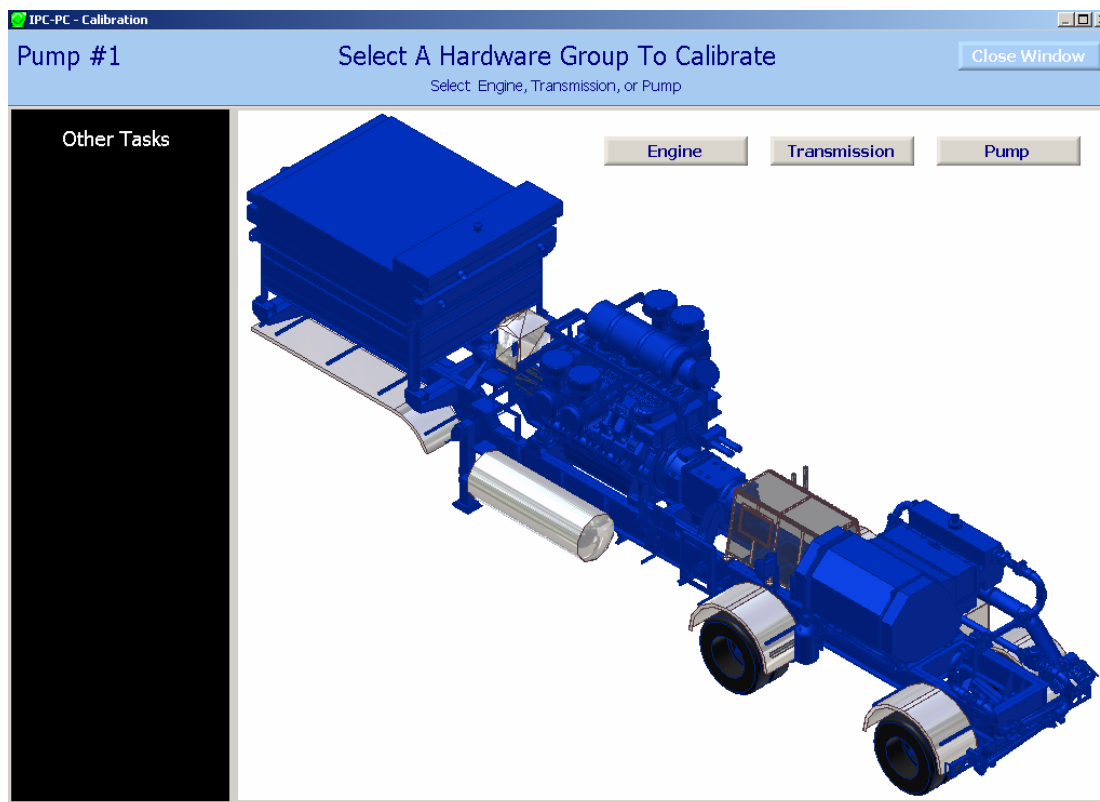


Figure 5-1: Hardware Calibration Window

5.1 Navigating to the Hardware Calibration Window

The first step in navigating to the *Hardware Calibration Window* is clicking the Resistor Button (shown in **Figure 3-11**)

corresponding to the desired pump located on the *Multi-Pump Control Window*. The operator will then be prompted for a password (shown in **Figure 5-2**) which can be entered using a digital key pad by depressing the left mouse button over the password field.

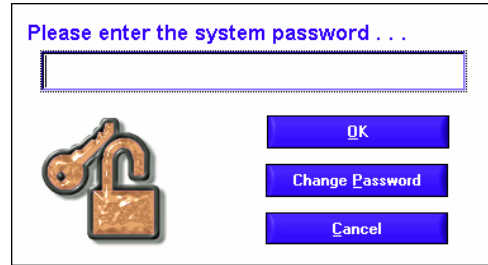


Figure 5-2: System Password Window

5.2 Throttle Setup

The operator can navigate to the Throttle Setup screen by clicking the Resistor Button > Engine Tab > Throttle. From here, the operator can modify the *throttle step size*, *scale*, and *RPM range*.

The *Throttle Step Size* changes the RPM increments when depressing the larger and smaller throttle step buttons shown in **Figure 3-2** and **4-3**. They are defaulted at 10 and 100 RPMs.

Note: The *offset* and *gain* are calibrated at the factory. Contact Stewart & Stevenson if these settings need to be changed.

After configuring the throttle steps, offset, and gain, it is necessary to calibrate the RPM range. The low limit RPM range is defaulted at 600 RPMs however, it is up to the operators discretion as to what these values should ultimately be set to. It should be noted, that the engine will not fall below its idling speed even with the low limit range set to zero. The same holds true for the high limit range.

⚠ The operator must click “set” in order to store new values.

Throttle Step Size	Scale	RPM Range
Small 10	Offset 0.000	Low Limit 600
Large 100	Gain 0.000	High Limit 0

Figure 5-3: Throttle Setup

5.3 Alarm Calibration

When calibrating the alarms, the operator should follow the same procedure as detailed in section 5.2 for configuring the low limit and high limit RPM range. When an alarm is tripped the corresponding display on *Diagnostics & Control Window* will turn red and the Alarm LED as shown in **Figure 3-8** will illuminate.

Figure 5-4: Engine Alarm Calibration Window

5.4 Transmission Oil Pressure Calibration

Calibrating the *Transmission Oil Pressure* is a six step process:

1. Enter the desired PSI into the Min-Scale Reading field.
2. Press the “Calibrate Min-Scale Reading” button.
3. Enter the desired PSI in the Max-Scale Reading field.
4. Press the “Calibrate Max-Scale Reading” button.
5. Press the “Auto-Scale” button.
6. Press the “Set” button to save your changes.

Figure 5-5: Transmission Oil Pressure Calibration Window

Note: There are four other screens (Transmission Oil Temperature, Pump Discharge Pressure, Pump Oil Temperature, and Pump Oil Pressure) that have the same layout and procedure as the Transmission Oil Pressure screen. Therefore, only the **Transmission Oil Pressure** screen will be covered in detail.

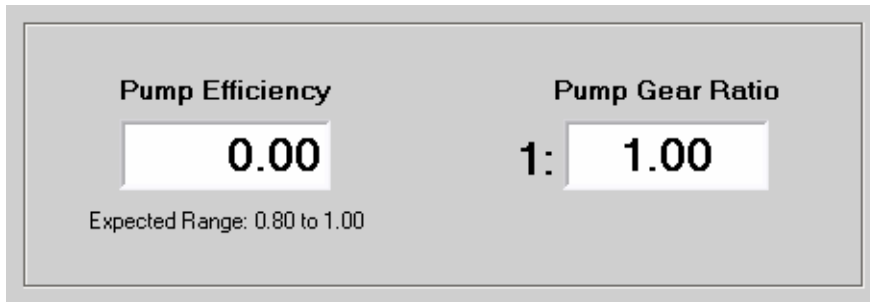
5.5 Transmission Filter Switch Calibration

Average Counts is the only setting available for calibration on the Transmission Filter Switch Screen. Average counts is defaulted to five which is the recommended setting for this particular application.

5.6 The Pump Setup Window

The Pump Setup Window allows the operator to set the pump efficiency factor and the pump gear ratio. The pump gear ratio should be a value that reflects the manufacturer's specifications for the specified pump.

The pump efficiency factor is simply used to correct theoretical displacement and is measured in percentages. Therefore, a rating of "1.00" is equal to one hundred percent efficiency and a rating of "0.50" is equal to fifty percent efficiency. As a pump wears the efficiency tends to decrease and it is up to the operator to compensate for this.



The screenshot shows a gray rectangular window with a thin black border. Inside, there are two main sections. The left section is titled "Pump Efficiency" in bold black text. Below the title is a white rectangular input field containing the value "0.00". Underneath this field, the text "Expected Range: 0.80 to 1.00" is displayed in a smaller font. The right section is titled "Pump Gear Ratio" in bold black text. Below the title is a white rectangular input field containing the value "1.00". To the left of this field is a bold black "1:" indicating a ratio.

Figure 5-6: Pump Efficiency & Gear Ratio Fields

5.7 The Pump Rate Setup Window

A K-Factor is used to convert a frequency into an engineering unit. If the operator knows the K-Factor, input it directly into the K-Factor field.

If the K-Factor is unknown the operator can complete the following steps:

1. Enter the desired current value.
2. Click the “Get Frequency” button.
3. Click the “Auto-Scale” button.
4. Press “Set” to store your changes.

Figure 5-7: The Pump Rate Setup Window

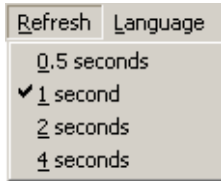
5.8 The Plunger Setup Window

The Plunger Setup Window asks the operator for the *number of plungers*, the *plunger size* (diameter), and the *plunger stroke* (length). All of this data except for the *number of plungers* can be derived from the manufacturer’s specifications and should be entered in the fields below in **Figure 5-8**.

Figure 5-8: The Plunger Setup Window

Taskbar Options

6.1 Refresh Tab



The speed at which the IPC-PC windows are updated can be adjusted in order to reduce CPU utilization when running IPC-PC on lower-performance computers. The default refresh period of one second is recommended for most cases.

Figure 6-1: Refresh Tab

6.2 Language Tab

The display language used on the application windows can be selected from the “Language” menu item. Currently the English and Chinese languages are supported.

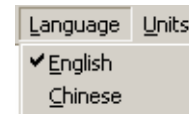


Figure 6-2:
Language Tab

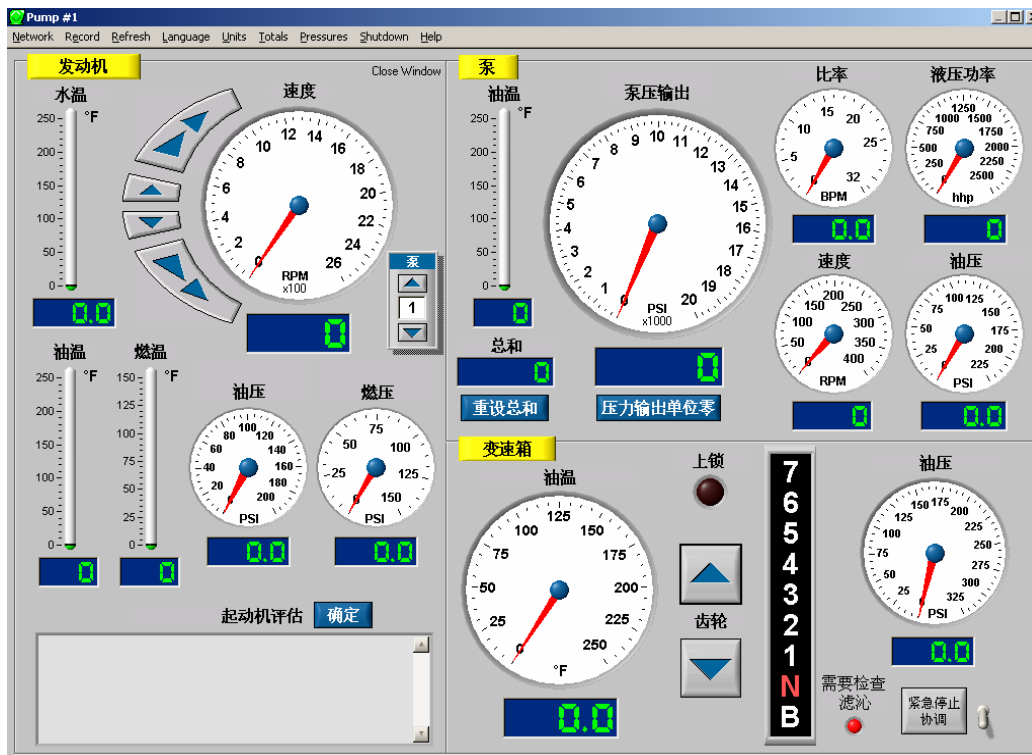


Figure 6-3: Chinese Display

6.3 Record Tab

The Record Tab allows the operator to start, stop, and pause data being gathered and recorded by IPC-PC to a CVS file for later analysis. The pump number, date, and time are all recorded in millisecond time intervals.

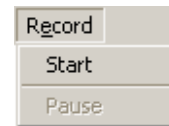


Figure 6-4:
Record Tab

6.4 Units Tab

The Units Tab allows the operator to choose whether the Metric System or English System of units is displayed on all gauges.

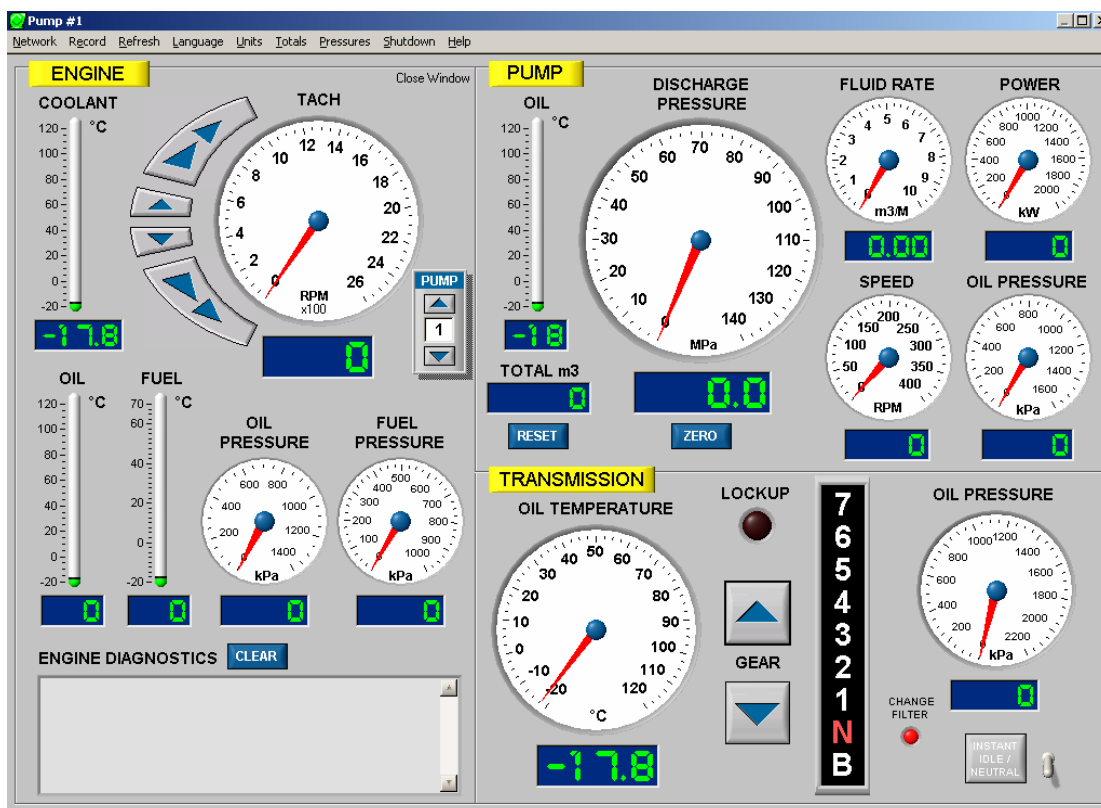


Figure 6-5: Metric Gauges

6.5 Totals Tab

By selecting *Reset Discharge Totals* under the **Totals Tab** the operator has the ability to reset the discharge total on all active pumps to zero.

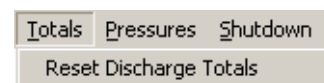


Figure 6-6: Totals Tab

6.6 Pressures Tab

The Pressures Tab is similar to the Totals Tab. It has one drop down sub menu called, “Zero Discharge Pressures.” It allows the operator to zero the discharge pressure on all active pumps.

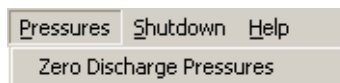


Figure 6-7: Pressures Tab

6.7 Shutdown Tab

The Shutdown Tab allows the operator to set all active pumps to idle / neutral.

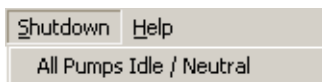


Figure 6-8: Shutdown Tab

Serial Data Output Values

The serial output data is formatted as comma-delimited ASCII text and consists of a timestamp in the form HH:MM:SS, followed by packets of real-time data for each online pump and ending with a carriage return / line feed. **Table B-1** is an example of the data output when two pumps are online.

Description	Position	Serial Output Data
Timestamp	1	HH:MM:SS
Pump #1 Data Packet	2	Engine RPM
	3	Engine Oil Pressure
	4	Engine Fuel Pressure
	5	Engine Oil Temperature
	6	Engine Fuel Temperature
	7	Engine Coolant Temperature
	8	Transmission Lockup
	9	Transmission Gear
	10	Transmission Oil Pressure
	11	Transmission Oil Temperature
	12	Pump Discharge Pressure
	13	Pump Hydraulic Power
	14	Pump Oil Pressure
	15	Pump Oil Temperature
	16	Pump RPM
	17	Pump Rate
	18	Pump Slurry Total
Pump #2 Data Packet	19	Engine RPM
	20	Engine Oil Pressure
	21	Engine Fuel Pressure
	22	Engine Oil Temperature
	23	Engine Fuel Temperature
	24	Engine Coolant Temperature
	25	Transmission Lockup
	26	Transmission Gear
	27	Transmission Oil Pressure
	28	Transmission Oil Temperature
	29	Pump Discharge Pressure
	30	Pump Hydraulic Power
	31	Pump Oil Pressure
	32	Pump Oil Temperature
	33	Pump RPM
	34	Pump Rate
	35	Pump Slurry Total
Terminators	35	CR LF

Table B-1: Serial Data Output

IPC-PC Measurement Units

IPC-PC can scale the process data to both the English and Metric measurement systems. This scaling is reflected in the values displayed on the screen as well as the values of the serial output data. **Table C-1** lists the units of measurement used for each data point.

Data Point	English	Metric
Engine Speed	RPM	RPM
Engine Oil Pressure	PSI	kPa
Engine Fuel Pressure	PSI	kPa
Engine Oil Temperature	°F	°C
Engine Fuel Temperature	°F	°C
Engine Coolant Temperature	°F	°C
Transmission Oil Pressure	PSI	kPa
Transmission Oil Temperature	°F	°C
Pump Discharge Pressure	PSI	MPa
Pump Overpressure Set Point	PSI	MPa
Pump Hydraulic Power	hp	kW
Pump Oil Pressure	PSI	kPa
Pump Oil Temperature	°F	°C
Pump Speed	RPM	RPM
Pump Rate	BBL / min	m ³ / min
Pump Slurry Total	BBL	m ³

Table C-1: Engineering Units

Intelligent Pump Control Release Notes

Network Controller (ICB)

Version 2.84 – Released 8/17/2007

- Adds support for Allison 6600 series transmission.
- Adds density input for mud pump applications.

Version 2.82 – Released 6/21/2007

- Adds Brake and Warm Up support for Twin Disc 8501 transmission.
- Must be used with MCB version 2.43 or later.

Version 2.8 – Released 5/01/2007

- Adds support for Twin Disc 8501 transmission.
- Adds support for Cummins QSK 45 and QSK 50 engines.
- Must be used with MCB version 2.41 or later.
- Must be used with touch screen version 2.19 or later.

Version 2.7 – Released 3/16/2006

- Added transmission oil under pressure trip. This function works exactly like pump over pressure trip, and can be disabled.
- Added transmission oil over temperature trip. This function works exactly like pump over pressure trip, and can be disabled.
- Added pump lube oil under pressure trip. This function works exactly like pump over pressure trip, and can be disabled.
- Added wireless network support.
- Must be used with MCB version 2.28 or later.
- Must be used with touch screen version 2.17 or later.

Version 2.61 – Released 10/03/2005

- Added suction under pressure trip. This function works exactly like pump over pressure trip, and can be disabled.
- Must be used with MCB version 2.25 or later.
- Must be used with touch screen version 2.15 or later.

Version 2.59 – Released 5/04/2005

- Network baud rate changed to 19200 to support RocketPort hardware.

Version 2.57 – Released 1/04/2005

- Added ability to password protect hardware settings and alarm set points.

Version 2.56 – Released 11/29/2004

- Removed 300-millisecond delay when sending ECM diagnostic messages to the touch screen.

Version 2.55 – Released 11/23/2004

- Removed flow control from ASCII serial output.

Version 2.54 – Released 11/15/2004

- Fixed a bug which prevented some engine ECM diagnostic messages from displaying properly on the QTerm.

Version 2.53 – Released 10/14/2004

- Expanded IPC-PC interface to include hardware setup.

Version 2.22 – Released 4/21/2004

- A bug was corrected that could cause the transmission in IPC-PC to appear in **Neutral** even though it is in **Brake**.

Version 2.21 – Released 4/7/2004

- Added Chinese language support.
- Added support for Detroit Diesel, Caterpillar, Allison, and Twin Disc.

- Added IPC-PC interface.
- Version 1.2 – Released 12/24/2003
- The over-pressure trip point screen was changed to prevent inadvertent changes to other pump parameters.

Controller (MCB)

Version 2.5.4T2 - Released 2/4/2009

- Improved J1939 message parsing speed and reliability
- Updating of the QTerm is faster

Version 2.5.2 – Released 11/20/2007

- Watchdog timer is now active when in Neutral or Brake.

Version 2.5 – Released 11/12/2007

- Improved engine start/stop controller. Only applies to situations where the start button is pressed immediately after stopping the engine (within 12 seconds).

Version 2.4.9 – Released 10/15/2007

- Revised shift controller to allow shifting directly from brake to any gear and vice versa. This only affects pumps which interface directly to FracCat (SLB).

Version 2.4.8 – Released 8/22/2007

- Changed Brake gray code for Twin Disc 8501 transmission.

Version 2.4.7 – Released 8/17/2007

- Adds support for Allison 6600 series transmission.
- Adds density input for mud pump applications.

Version 2.4.6 – Released 8/9/2007

- Changed Brake gray code for Twin Disc 8501 transmission.

Version 2.4.5 – Released 7/18/2007

- Fixes issue that caused J1587 data to be decoded improperly when used with certain engine types.

Version 2.43 – Released 6/21/2007

- Adds Brake and Warm Up support for Twin Disc 8501 transmission.
- Must be used with Gateway version 2.82 or later.

Version 2.41 – Released 5/01/2007

- Adds support for Twin Disc 8501 transmission.
- Adds support for Cummins QSK 45 and QSK 50 engines.
- Must be used with Gateway version 2.80 or later.

Version 2.29 – Released 4/04/2006

- Added handlers for divide-by-zero and overflow exceptions.

Version 2.28 – Released 3/16/2006

- Added transmission oil under pressure trip. This function works exactly like pump over pressure trip, and can be disabled.
- Added transmission oil over temperature trip. This function works exactly like pump over pressure trip, and can be disabled.
- Added pump lube oil under pressure trip. This function works exactly like pump over pressure trip, and can be disabled.
- Added wireless network support.
- Added engine start / stop controls for use with IPC-PC.
- Added watchdog timer control (go to idle / neutral) for communication timeouts. Timeout value is user selectable and can be disabled.
- Must be used with ICB version 2.7 or later.

Version 2.25 – Released 10/03/2005

- Added suction under pressure trip. This function works exactly like pump over pressure trip, and can be disabled.

- Must be used with ICB version 2.61 or later.
- Version 2.24 – Released 4/15/2005
- Network baud rate changed to 19200 to support RocketPort hardware.
- Version 2.23 – Released 11/29/2004
- Fixed a bug which reported an extra ECM diagnostic message when a single message was received.
- Version 2.21 – Released 11/15/2004
- Fixed a bug which interfered with throttle operation if the throttle low limit was greater than 600 RPM.
 - Added default low limit of 600 RPM for the throttle.
- Version 2.2 – Released 10/14/2004
- Added support for additional Allison transmission.
 - Added default values for throttle steps.
- Version 2.0 – Released 4/7/2004
- Added support for Detroit Diesel, Caterpillar, Allison, and Twin Disc.

Touch Screen

- Version 2.22 – Released 8/17/2007
- Adds support for Allison 6600 series transmission.
 - Adds density input for mud pump applications.
- Version 2.19 – Released 5/01/2007
- Adds support for Twin Disc 8501 transmission.
 - Adds support for Cummins QSK 45 and QSK 50 engines.
 - Must be used with Gateway version 2.80 or later.
- Version 2.17 – Released 3/16/2006
- Added transmission oil under pressure trip. This function works exactly like pump over pressure trip, and can be disabled.
 - Added transmission oil over temperature trip. This function works exactly like pump over pressure trip, and can be disabled.
 - Added pump lube oil under pressure trip. This function works exactly like pump over pressure trip, and can be disabled.
 - Must be used with ICB version 2.7 or later.
- Version 2.15 – Released 10/03/2005
- Added suction under pressure trip. This function works exactly like pump over pressure trip, and can be disabled.
 - Must be used with MCB version 2.25 or later.
 - Must be used with ICB version 2.61 or later.
- Version 2.13 – Released 1/04/2005
- Added ability to password protect hardware settings and alarm set points. Must use with network controller version 2.57 or higher.
- Version 2.12 – Released 10/14/2004
- Fixed disappearing torque converter / lockup text introduced in version 2.11.
- Version 2.11 – Released 10/14/2004
- Added support for additional Allison transmission.
 - Language translation now occurs only when needed instead of at every power up.
- Version 2.0 – Released 4/7/2004
- Added Chinese language support.
 - Added support for Detroit Diesel, Caterpillar, Allison, and Twin Disc.
 - Added IPC-PC protocol support.

Version 1.4 – Released 2/09/2004

- A problem was fixed that could cause the terminal to lock up in the *Auto-Scale Analog Input* screen.

Version 1.3 – Released 1/30/2004

- The over-pressure trip point screen was changed to prevent inadvertent changes to other pump parameters.

INTELLIGENT PUMP CONTROL SYSTEM



Record of Revisions

Property of: _____

Company: _____

Address: _____

City: _____ State: _____ Zip Code: _____

Revision Data

Check each revision received, and insert the revised and supplementary pages in your manual. Stewart & Stevenson Services, Inc. assumes no liability for personal injury or equipment failure due to any operation performed without heed to manual revisions.

Date of original publication: August 2003

Revision Number	Date	Brief Description
1	_____	_____
2	_____	_____
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About This Manual

This manual is not a textbook on mechanics, electronics, or hydraulics. Sufficient descriptive material and illustrations are included to enable the operator to understand the basic construction and theory of operation of this equipment. The intent of this manual is to guide the operators and maintenance personnel in the proper use of the equipment. This manual is not a substitute for properly trained personnel or common sense.

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1.0 Overview

Chapter

1

Stewart & Stevenson's Intelligent Pump Control System (IPC) is capable of monitoring and controlling multiple fracturing pumps simultaneously from a single location, giving the operator precise, remote control over an entire fracturing spread. The IPC System allows users to control various functions of the equipment through a touch screen interface. Status lights are used to notify the operator of alarms when a problem exists with the engine, transmission, or the pump. Functions, such as start/shutdown of the engine, increasing/decreasing throttle, and gear selection, can be controlled via the pump control panel.

The IPC is a microprocessor-based system with a touchscreen operator interface that can be stored in a weather tight suitcase or panel-mounted inside a Control Center. The display is a touch sensitive 8.5" X 6.25" graphical display. IPC simplifies operations by reducing the amount of electronic components required to control the various functions of fracturing equipment.

Control Functions

- Engine throttle
- Transmission shift
- Transmission brake
- Engine emergency shutdown (optional)
- Engine normal shutdown
- Engine start

Control Parameters

- Engine fault codes with translations
- Engine speed
- Engine oil pressure and temperature
- Engine water temperature
- Transmission oil pressure
- Torque converter status indicator for converter and lockup modes
- Pump speed
- Pump oil pressure and temperature
- Pump discharge pressure with overpressure module
- Pump discharge rate and total hydraulic horsepower production (calculated)

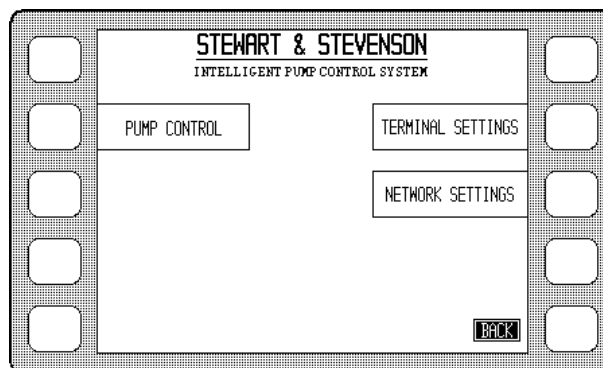


Figure 1: Main Menu

2.0 Operation

Chapter

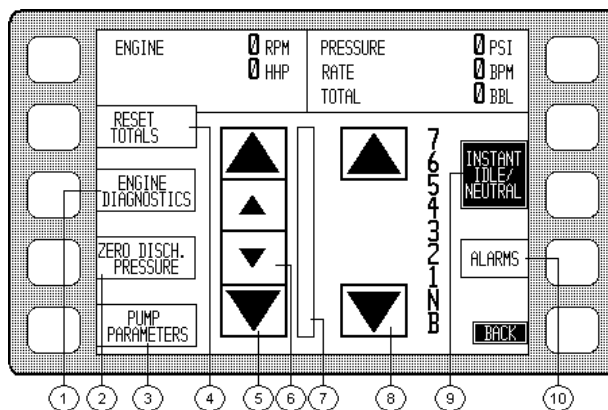
2

This chapter covers the specific details of operating the Intelligent Pump Control System. It also explains the many different abbreviations, buttons, screens, and controls used on the following display windows, how they are used, and what they mean. These display windows include the *Control Screen*, *Engine Diagnostics Screen*, *Alarms Screen*, and *Over Pressure Trip Point*.

2.1 Control Screen

The *control screen* is the main screen from which the operator controls the pump. From this window the operator can view engine diagnostics, zero discharge pressure, modify the alarms, increase engine throttle, and switch between gears.

- To access the control screen clicking the **Control** button on the *Intelligent Pump Control* screen.



Values displayed across the top of the screen come from the Electronic Control Module (ECM) sensors, and calculated values.

Below the ECM values, the operator can increase/decrease the engine RPM's and change gears by pushing the up/down arrows. Refer to Figure 2 for more details on the Control Screen.

Figure 2: Control Screen

1. Takes the operator to the *Engine Diagnostics* screen, which will display all the values from the engine's ECM.
2. Clicking the **Zero Discharge Pressure** button will reset the Pressure (PSI) to 0.
3. Allows the operator to quickly modify the various features on the *Pump Characteristics* screen.
4. **Reset Totals** will reset the slurry total (BBL).
5. Adjusts the **Small Throttle**.
6. Adjusts the **Large Throttle**.
7. Throttle indicator that graphically displays when the operator increases/decreases the throttle.
8. Shifts the transmission.
9. Will set the transmission to neutral and the engine to idle.
10. Takes the operator to the *Alarms* screen. This button will blink when an alarm is active.

2.2 Engine Diagnostics

The *Engine Diagnostics* screen will allow the operator to view any diagnostic message from the ECM. The message will display the date, time, and description of the problem. The operator can then use the available information to correct any engine problem or malfunction.

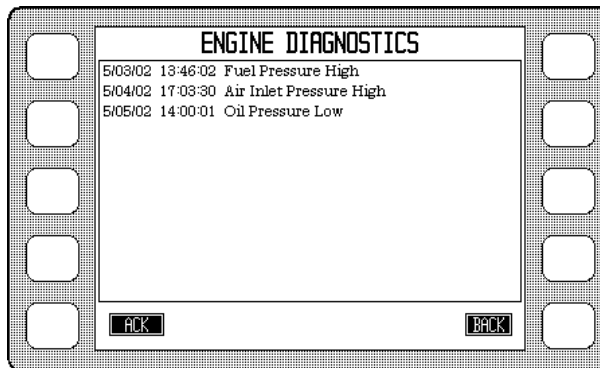


Figure 3: Engine Diagnostics

2.3 Alarms

The *Alarms* screen is setup to allow the operator to view in real time all the incoming data from the engine, transmission, and pump sensors.

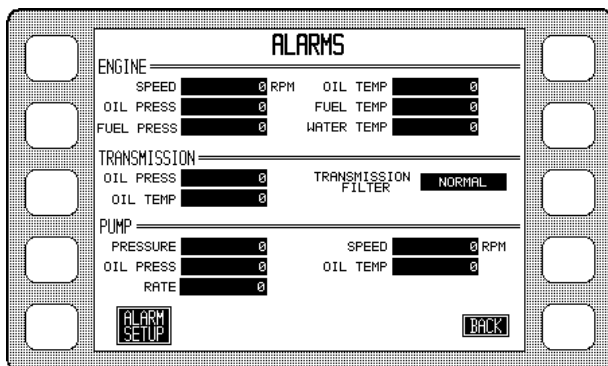


Figure 4: Alarms

To access the *Alarms* control screen press the **Alarms** button on the *Control* screen.

To configure the alarms and their high and low limits refer to the Configuring the Alarms section (**Refer to page 9**).

2.4 Configuring the Over Pressure Trip Point

The **Over Pressure Trip Point** is a fail-safe designed to prevent damage to the well by idling the engine, and switching the transmission to neutral if the trip point is reached.

The over pressure trip point can be set by clicking the **Pump Parameters** button on the *control* screen.

If the over pressure trip point value is reached, the pressure on the *control* screen will blink and the fail-safe will be engaged. The operator **must** select the **Instant Idle/Neutral** button in order to regain engine and transmission control.

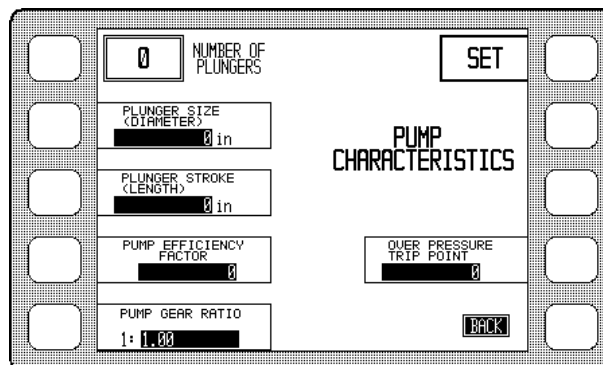


Figure 5: Pump Characteristics

3.0 Maintenance

Chapter

3

The maintenance section covers setting up and configuring the various pump, transmission, and engine control parameters.

3.1 Setting Up the Terminal

3.1.1 Terminal Settings

The *Terminal Settings* display window allows the operator to modify the contrast, backlight, and keyclick. From the *Terminal Settings* screen, the operator can increase/decrease the contrast and backlight. Keyclick volume can be turned on and off. The default keyclick setting is on.

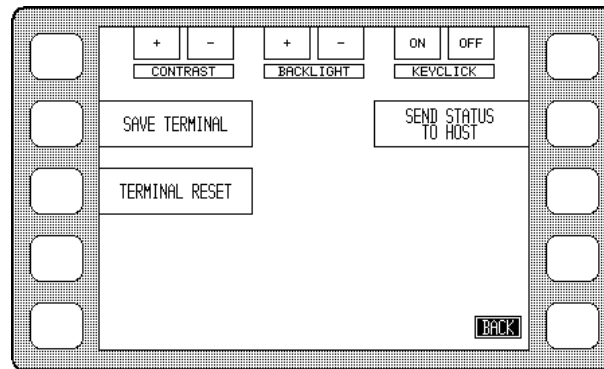


Figure 6: Terminal Settings

Other functions found on the *Terminal Settings* window include:

Save Terminal

Stores the configured display settings into memory. In order to save your settings, **Save Terminal** must be selected prior to exiting the *Terminal Settings* window.

Terminal Reset

Cycles the terminal's power and resets terminal settings to their saved values.

Send Status To Host

Sends the information currently associated with the Intelligent Pump Control terminal will be sent via a RS232 serial cable to the desired host.

Note: Exiting this screen without selecting the **Save Terminal** button will cause the desired changes to be lost when power is turned off.

3.1.2 Network Settings

The *Network Settings* screen allows the user to set the address of the current workstation, modify the time and date, map the network, and clear the memory.

NODE	DESCRIPTION	VERSION
240	DISPLAY	1.03
1	PUMP CONTROL	1.31

QT Version 1.00APC

The screen will graphically display the node on the network, description, and version of the software.

Display refers to the network controller software. **Pump Control** refers to the black box software. **QT Version** refers to the touch screen software. Version numbers help determine if hardware or software needs to be updated.

Figure 7: Network Settings Screen

Note: The address should be set to 240.

By clicking the “Clear Memory” button the unit **will not** reset all the data stored in memory. Only the *Small Throttle Step* and the *Large Throttle Step* will be cleared of their user defined values.

Note: Clearing the memory will default the display units to English.

Another feature that the operator can edit is the **time** and **date**. When clicking the “Set Time/Date” button the user will be forwarded to the following screen:

On the left portion of the screen are all the options related to date while on the right side are all the options relating to time. These can be modified by:

1. Click the desired field.
2. Entering the desired numbers on the keypad.
3. Click **Enter** when finished.

Figure 8: Time & Date

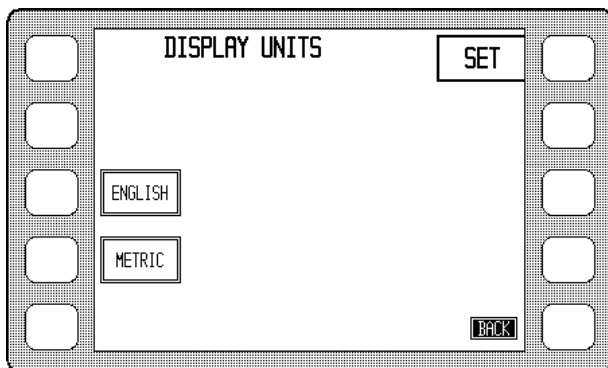
Note: The operator must click the **Set** button before exiting the screen or the information **will not** be stored into memory.

The operator can also automatically set the date and time by clicking the “Get” button on the top left corner of the screen. This option retrieves the date and time from the network if available.

3.1.3 Display Units

The display units screen allows the operator to switch between the English and Metric system units. The display units screen can be reached by clicking:

Pump Control > Display Units



English Units:

- PSI ➤ RPM
- DegF ➤ BPM
- BBL ➤ HHP

Metric Units:

- Mpa ➤ DegC
- MP3M ➤ mm
- M3

Figure 9: Display Units

3.1.4 Communication Test

The communication test screen allows the operator to test the stability of the network and will report back how many iterations, packets, retries, lost packets, and the success rate. The communication test screen can be reached by clicking:

Pump Control > Communication Test

Iterations per second: How many times one cycle of a set of instructions is repeated.

Total Packets: Number of packets sent.

Retries: Reports how many communication failures occurred between devices.

Lost Packets: Total number of packets lost during transmission.

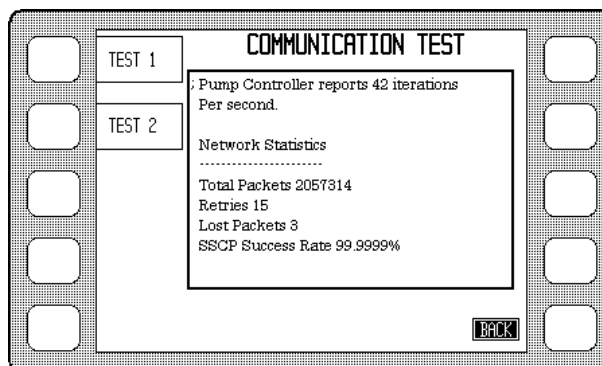


Figure 10: Communication Test

Note: Test two uses every letter in the alphabet to check the transmission of certain bytes; therefore, it is important that the operator run both test.

3.2 Setting Up the Engine

3.2.1 Engine Setup

This screen allows the operator to modify the large and small throttle step. When the operator presses ▲ ▼ the engine RPM increases/decreases by **large** throttle step. When the operator presses ▲ ▼ the engine RPM increases/decreases by **small** throttle step.

The operator can get to this screen in a few easy steps by clicking:

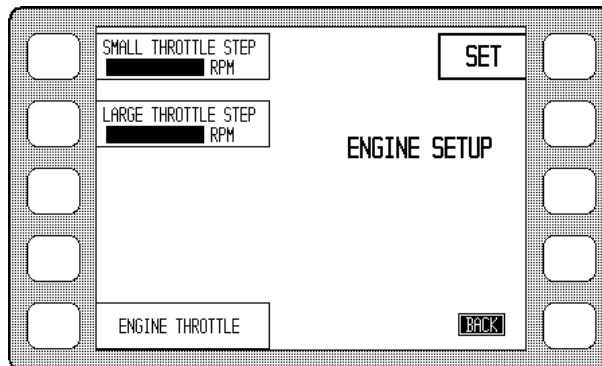


Figure 11: Engine Setup

Pump Control > Hardware Setup > Engine

From here the operator can then alter the engine throttle characteristics by clicking on the “Engine Throttle” button.

3.2.2 Engine Throttle

The settings on this display screen are crucial to accurately controlling the throttle. If the **offset** and **gain** are not properly configured then the DAC (Digital Analog Converter) counter **will not** correspond to the right RPM.

Use the coefficient calculator located on the Stewart & Stevenson website to calculate the **offset** and **gain**.

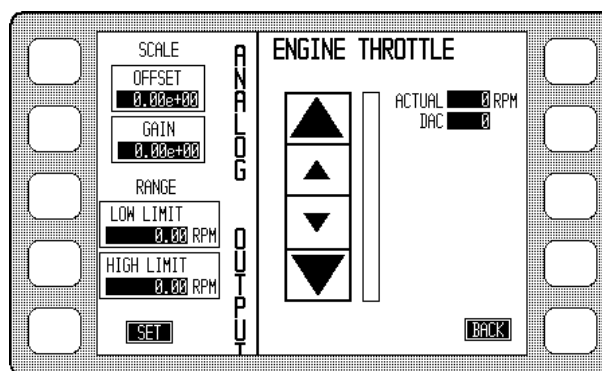


Figure 12: Engine Throttle

Note: To get the coefficient calculator, go to www.ssss.com/petroleum/download.asp

Below the **offset** and **gain** fields are the **low limit** and **high limit** fields. It is imperative that the operator input acceptable RPM's into these fields otherwise engine complications may result. The operator should check with S&S on what these settings should be.

The **throttle control increments** are shown in **Figure 8**. The speed of the engine will adjust depending on the increment values and whether or not the operator is increasing or decreasing the throttle control.

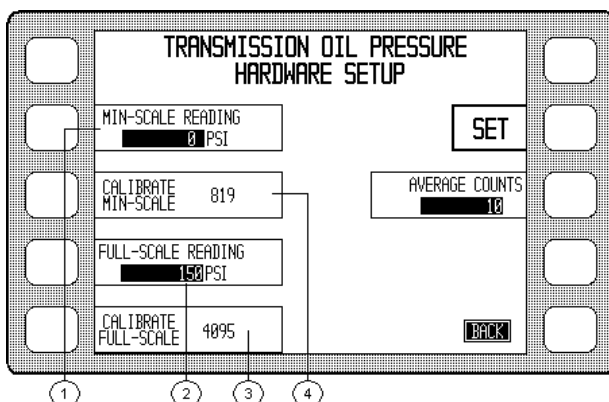
3.3 Setting Up the Transmission

3.3.1 Transmission Oil Pressure

To access the *Transmission Oil Pressure* screen, press:

Hardware Setup > Transmission > Transmission Sensor > Trans Oil Pressure

Note: There are four other screens (Transmission Oil Temperature, Pump Oil Pressure, Pump Oil Temperature, Pump Discharge Pressure) that have the same layout as the Transmission Oil Pressure screen. Since these screens are identical, only the **Transmission Oil Pressure** screen will be covered in detail



This screen in particular is measured in PSI. The sensors ADC will be calibrated based on what the user inputs in the “Min-Scale Reading” and “Full-Scale Reading” fields. To calibrate:

1. Input the desired PSI into the field.
2. Click the calibrate button.
3. Click the **set** button.
4. Repeat process for each field pairs.

Figure 13: Hardware Calibration

1. **Min-Scale Reading** is the minimum value for the sensor being used. For example on a 0-15,000 PSI transducer, the min-scale reading would be 0.
2. **Full-Scale Reading** is the maximum value for the sensor being used. For example on a 0-15,000 PSI transducer, full-scale reading would be 15,000.
3. **Calibrate Full-Scale** adjusts the unit to read correctly at a high end set point.
4. **Calibrate Min-Scale** captures the current input level from the sensor.

3.3.2 Transmission Filter Switch

The transmission filter switch notifies the operator when the transmission filter needs to be changed.

- When the *state* is zero the filter is bad.
- When the *state* is one the filter is good.

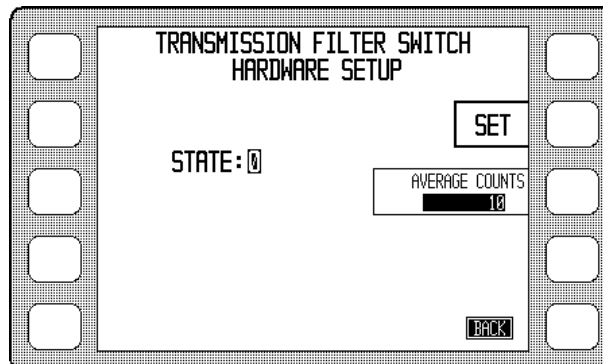


Figure 14: Transmission Filter Switch

3.4 Setting Up the Pump

3.4.1 Pump Characteristics

The **Pump Characteristics** screen is used to calculate the total barrels per minute. The **Pump Characteristics** screen requires the operator to input the values for each field depending on the manufacturers specifications. The **Pump Characteristics** screen can be reached by:

Hardware Setup > Pump > Pump Parameters

To change the number of plungers:

1. Click the top left box.
2. Continue cycling through until the desired number appears.

Enter the plunger size, stroke, and pump gear ratio based on the manufacturers specifications.

Figure 15: Pump Characteristics

The efficiency factor is used to correct the theoretical displacement.

- A rating of “1.00” is equal to one hundred percent efficiency.
- A rating of “0.50” is equal to fifty percent efficiency.

Note: As a pump wears the efficiency tends to decrease.

3.4.2 Pump Rate

The main point of focus on this screen is setting up the K-Factor. A K-Factor is used to convert a frequency into an engineering unit. To set the K-Factor:

If the operator knows the K-Factor:

1. Input it directly into the K-Factor field

OR

If the operator knows the current rate:

1. Input “1” into the K-Factor field and click **SET**.
2. Input the current BPM into the provided field.
3. Click **AUTO-SCALE > SET**.

Figure 16: Pump Rate

3.5 Configuring the Alarms

As stated earlier there are three different alarm setup pages. The first page consists of all engine alarms, the second page all transmission alarms, and the third page all pump alarms.

Note: The *Engine Alarms*, *Transmission Alarms*, and *Pump Alarms* screens follow the same setup procedures.

Each alarm setup page will consist of a **High Limit** and **Low Limit** configurable field.

To change these fields click on them, input the desired value with the number pad, click **Enter** > **SET**.

Click **Next** to continue to the next Alarm Setup page.

SPEED		OIL PRESS		FUEL PRESS		ENGINE ALARMS
LOW LIMIT	0 RPM	LOW LIMIT	0 PSI	LOW LIMIT	0 PSI	
HIGH LIMIT	0 RPM	HIGH LIMIT	0 PSI	HIGH LIMIT	0 PSI	
[SET]		[SET]		[SET]		[NEXT]
OIL TEMP		FUEL TEMP		WATER TEMP		
LOW LIMIT	0 degF	LOW LIMIT	0 degF	LOW LIMIT	0 degF	
HIGH LIMIT	0 degF	HIGH LIMIT	0 degF	HIGH LIMIT	0 degF	
[SET]		[SET]		[SET]		[BACK]

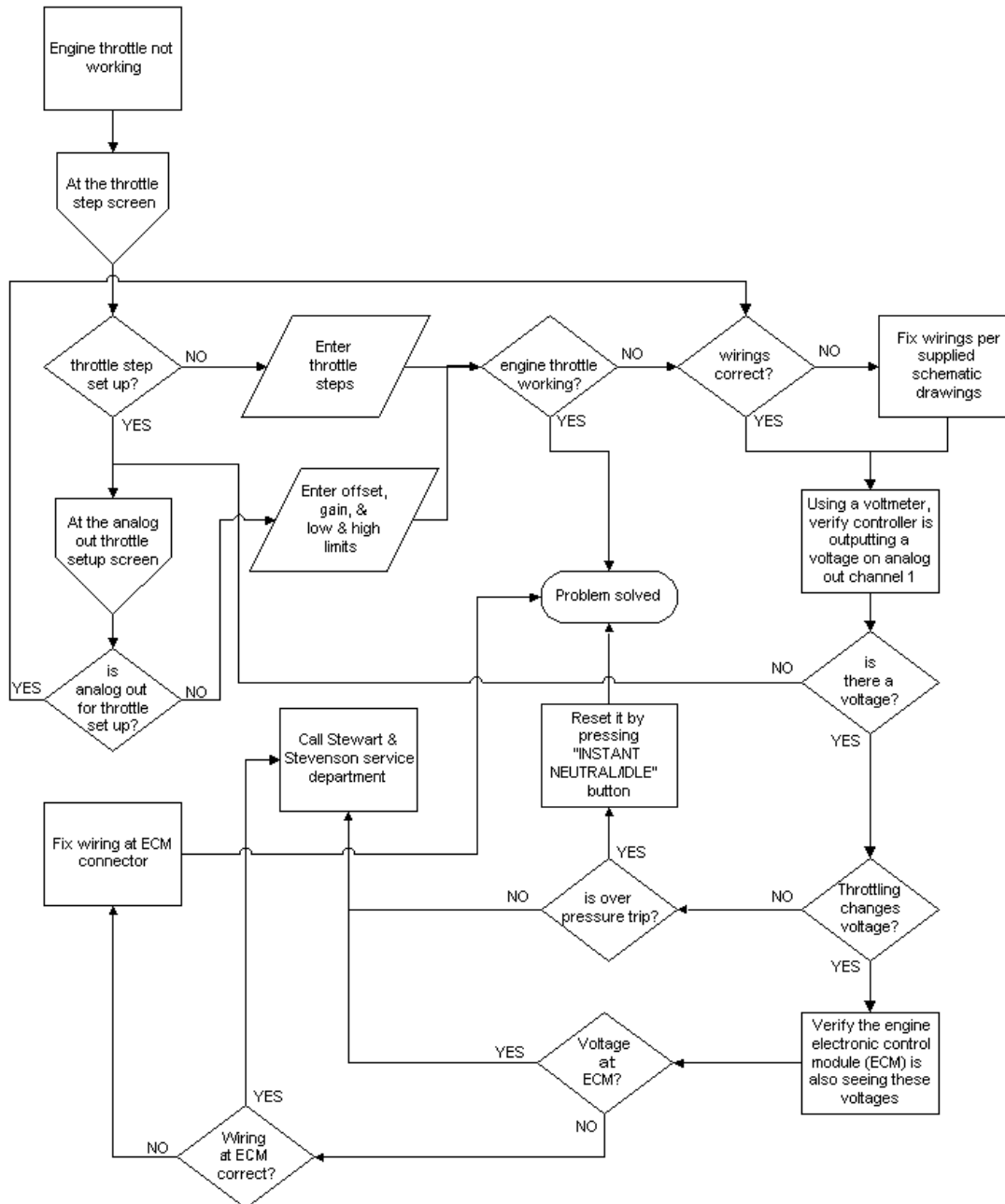
Figure 17: Engine Alarms

Note: The unit characteristics will vary between each of the different alarm setup screens. Each screen will either have **degF**, **PSI**, and or **BBL** units.

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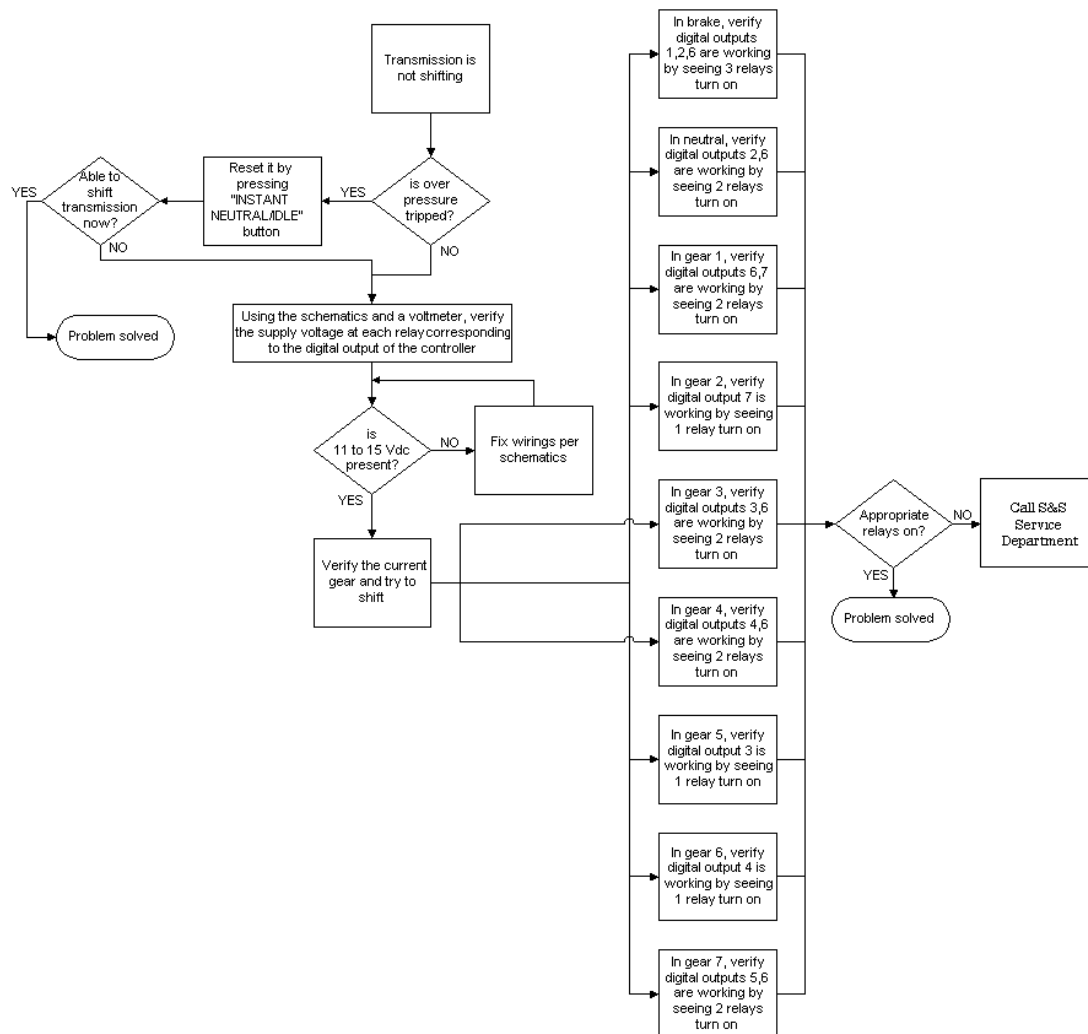
Intelligent Pump Control

Troubleshooting Engine Throttle



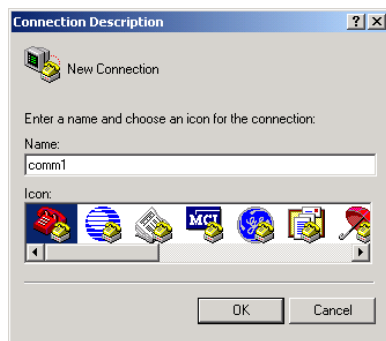
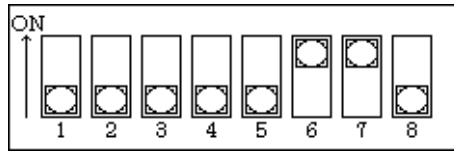
Intelligent Pump Control

Troubleshooting Allison Transmission

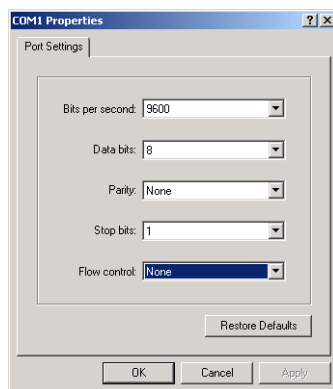


Saving Parameters to a Computer

- Set all the dipswitches to the **OFF** position **EXCEPT** for 6 and 7.

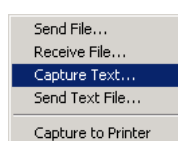


- Cycle the power of the pump control board.
- Start up hyper terminal.
- Input a connection description.
- Click **OK**.
- Select the COM Port in which the data transfer will take place.
- Click **OK**.

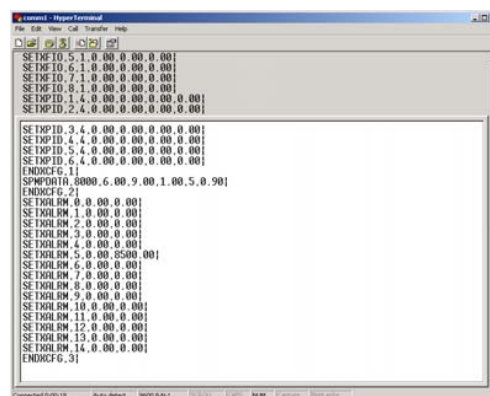


- Set **Baud Rate** (Bits per second) to *9600*.
- Set **Data Bits** to *8*.
- Set **Parity** to *None*.
- Set **Stop bits** to *1*.
- Set **Flow control** to *None*.
- Click **OK**.

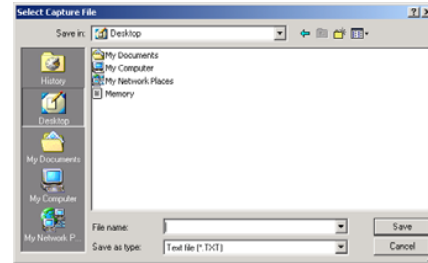
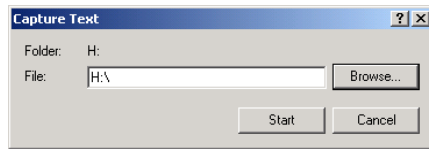
- Click **Transfer** at the top of the screen.
- Select **Capture text...** from the menu.
- Click **Transfer** at the top of the screen.
- Select **Capture Text...** from the menu.



- Click **Browse**.
- Select a folder for storage.

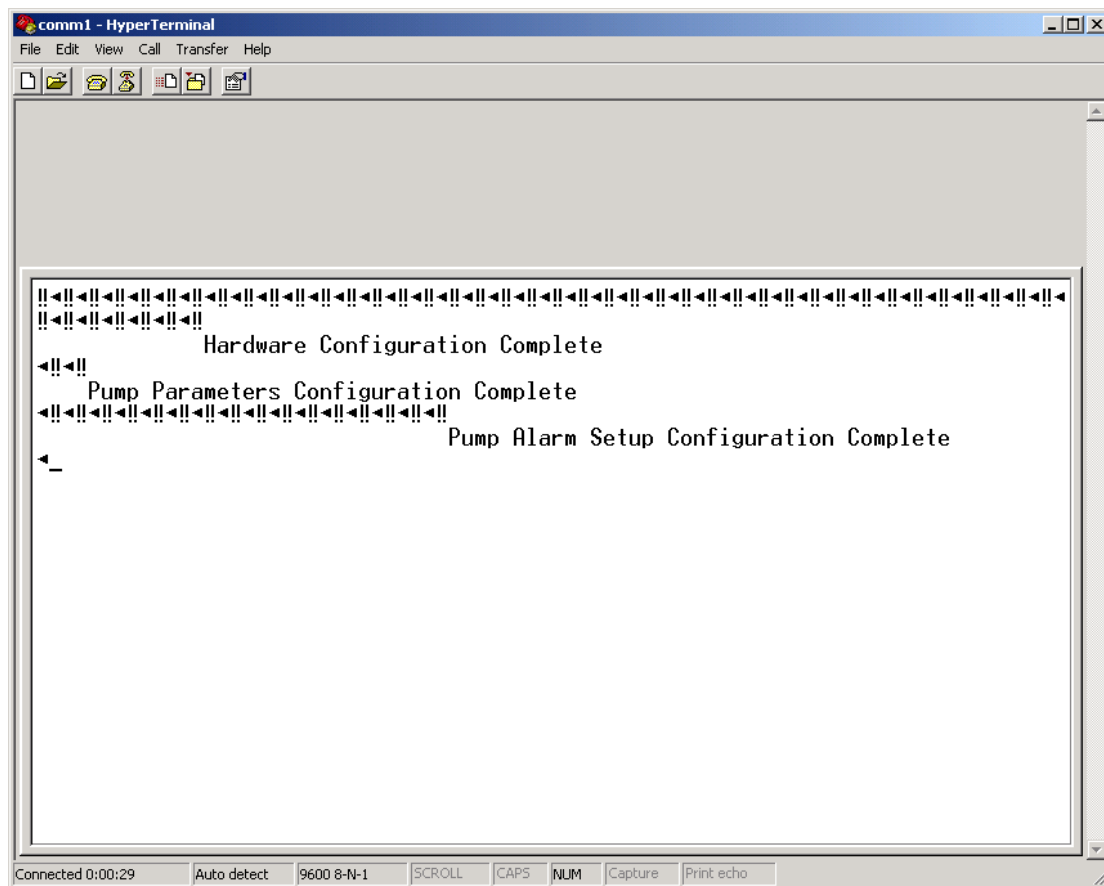


20. Input file name and click **Save**.
21. Click the **Start** button.
22. Press **CTRL-A** to retrieve data from the IPC.



To upload the saved file:

1. Click **Send text file...** from the **transfer** menu.
2. Find the desired file and click **OK**.
3. A screen similar to the one below will appear.



Average Counts – Number of readings used to acquire an average value.

BBL - Barrel.

BPM - Barrels per minute.

Calibrate Full-Scale – Adjust the unit to read correctly at a high-end set point.

Calibrate Min-Scale – Captures the current input level from the sensor.

Current Value – Is the current value of the signal being monitored.

degC - Degree Celsius.

degF - Degree Fahrenheit.

Full-Scale Reading – The maximum value for the sensor being used. For example on a 0 – 15,000 PSI transducer, the Full-Scale Reading would be 15,000.

Gear Ratio - Speed of rotation ratio of the powered gear to the driven gear.

HHP - Hydraulic Horsepower.

in - inches.

K - Factor – Converts a frequency to an engineering unit.

M3 - Meters cubed.

M3PM - Meters cubed per minute.

Min-Scale Reading – The minimum value for the sensor being used. For example on a 0 – 15,000 PSI transducer, the Min-Scale Reading would be 0.

mm - Millimeters.

MPa - Mega Pascal.

Node - A point on a network that either relays the transmission of data or terminates it.

Plunger - A piston used to create pressure pumps.

PSI - Pounds per square inch.

RPM - Rotations per minute.

SSCP - Stewart & Stevenson Communication Protocol.

Torque - Twisting or turning force.

Transducer – An electronic apparatus that converts energy from one form to another.

A

Alarm
 limits, 3
Alarms
 High Limit, 14
 Low Limit, 14

B

backlight, 5
bbl, 2

C

contrast, 5

D

DAC, 8, 10
date, 6

E

ECM, 3
Engine, 1
 alarm, 14
 alarm setup, 14
 Alarms, 3
 ECM, 3
 engine diagnostics, 2
 Engine Diagnostics, 2, 3
 gain, 8
 high limit, 8
 increase engine throttle, 2
 Large Throttle Step, 6
 low limit, 8
 malfunction, 3
 offset, 8
 RPM, 2, 7, 8
 small throttle step, 8
 Small Throttle Step, 6
English, 7

F

filter, 10
Full-Scale Reading, 10

I

Iterations per second, 7

K

keypad, 6
K-Factor, 12

M

memory, 5
Metric, 7
Min-Scale Reading, 10

N

network, 6

P

Packets, 7
Pump, 1
 alarm setup, 14
 Characteristics, 12
 Over Pressure Trip Point, 3
 Parameters, 4
 plungers, 12
 PSI, 2
 rate, 12
 Zero Discharge Pressure, 2

R

Reset Totals, 2
Retries, 7

S

serial cable, 5

T

throttle control increments, 9
time, 6
Transmission, 1
 Alarms, 3
 change gears, 2
 state, 10
 transmission filter switch, 10
 Transmission Oil Pressure, 10

Stimulation Systems



Stewart & Stevenson



Building For The Next Century

Stimulation Systems

Quality engineered well-servicing products manufactured by **Stewart & Stevenson®** have supported the worldwide oil and gas industry since the 1950s. Today our stimulation equipment with technically advanced controls is aiding in improving the production of oil and gas in onshore and offshore fields from Texas to China, in the Gulf of Mexico and the Caspian Sea, in Middle East deserts and the coldest regions of Siberia, and at numerous other locations around the globe.



Building For The Next Century

Stewart & Stevenson's fully integrated stimulation equipment works as a system to perform fracturing treatment. It includes:

- Fracturing Pumps
- Blenders
- Chemical Additive and Hydration Systems
- Acidizing Equipment
- Support Equipment
- Data Acquisition and Control Centers

Combining 50 years of fracturing equipment experience with in-house engineering, software development and quality control expertise, Stewart & Stevenson develops leading edge stimulation equipment that offers maximum reliability.

- Our fit-for-purpose systems are designed for each operating region's specific environment.
- Our advanced control systems serve single or multiple pieces of equipment.
- Our data vans have controls, data acquisition software and wireless technology that makes complete control of field operations possible onsite or remotely.
- Quality control in all phases of equipment design and construction ensures consistent quality that minimizes maintenance requirements.

Stewart & Stevenson's fully integrated stimulation systems offer simplified operation and improved job quality while requiring fewer trained operators to perform a fracturing treatment.

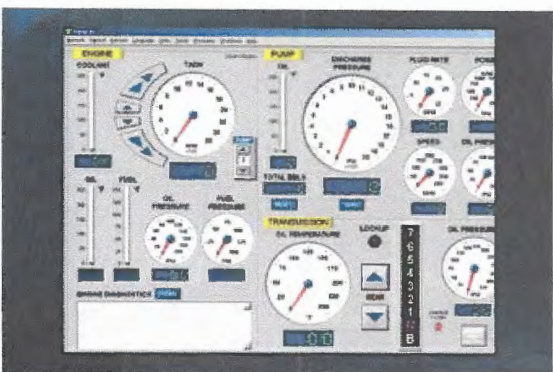
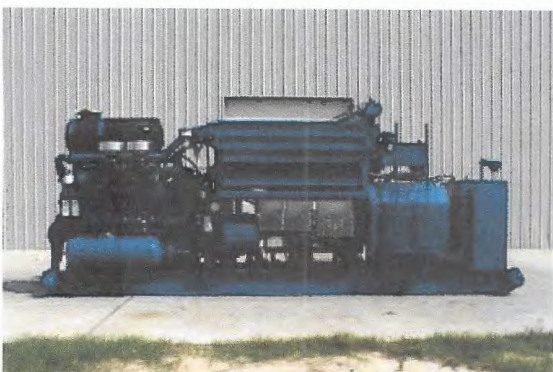
Specialized Support

Stewart & Stevenson technicians travel worldwide to provide equipment training, commissioning and servicing. Customers have access to equipment service at our product support centers located near oil and gas fields in the United States and in a number of the world's major energy producing countries.



Integrated Controls

Stewart & Stevenson's fully integrated control platform provides unparalleled job quality through centralized control, while requiring fewer trained operators.



Fracturing Pumps

Stewart & Stevenson's Fracturing Pumps are designed to provide optimal horsepower in a maneuverable package. Our fit-for-purpose units are field proven to provide reliable operation in the harshest environments.

- Stewart & Stevenson's Intelligent Pump Control (IPC) combines advanced unit controls and diagnostics with a touchscreen interface capable of controlling up to 24 units from a single workstation.
- Trailer mounted units are available in triplex and quintuplex packages that are weight legal with high ambient cooling packages.
- Bodyload units are designed to traverse the roughest terrain and operate in the harshest environments.
- Maintenance friendly features and high strength materials ensure reliable operation.
- Specialized combination blender and fracturing pumps provide complete fracturing capabilities in a single unit.





Pioneering Technology

Stewart & Stevenson has pioneered the development of high horsepower fracturing units with emissions compliance.

STEWART & STEVENSON FRACTURING PUMPS					
MODEL	FT-2251 TRAILER MOUNTED FRAC	FC-2251 BODYLOAD FRAC	FS-2251 SKID MOUNTED FRAC	FT-3001 TRAILER MOUNTED FRAC	FC-3001 BODYLOAD FRAC
CARRIER TYPE	Stewart & Stevenson Trailer	Kenworth, Mercedes Benz, or Other Truck Chassis	Stewart & Stevenson Oilfield Skid	Stewart & Stevenson Trailer	Kenworth, Mercedes Benz, or Other Truck Chassis
CARRIER DRIVE CONFIGURATION	Tandem or Tridem Air Ride	6×4, 6×6, 8×4, 8×6, or 8×8	N/A	Tridem Air Ride	8×4 or 8×8
SIZE: L × W × H	42'0" × 8'6" × 13'6"	37'7" × 8'6" × 13'2"	27'0" × 8'0" × 10'6"	45' × 8'6" × 13'6"	40' × 8'6" × 13'6"
ENGINE*	MTU DD 12V4000	MTU DD 12V4000	MTU DD 12V4000	MTU DD 16V4000	MTU DD 16V4000
ENGINE RATING	2250 bhp	2250 bhp	2250 bhp (2500 and 3000 optional)	3000 bhp (2500 optional)	3000 bhp (2500 optional)
MAXIMUM AMBIENT OPERATING TEMPERATURE	122 °F/50 °C	122 °F/50 °C	122 °F/50 °C	122 °F/50 °C	122 °F/50 °C
TRANSMISSION	Allison S9820	Allison S9820	Allison S9820	Twin Disc TA-8500	Twin Disc TA-8500
PUMP	Triplex or Quintuplex	Triplex or Quintuplex	Triplex or Quintuplex	Triplex or Quintuplex	Triplex or Quintuplex
CONTROL SYSTEM	Stewart & Stevenson IPC	Stewart & Stevenson IPC	Stewart & Stevenson IPC	Stewart & Stevenson IPC	Stewart & Stevenson IPC
WIRELESS CONTROL OPTION	Optional	Optional	Optional	Optional	Optional
COLD WEATHER PACKAGE	Optional	Optional	Optional	Optional	Optional

* Other manufacturers available



Fracturing Blenders

Stewart & Stevenson's Fracturing Blenders provide industry-leading job performance and reliability. Our Blenders allow operators to mix complex fracturing slurries with varying densities for the most complex jobs.

- Stewart & Stevenson's AccuFrac System provides automated density and chemical controls in a user-friendly interface from the unit or Data Van.
- The unique Stewart & Stevenson concentric mixing chamber provides accurate and homogenous proppant mixing at both low and high rates without air entrainment.
- Highly efficient closed loop hydraulic systems provide faster response than open loop systems while consuming less power and producing less waste heat for longer component life and reduced maintenance requirements.





Proven Experience

Stewart & Stevenson developed the world's first 100 bbl/min blender in 1959.

STEWART & STEVENSON BLENDER

MODEL	MT-132 TRAILER MOUNTED BLENDER	MT-102 TRAILER MOUNTED BLENDER	MC-100 BODYLOAD BLENDER	MC-60 BODYLOAD BLENDER	MS-60 SKID MOUNTED BLENDER	MS-30 SKID MOUNTED BLENDER
MAXIMUM DISCHARGE RATE	130+ bbl/min	100 bbl/min	100 bbl/min	60 bbl/min. (75 bbl/min. optional)	60 bbl/min	30 bbl/min
MAXIMUM DISCHARGE DENSITY	21 lb/gal	21 lb/gal	21 lb/gal	21 lb/gal	21 lb/gal	21 lb/gal
MAXIMUM PROPPANT INPUT RATE	21,250 lb/min (optional higher rates are available)	21,250 lb/min (optional higher rates are available)	16,000 lb/min (optional higher rates are available)	16,000 lb/min (optional higher rates are available)	16,000 lb/min (optional higher rates are available)	6000 lb/min (optional higher rates are available)
CARRIER TYPE	Stewart & Stevenson Trailer	Stewart & Stevenson Trailer	Kenworth, Mercedes Benz, or Other Truck Chassis	Kenworth, Mercedes Benz, or Other Truck Chassis	Oilfield Skid	Oilfield Skid
CARRIER DRIVE CONFIGURATION	Tandem Air Ride	Tandem Air Ride	6x4, 6x6, 8x4, 8x6, or 8x8	6x4, 6x6, 8x4, 8x6, or 8x8	N/A	N/A
SIZE: L x W x H	48'0" x 8'6" x 13'6"	48'0" x 8'6" x 13'6"	36'8" x 8'6" x 13'2"	34'8" x 8'6" x 13'2"	24'8" x 8'6" x 12'0"	19'6" x 8'6" x 8'0"
MIXING CHAMBER	Concentric Tub with Automatic Level Control	Concentric Tub with Automatic Level Control	Concentric Tub with Automatic Level Control	Pressurized Mixing Chamber	Pressurized Mixing Chamber	Hydrojet Tub
DRIVE SYSTEM*	(2) MTU DD Engines	(2) MTU DD Engines	(1) Truck Engine and (1) Deck Engine	(1) Truck Engine	(1) MTU DD Engine	(1) MTU DD Engine
TOTAL HORSEPOWER	1450 bhp (total)	1130 bhp	1050 bhp	500 bhp	600 bhp	330 bhp
NUMBER OF LIQUID ADDITIVE SYSTEMS	Up to 6	Up to 6	Up to 6	Up to 6	Up to 6	Up to 6
NUMBER OF DRY ADDITIVE SYSTEMS	Up to 2	Up to 2	Up to 2	Up to 2	Up to 2	Up to 2
DISCHARGE PUMP	14x12	14x12	14x12	Not Required	Not Required	5x6
SUCTION PUMP	12x12	12x10	12x10	8x10	8x10	5x6
AUTOMATED CONTROL SYSTEM	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac
WIRELESS CONTROL	Optional	Optional	Optional	Optional	Optional	Optional
COLD WEATHER PACKAGE	Optional	Optional	Optional	Optional	Optional	Optional

* Other manufacturers available



Chemical Additive and Hydration Systems

Stewart & Stevenson's combination Chemical Additive and Hydration Systems provide on-the-fly polymer injection and hydration to eliminate post job waste while increasing slurry viscosity. Stewart & Stevenson also offers stand alone Chemical Additive Systems to inject chemicals at multiple sites, depending upon each specific chemical's requirement.

- Stewart & Stevenson's AccuFrac Chemical controller provides automated chemical injection dosage control with varying rates from the Blender, Hydration Unit and other external sources.
- Our variable level Hydration chamber allows for final stage rundown to eliminate gelled fluid disposal problems.
- The Chemical Additive Units are equipped with quick-changeout tank systems to allow operators to replenish chemicals at the yard in a few minutes versus hours required for a refill.





Custom Designs

Stewart & Stevenson can provide a custom designed injection system for proprietary polymer systems.

STEWART & STEVENSON CHEMICAL ADDITIVE AND HYDRATION UNITS

MODEL	CT-10CAS	CC-6CAS	CT-5CAS/BT-200	CT-5CAS/BT-100	CS-6CAS/BT-80
CARRIER TYPE	Stewart & Stevenson Trailer	Kenworth, Mercedes Benz, or Other Truck Chassis	Stewart & Stevenson Trailer	Stewart & Stevenson Trailer	Oilfield Skid
CARRIER DRIVE CONFIGURATION	Tandem Air Ride	6×4, 6×6, 8×4, 8×6, or 8×8	Tandem Air Ride	Tandem Air Ride	N/A
SIZE: L × W × H	46'0" × 8'6" × 13'6"	37'6" × 8'6" × 12'6"	48'0" × 8'6" × 13'6"	44'0" × 8'6" × 13'6"	39'6" × 11'0" × 25'0"
ENGINE*	Dual MTU DD D706	Truck Chassis Engine Driven	MTU DD Series 60	MTU DD Series 60	MTU DD Series 60
ENGINE RATING	110 bhp (each)	400 bhp (minimum)	600 bhp	500 bhp	500 bhp
NUMBER OF CHEMICAL INJECTION CIRCUITS	10	6	5	5	6
PUMP TYPE	Progressive Cavity, Lobe, Piston, or Gear	Progressive Cavity, Lobe, Piston, or Gear	Progressive Cavity, Lobe, Piston, or Gear	Progressive Cavity, Lobe, Piston, or Gear	Progressive Cavity, Lobe, Piston, or Gear
HYDRATION TANK VOLUME	N/A	N/A	200 bbl	100 bbl	80 bbl
MAXIMUM HYDRATION TANK PUMP INLET RATE	N/A	N/A	100 bbl/min	60 bbl/min	50 bbl/min
CONTROL SYSTEM	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac
WIRELESS CONTROL	Optional	Optional	Optional	Optional	Optional
TRANSFER PUMP SYSTEM	Standard	Standard	Standard	Standard	Standard
ENVIRONMENTAL ENCLOSURE	Optional	Optional	Optional	Optional	Optional

* Other manufacturers available



Data Acquisition and Control Centers (Data Vans)

Stewart & Stevenson's Data Acquisition and Control Centers provide a centralized command center to control all of the critical wellsite equipment while monitoring, recording, and supervising the fracturing treatment. The Data Acquisition and Control Center reduces the number of equipment operators required to complete the treatment while greatly improving job quality through centralized real-time data gathering and presentation.

- Stewart & Stevenson's IPC-PC interface provides control of up to 24 Fracturing Pumps at a single operator workstation.
- Stewart & Stevenson's AccuFrac-PC interface provides control of multiple Blenders, Hydration Units, and Chemical Additive Units from the Data Acquisition and Control Center.
- UPS systems and solid-state CPU components provide reliable operation with backup systems.
- Our control systems are available as discrete components, giving our customers the ability to upgrade their existing equipment.
- The wireless control options provide a "cable free" wellsite, eliminating all issues with damaged equipment cables and contaminated connections.



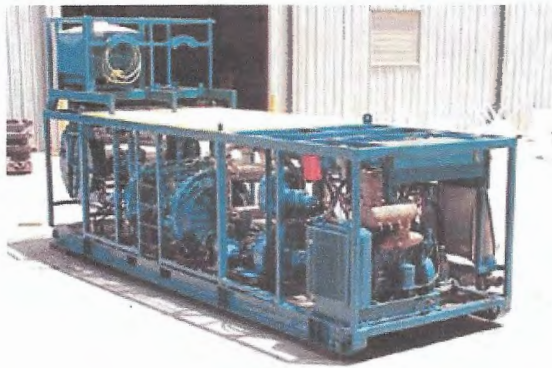


Advanced Controls

AccuFrac-PC's data displays are easily customized to meet the evolving needs of each customer.

STEWART & STEVENSON DATA ACQUISITION & CONTROL UNITS

MODEL	EC-26- ACD	EC-22-ACD	EC-8ACD	ET-40-ACD
CONTROL CABIN SIZE L x W x H	26'0" x 8'0" x 7'8"	22'0" x 8'0" x 7'8"	12'0" x 7'0" x 6'6"	40'0" x 8'0" x 7'8"
CARRIER TYPE	Kenworth, Mercedes Benz, or Other Truck Chassis	Kenworth, Mercedes Benz, or Other Truck Chassis	Kenworth, Mercedes Benz, or Other Truck Chassis	Stewart & Stevenson Trailer
CARRIER DRIVE CONFIGURATION	4x2, 4x4, 6x4, or 6x6	4x2, 4x4, 6x4, or 6x6	4x2, 4x4, 6x4, or 6x6	Tandem Air Ride
MAXIMUM NUMBER OF FRACTURING UNIT CONTROLS	24	24	16	24
MAXIMUM NUMBER OF BLENDER CONTROLS	2	2	2	2
MAXIMUM NUMBER OF CHEMICAL ADDITIVE / HYDRATION CONTROLS	2	2	2	2
NUMBER OF DISCRETE PHYSICAL DATA CHANNELS	16	16	16	16
NUMBER OF VIRTUAL DATA CHANNELS	500	500	250	500
FRACTURING PUMP CONTROL SYSTEM	IPC - PC	IPC - PC	IPC - PC	IPC - PC
BLENDER, CHEMICAL ADDITIVE, AND HYDRATION CONTROL SYSTEM	AccuFrac - PC	AccuFrac - PC	AccuFrac - PC	AccuFrac - PC
TOUCHSCREEN IPC - PC INTERFACES	3	3	2	3
INDUSTRIAL COMPUTERS	3	3	2	3
ACCUFRAC - PC AND MODELING SOFTWARE SCREENS	7	6	4	7
PRINTERS	2	2	1	2
GENERATOR SYSTEM	20 kW Chassis Engine Driven	10 kW Stand Alone Diesel Engine	5 kW Chassis Engine Driven	20 kW Stand Alone Diesel Engine
COMMUNICATION SYSTEM	5-Station Internal Intercom, 18 External Radios	4-Station Internal Intercom, 12 External Radios	3-Station Internal Intercom, 12 External Radios	5-Station Internal Intercom, 18 External Radios
WIRELESS CONTROL	Option	Option	Option	Option

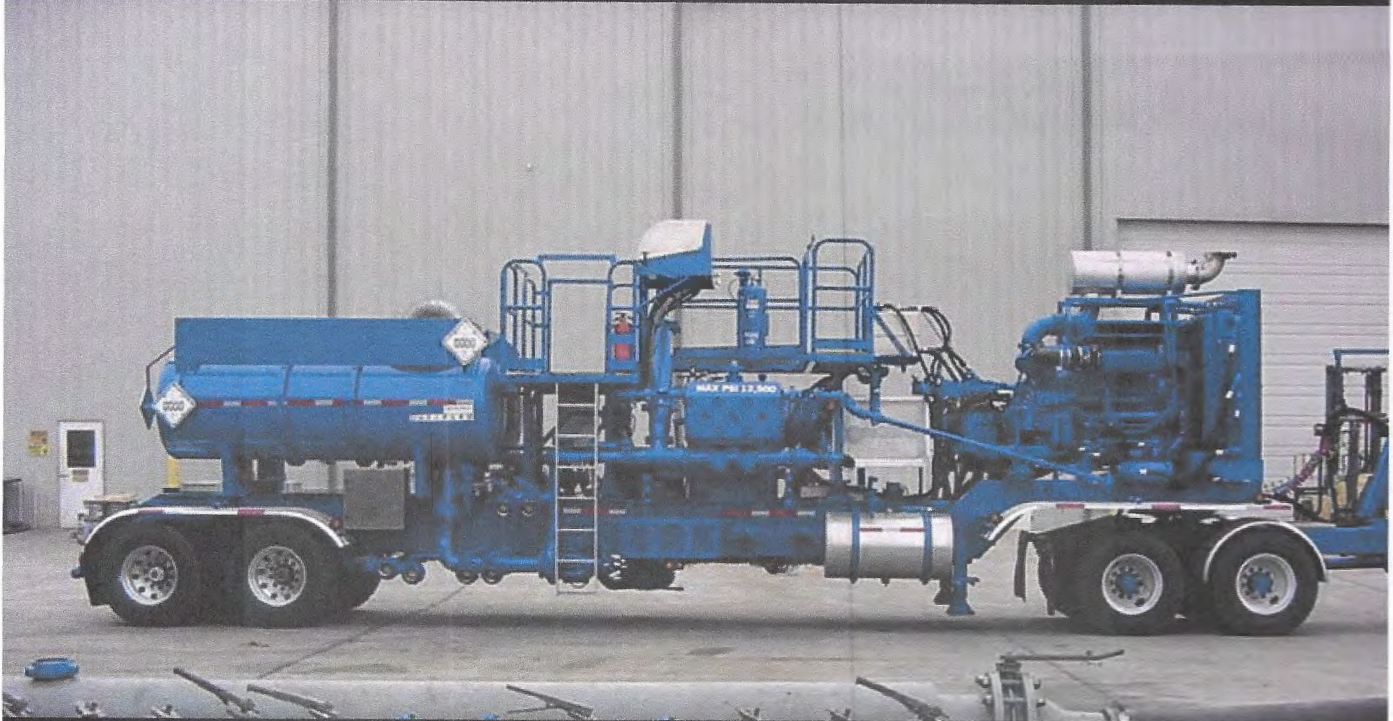


Acidizing Units

Stewart & Stevenson Acidizing Units bring high horsepower pumping, acid transportation, and fluid mixing capabilities to the wellsite in a single unit package. The efficient and fully integrated design of the units allow operators to accomplish multiple acidizing treatments in rapid succession. Our flexible designs provide many different configuration options with varying power to tailor a fit-for-purpose unit to meet the demands of various formations and treatment programs.

- Units are available in trailer mounted, bodyload, and tractor mounted with transport trailer versions.
- Different piping system materials (Stainless Steel, Hastalloy, and Carbon Steel) are available to fit any application and budget.
- Stand Alone Data Acquisition Systems (Stewart & Stevenson DAQPAQ) can be added to any unit to provide real time monitoring and recording with a post job report for the customer.
- Stewart & Stevenson can provide skid mounted blending systems for offshore applications.





Flexibility

Our Acidizing Booster Module can be added to a Stewart & Stevenson Fracturing Pump for high horsepower treatments.

STEWART & STEVENSON ACIDIZING UNITS

MODEL	AT-601 TRAILER MOUNTED UNIT	AT-851 TRAILER MOUNTED UNIT	AT-1001 TRAILER MOUNTED UNIT	AC-501 BODYLOAD UNIT	AC-501 TRACTOR MOUNTED UNIT
CARRIER TYPE	Stewart & Stevenson Trailer	Stewart & Stevenson Trailer	Stewart & Stevenson Trailer	Kenworth, Mercedes Benz, or Other Truck Chassis	Kenworth, Mercedes Benz, or Other Truck Chassis
CARRIER DRIVE CONFIGURATION	Tandem Air Ride	Tandem Air Ride	Tandem Air Ride	6×4, 6×6, 8×4, 8×6, or 8×8	6×4 or 6×6
SIZE: L × W × H	37'11" × 8'6" × 13'6"	41'6" × 8'6" × 13'6"	41'6" × 8'6" × 13'6"	37'7" × 8'6" × 13'2"	25'10" × 8'6" × 13'2"
ENGINE*	MTU DD Series 60	MTU DD 12V2000	MTU DD 12V2000	Truck Chassis Engine	Truck Chassis Engine
ENGINE RATING	600 bhp	850 bhp	1000 bhp	500 bhp	500 bhp
MAX. AMBIENT TEMP.	115 °F	115 °F	115 °F	115 °F	115 °F
TRANSMISSION	Allison 4700 OFS	Allison S6610	Allison S8610	Truck Chassis Transmission	Truck Chassis Transmission
PUMP	Triplex	Quintuplex	Quintuplex	Triplex	Triplex
ACID TRANSPORTATION CAPABILITY	1500 gal	1500 gal	1500 gal	1000 gal	Transport Trailer (3000–5000 gal)
MIXING TUB	Optional	Optional	Optional	Optional	Optional
COLD WEATHER PACKAGE	Optional	Optional	Optional	Optional	Optional
DATA ACQUISITION SYSTEM	Optional	Optional	Optional	Optional	Optional

* Other manufacturers available



Support Equipment

Stewart & Stevenson is able to provide all of the necessary Stimulation support equipment required to complete various treatments. Our comprehensive list of support equipment includes:

- Quality control and lab units
- CO₂ equipment
- High and low pressure manifold trailers, trucks and skids
- Proppant transport and storage systems
- Mobile jobsite laboratories
- Treating line safety restraint trailers
- Field iron transports
- Centrifugal pump units



Aftermarket Support

Like the quality craftsmanship that goes into our products, Aftermarket Support is a century-old tradition at Stewart & Stevenson. We provide:

- **Equipment Commissioning**—Wherever your equipment is put into service, our certified technicians and trainers will travel there to ensure that your equipment is properly installed, fully serviced, fully operational, and that your personnel are trained to operate your equipment.
- **Service and Maintenance**—Life-cycle service management of your oilfield equipment includes periodic maintenance, emergency repair, refurbishment, overhauls, and upgrades. We have 690 certified technicians at 53 locations around the globe that provide worldwide equipment repair and service.
- **Parts**—We keep in stock certified OEM parts and have a wide network of vendor suppliers of parts and components, with an experienced, knowledgeable staff to handle your needs.

From 3-D design to lean manufacturing flow line to aftermarket support, Stewart & Stevenson provides state-of-the-art stimulation equipment and service.



Stewart & Stevenson

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On the Web

www.stewartandstevenson.com



Building For The Next Century



STEWART & STEVENSON CONTROL CENTERS



CONTROL CENTERS

Stewart & Stevenson Control Centers centralize all oilfield equipment operations in sturdy, insulated cabins. Based on a 16-foot skid, in a 20-foot trailer, or in a 26-foot van with lab, Control Centers can contain the following:

- ▶ Engineering and job monitoring computer systems
- ▶ Power generation and distribution equipment
- ▶ Data acquisition systems
- ▶ Equipment control stations
- ▶ Communication equipment

Designed to be "oilfield tough", standard units are capable of operating for prolonged periods where ambient temperatures range from -40°C to $+50^{\circ}\text{C}$. They can be driven over the nongrade road surfaces typically found in windy, dusty oilfield environments. Stewart & Stevenson Control Centers provide a suitable operating environment for company service engineers, operators and customer representatives.

Stewart & Stevenson

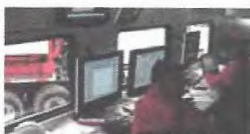
10750 Telge Road
Houston, Texas 77095
281-345-5100
controls.info@ssss.com
controls.service@ssss.com



REAR VIEW OF INTERIOR

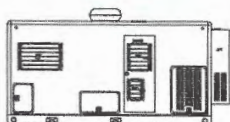


TOUCH SCREEN PC BASED INTELLIGENT PUMP CONTROL CONSOLE

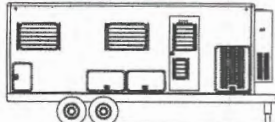


TREATER CONTROL STATION

16' SKID



20' TRAILER



26' VAN WITH LAB



FEATURES

- ▶ Cabin packaging options
 - Skid mounted
 - Trailer mounted
 - Truck mounted
- ▶ State-of-the-art computer equipment
- ▶ Flat panel monitors mounted throughout cabin on walls and counters
- ▶ Multiple frac pump controls
- ▶ Blender controls
- ▶ Data acquisition system with real time report and analysis software
- ▶ Communications systems for outdoor/indoor personnel
- ▶ Generator options
- ▶ Multiple interior layouts
- ▶ Cable reel compartment accessible from outside and lockable
- ▶ Insulated metal walls, side doors, counters, storage windows
- ▶ Software for design modeling
- ▶ Pressure, flow and density measurement devices
- ▶ Roof or wall mounted air conditioner and heater
- ▶ Storage compartments

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BUILDING FOR THE NEXT CENTURY





BUILDING FOR THE NEXT CENTURY





Building For The Next Century

Quality engineered well-servicing products manufactured by Stewart & Stevenson have supported the worldwide oil and gas industry since the 1950s. Today our stimulation equipment with technically advanced controls is aiding in improving the production of oil and gas in onshore and offshore fields from Texas to China, in the Gulf of Mexico and the Caspian Sea, in Middle East deserts and the coldest regions of Siberia, and at numerous other locations around the globe.

Stewart & Stevenson's fully integrated stimulation equipment works as a system to perform fracturing treatment. It includes:

- ▶ Fracturing Pumps
- ▶ Blenders
- ▶ Chemical Additive and Hydration Systems
- ▶ Acidizing Equipment
- ▶ Support Equipment
- ▶ Data Acquisition and Control Centers

More than 50 years of fracturing equipment experience goes into the design and manufacture of every unit in the stimulation system. In-house engineering, software development and quality control teams give Stewart & Stevenson complete control of product development, providing equipment that is on the leading edge of technology while ensuring maximum reliability.

- ▶ Stewart & Stevenson designs and builds fit-for-purpose systems to meet each operating region's specific environment.
- ▶ Our control systems development group provides advanced control systems for single and multiple pieces of equipment, as well as controls and data acquisition software for data vans from which complete control of an operation is possible—remotely, with wireless technology.
- ▶ Our dedicated quality control is involved in all phases of design and construction, resulting in consistent quality that minimizes maintenance requirements.

Stewart & Stevenson's fully integrated stimulation system improves job quality, simplifies equipment operation and requires fewer trained operators to perform a fracturing treatment.

Specialized Support

Stewart & Stevenson technicians travel to customer locations around the globe to provide equipment training, commissioning and servicing. Customers also have access to equipment service at Stewart & Stevenson product support centers strategically located near onshore and offshore oil and gas fields in the United States and in a number of the world's major energy producing countries.



Integrated Controls

Stewart & Stevenson's fully integrated control platform provides unparalleled job quality through centralized control, while requiring fewer trained operators.



Fracturing Pumps

Stewart & Stevenson's Fracturing Pumps are designed to provide optimal horsepower in a maneuverable package. Our fit-for-purpose units are field proven to provide reliable operation in the harshest environments.

- ▶ Stewart & Stevenson's Intelligent Pump Control (IPC) combines advanced unit controls and diagnostics with a touchscreen interface capable of controlling up to 24 units from a single workstation.
- ▶ Trailer mounted units are available in triplex and quintuplex packages that are weight legal with high ambient cooling packages.
- ▶ Bodyload units are designed to transverse the roughest terrain and operate in the harshest environments.
- ▶ Maintenance friendly features and high strength materials ensure reliable operation.



STIMULATION SYSTEMS



Pioneering Technology

Stewart & Stevenson has pioneered the development of high horsepower fracturing units with emissions compliance.

STEWART & STEVENSON FRACTURING PUMPS

MODEL	FT-2251-T TRAILER MOUNTED FRAC	FT-2551-Q TRAILER MOUNTED FRAC	FC-2251 BODYLOAD FRAC	FS-2251 SKID MOUNTED FRAC
CARRIER TYPE	Stewart & Stevenson Trailer	Stewart & Stevenson Trailer	Kenworth, Mercedes Benz, or Other Truck Chassis	Oilfield Skid
CARRIER DRIVE CONFIGURATION	Tandem or Tridem Air Ride	Tandem or Tridem Air Ride	6×4, 6×6, 8×4, 8×6, or 8×8	N/A
SIZE: L × W × H	42'0" × 8'6" × 13'6"	42'0" × 8'6" × 13'6"	37'7" × 8'6" × 13'2"	27'0" × 8'0" × 10'6"
ENGINE	DD12V4000, CAT 3512, or Cummins QSK-50	DD12V4000, CAT 3512, or Cummins QSK-50	DD12V4000, CAT 3512, or Cummins QSK-50	DD12V4000, CAT 3512, or Cummins QSK-50
ENGINE RATING	2250 bhp (2500 and 3000 optional)	2250 bhp (2500 and 3000 optional)	2250 bhp (2500 and 3000 optional)	2250 bhp (2500 and 3000 optional)
MAXIMUM AMBIENT OPERATING TEMPERATURE	120 °F	120 °F	120 °F	120 °F
TRANSMISSION	Allison S9820	Allison S9820	Allison S9820	Allison S9820
PUMP	Triplex	Quintuplex	Triplex or Quintuplex	Triplex or Quintuplex
CONTROL SYSTEM	Stewart & Stevenson IPC	Stewart & Stevenson IPC	Stewart & Stevenson IPC	Stewart & Stevenson IPC
WIRELESS CONTROL OPTION	Optional	Optional	Optional	Optional
COLD WEATHER PACKAGE	Optional	Optional	Optional	Optional



Fracturing Blenders

Stewart & Stevenson's Fracturing Blenders provide industry-leading job performance and reliability. Our Blenders allow operators to mix complex fracturing slurries with varying densities for the most complex jobs.

- ▶ Stewart & Stevenson's AccuFrac System provides automated density and chemical controls in a user-friendly interface from the unit or Data Van.
- ▶ The unique Stewart & Stevenson concentric mixing chamber provides accurate and homogenous proppant mixing at both low and high rates without air entrainment.
- ▶ Highly efficient closed loop hydraulic systems provide faster response than open loop systems while consuming less power and producing less waste heat for longer component life and reduced maintenance requirements.



STIMULATION SYSTEMS



Proven Experience

Stewart & Stevenson developed the world's first 100 bbl/min blender in 1959.

STEWART & STEVENSON BLENDER

MODEL	MT-132 TRAILER MOUNTED BLENDER	MT-102 TRAILER MOUNTED BLENDER	MC-100 BODYLOAD BLENDER	MC-60 BODYLOAD BLENDER	MS-60 SKID MOUNTED BLENDER	MS-30 SKID MOUNTED BLENDER
MAXIMUM DISCHARGE RATE	130+ bbl/min	100 bbl/min	100 bbl/min	60 bbl/min. (75 bbl/min. optional)	60 bbl/min	30 bbl/min
MAXIMUM DISCHARGE DENSITY	21 lb/gal	21 lb/gal	21 lb/gal	21 lb/gal	21 lb/gal	21 lb/gal
MAXIMUM PROPPANT INPUT RATE	21,250 lb/min (optional higher rates are available)	21,250 lb/min (optional higher rates are available)	16,000 lb/min (optional higher rates are available)	16,000 lb/min (optional higher rates are available)	16,000 lb/min (optional higher rates are available)	6000 lb/min (optional higher rates are available)
CARRIER TYPE	Stewart & Stevenson Trailer	Stewart & Stevenson Trailer	Kenworth, Mercedes Benz, or Other Truck Chassis	Kenworth, Mercedes Benz, or Other Truck Chassis	Oilfield Skid	Oilfield Skid
CARRIER DRIVE CONFIGURATION	Tandem Air Ride	Tandem Air Ride	6×4, 6×6, 8×4, 8×6, or 8×8	6×4, 6×6, 8×4, 8×6, or 8×8	N/A	N/A
SIZE: L × W × H	48'0" × 8'6" × 13'6"	48'0" × 8'6" × 13'6"	36'8" × 8'6" × 13'2"	34'8" × 8'6" × 13'2"	24'8" × 8'6" × 12'0"	19'6" × 8'6" × 8'0"
MIXING CHAMBER	Concentric Tub with Automatic Level Control	Concentric Tub with Automatic Level Control	Concentric Tub with Automatic Level Control	Concentric Tub with Automatic Level Control	Concentric Tub with Automatic Level Control	Hydrojet Tub
DRIVE SYSTEM	Two (2) Diesel Engines	Two (2) Diesel Engines	One (1) Truck Engine and One (1) Deck Engine	One (1) Truck Engine	One (1) Diesel Engine	One (1) Diesel Engine
TOTAL HORSEPOWER	1450 bhp (total)	1130 bhp	1050 bhp	500 bhp	600 bhp	330 bhp
NUMBER OF LIQUID ADDITIVE SYSTEMS	Up to 6	Up to 6	Up to 6	Up to 6	Up to 6	Up to 6
NUMBER OF DRY ADDITIVE SYSTEMS	Up to 2	Up to 2	Up to 2	Up to 2	Up to 2	Up to 2
DISCHARGE PUMP	14×12	14×12	14×12	8×10	8×10	5×6
SUCTION PUMP	12×12	12×10	12×10	8×10	8×10	5×6
AUTOMATED CONTROL SYSTEM	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac
WIRELESS CONTROL	Optional	Optional	Optional	Optional	Optional	Optional
COLD WEATHER PACKAGE	Optional	Optional	Optional	Optional	Optional	Optional

7



Chemical Additive and Hydration Systems

Stewart & Stevenson's combination Chemical Additive and Hydration Systems provide on-the-fly polymer injection and hydration to eliminate post job waste while increasing slurry viscosity. Stewart & Stevenson also offers stand alone Chemical Additive Systems to inject chemicals at multiple sites, depending upon each specific chemical's requirement.

- ▶ Stewart & Stevenson's AccuFrac Chemical controller provides automated chemical injection dosage control with varying rates from the Blender, Hydration Unit and other external sources.
- ▶ Our variable level Hydration chamber allows for final stage rundown to eliminate gelled fluid disposal problems.
- ▶ The Chemical Additive Units are equipped with quick-changeout tank systems to allow operators to replenish chemicals at the yard in a few minutes versus hours required for a refill.



STIMULATION SYSTEMS



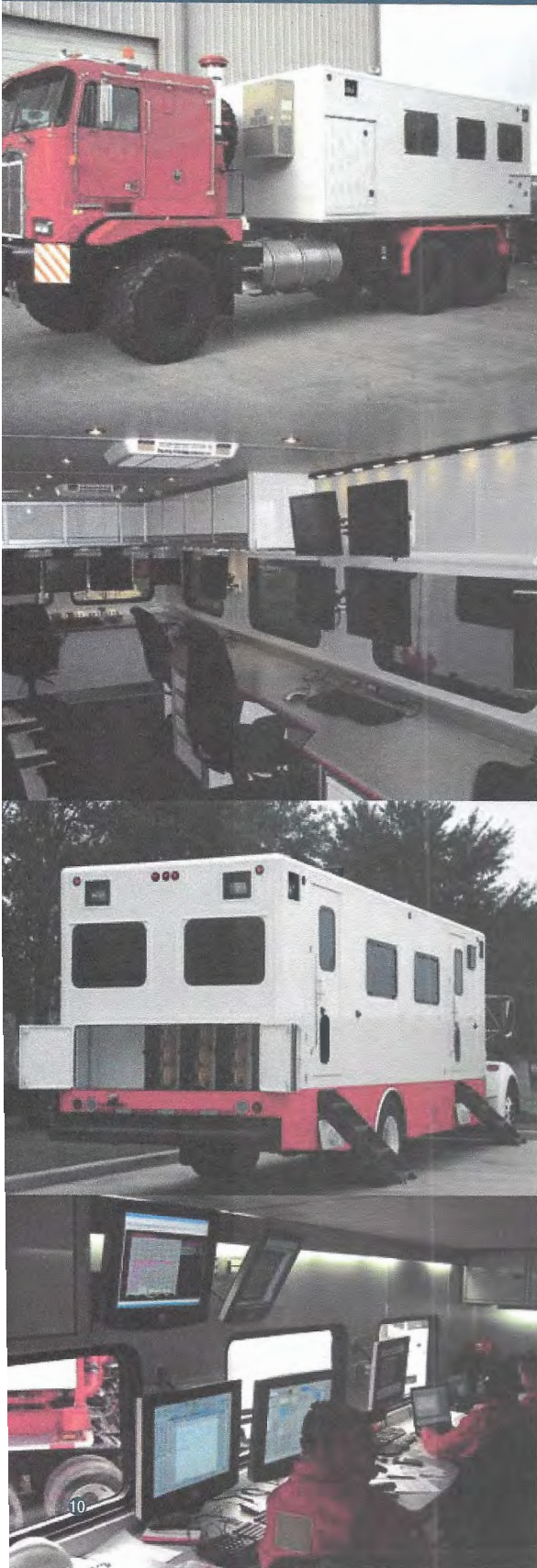
Custom Designs

Stewart & Stevenson can provide a custom designed injection system for proprietary polymer systems.

STEWART & STEVENSON CHEMICAL ADDITIVE AND HYDRATION UNITS

MODEL	CT-10CAS	CC-6CAS	CT-5CAS/BT-200	CT-5CAS/BT-100	CS-6CAS/BT-80
CARRIER TYPE	Stewart & Stevenson Trailer	Kenworth, Mercedes Benz, or Other Truck Chassis	Stewart & Stevenson Trailer	Stewart & Stevenson Trailer	Oilfield Skid
CARRIER DRIVE CONFIGURATION	Tandem Air Ride	6x4, 6x6, 8x4, 8x6, or 8x8	Tandem Air Ride	Tandem Air Ride	N/A
SIZE: L x W x H	46'0" x 8'6" x 13'6"	37'6" x 8'6" x 12'6"	48'0" x 8'6" x 13'6"	44'0" x 8'6" x 13'6"	39'6" x 11'0" x 25'0"
ENGINE	Dual DD D706 or CAT/Cummins option	Truck Chassis Engine Driven	DD Series 60 or CAT/Cummins option	DD Series 60 or CAT/Cummins option	DD Series 60 or CAT/Cummins option
ENGINE RATING	110 bhp (each)	400 bhp (minimum)	600 bhp	500 bhp	500 bhp
NUMBER OF CHEMICAL INJECTION CIRCUITS	10	6	5	5	6
PUMP TYPE	Progressive Cavity, Lobe, Piston, or Gear	Progressive Cavity, Lobe, Piston, or Gear	Progressive Cavity, Lobe, Piston, or Gear	Progressive Cavity, Lobe, Piston, or Gear	Progressive Cavity, Lobe, Piston, or Gear
HYDRATION TANK VOLUME	N/A	N/A	200 bbl	100 bbl	80 bbl
MAXIMUM HYDRATION TANK PUMP INLET RATE	N/A	N/A	100 bbl/min	60 bbl/min	50 bbl/min
CONTROL SYSTEM	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac	Stewart & Stevenson AccuFrac
WIRELESS CONTROL	Optional	Optional	Optional	Optional	Optional
TRANSFER PUMP SYSTEM	Standard	Standard	Standard	Standard	Standard
ENVIRONMENTAL ENCLOSURE	Optional	Optional	Optional	Optional	Optional

9



Data Acquisition and Control Centers (Data Vans)

Stewart & Stevenson's Data Acquisition and Control Centers provide a centralized command center to control all of the critical wellsite equipment while monitoring, recording, and supervising the fracturing treatment. The Data Acquisition and Control Center reduces the number of equipment operators required to complete the treatment while greatly improving job quality through centralized real-time data gathering and presentation.

- ▶ Stewart & Stevenson's IPC-PC interface provides control of up to 24 Fracturing Pumps at a single operator workstation.
- ▶ Stewart & Stevenson's AccuFrac-PC interface provides control of multiple Blenders, Hydration Units, and Chemical Additive Units from the Data Acquisition and Control Center.
- ▶ UPS systems and solid-state CPU components provide reliable operation with backup systems.
- ▶ Our control systems are available as discrete components, giving our customers the ability to upgrade their existing equipment.
- ▶ The wireless control options provide a "cable free" wellsite, eliminating all issues with damaged equipment cables and contaminated connections.



STIMULATION SYSTEMS



Advanced Controls

AccuFrac-PC's data displays are easily customized to meet the evolving needs of each customer.

STEWART & STEVENSON DATA ACQUISITION & CONTROL UNITS

MODEL	EC-26- ACD	EC-22-ACD	EC-8ACD	ET-40-ACD
CONTROL CABIN SIZE L x W x H	26'0" x 8'0" x 7'8"	22'0" x 8'0" x 7'8"	12'0" x 7'0" x 6'6"	40'0" x 8'0" x 7'8"
CARRIER TYPE	Kenworth, Mercedes Benz, or Other Truck Chassis	Kenworth, Mercedes Benz, or Other Truck Chassis	Kenworth, Mercedes Benz, or Other Truck Chassis	Stewart & Stevenson Trailer
CARRIER DRIVE CONFIGURATION	4x2, 4x4, 6x4, or 6x6	4x2, 4x4, 6x4, or 6x6	4x2, 4x4, 6x4, or 6x6	Tandem Air Ride
MAXIMUM NUMBER OF FRACTURING UNIT CONTROLS	24	24	16	24
MAXIMUM NUMBER OF BLENDER CONTROLS	2	2	2	2
MAXIMUM NUMBER OF CHEMICAL ADDITIVE / HYDRATION CONTROLS	2	2	2	2
NUMBER OF DISCRETE PHYSICAL DATA CHANNELS	16	16	16	16
NUMBER OF VIRTUAL DATA CHANNELS	500	500	250	500
FRACTURING PUMP CONTROL SYSTEM	IPC - PC	IPC - PC	IPC - PC	IPC - PC
BLENDER, CHEMICAL ADDITIVE, AND HYDRATION CONTROL SYSTEM	AccuFrac - PC	AccuFrac - PC	AccuFrac - PC	AccuFrac - PC
TOUCHSCREEN IPC - PC INTERFACES	3	3	2	3
INDUSTRIAL COMPUTERS	3	3	2	3
ACCUFRAC - PC AND MODELING SOFTWARE SCREENS	7	6	4	7
PRINTERS	2	2	1	2
GENERATOR SYSTEM	20 kW Chassis Engine Driven	10 kW Stand Alone Diesel Engine	5 kW Chassis Engine Driven	20 kW Stand Alone Diesel Engine
COMMUNICATION SYSTEM	5-Station Internal Intercom, 18 External Radios	4-Station Internal Intercom, 12 External Radios	3-Station Internal Intercom, 12 External Radios	5-Station Internal Intercom, 18 External Radios
WIRELESS CONTROL	Option	Option	Option	Option



Acidizing Units

Stewart & Stevenson Acidizing Units bring high horsepower pumping, acid transportation, and fluid mixing capabilities to the wellsite in a single unit package. The efficient and fully integrated design of the units allow operators to accomplish multiple acidizing treatments in rapid succession. Our flexible designs provide many different configuration options with varying power to tailor a fit-for-purpose unit to meet the demands of various formations and treatment programs.

- ▶ Units are available in trailer mounted, bodyload, and tractor mounted with transport trailer versions.
- ▶ Different piping system materials (Stainless Steel, Hastalloy, and Carbon Steel) are available to fit any application and budget.
- ▶ Stand Alone Data Acquisition Systems (Stewart & Stevenson DAQPAQ) can be added to any unit to provide real time monitoring and recording with a post job report for the customer.
- ▶ Stewart & Stevenson can provide skid mounted blending systems for offshore applications.



STIMULATION SYSTEMS



Flexibility

Our Acidizing Booster Module can be added to a Stewart & Stevenson Fracturing Pump for high horsepower treatments.

STEWART & STEVENSON ACIDIZING UNITS

MODEL	AT-601 TRAILER MOUNTED UNIT	AT-851 TRAILER MOUNTED UNIT	AT-1001 TRAILER MOUNTED UNIT	AC-501 BODYLOAD UNIT	AC-501 TRACTOR MOUNTED UNIT
CARRIER TYPE	Stewart & Stevenson Trailer	Stewart & Stevenson Trailer	Stewart & Stevenson Trailer	Kenworth, Mercedes Benz, or Other Truck Chassis	Kenworth, Mercedes Benz, or Other Truck Chassis
CARRIER DRIVE CONFIGURATION	Tandem Air Ride	Tandem Air Ride	Tandem Air Ride	6x4, 6x6, 8x4, 8x6, or 8x8	6x4 or 6x6
SIZE: L x W x H	37'11" x 8'6" x 13'6"	41'6" x 8'6" x 13'6"	41'6" x 8'6" x 13'6"	37'7" x 8'6" x 13'2"	25'10" x 8'6" x 13'2"
ENGINE	DD Series 60 or CAT/ Cummins option	DD12V2000 or CAT/ Cummins option	DD12V2000 or CAT/ Cummins option	Truck Chassis Engine	Truck Chassis Engine
ENGINE RATING	600 bhp	850 bhp	1000 bhp	500 bhp	500 bhp
MAX. AMBIENT TEMP.	115 °F	115 °F	115 °F	115 °F	115 °F
TRANSMISSION	Allison 4700 OFS	Allison S6610	Allison S8610	Truck Chassis Transmission	Truck Chassis Transmission
PUMP	Triplex	Quintuplex	Quintuplex	Triplex	Triplex
ACID TRANSPORTATION CAPABILITY	1500 gal	1500 gal	1500 gal	1000 gal	Transport Trailer (3000–5000 gal)
MIXING TUB	Optional	Optional	Optional	Optional	Optional
COLD WEATHER PACKAGE	Optional	Optional	Optional	Optional	Optional
DATA ACQUISITION SYSTEM	Optional	Optional	Optional	Optional	Optional





Support Equipment

Stewart & Stevenson is able to provide all of the necessary Stimulation support equipment required to complete various treatments. Our comprehensive list of support equipment includes:

- ▶ Quality control and lab units
- ▶ CO₂ equipment
- ▶ High and low pressure manifold trailers, trucks and skids
- ▶ Proppant transport and storage systems
- ▶ Mobile jobsite laboratories
- ▶ Treating line safety restraint trailers
- ▶ Field iron transports
- ▶ Centrifugal pump units



Aftermarket Support

Like the quality craftsmanship that goes into our products, Aftermarket Support is a century-old tradition at Stewart & Stevenson. We provide:

- ▶ **Equipment Commissioning**—Wherever your equipment is put into service, our certified technicians and trainers will travel there to ensure that your equipment is properly installed, fully serviced, fully operational, and that your personnel are trained to operate your equipment.
- ▶ **Service and Maintenance**—Life-cycle service management of your oilfield equipment includes periodic maintenance, emergency repair, refurbishment, overhauls, and upgrades. We have 650 certified technicians at 47 locations around the globe that provide worldwide equipment repair and service.
- ▶ **Parts**—We keep in stock certified OEM parts and have a wide network of vendor suppliers of parts and components, with an experienced, knowledgeable staff to handle your needs.

From 3-D design to lean manufacturing flow line to aftermarket support, Stewart & Stevenson provides state-of-the-art stimulation equipment and service.



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