AccuFrac+™ plus

AccuFrac+™ User's Guide

STEWART & STEVENSON®

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1. Introduction to AccuFrac+

The AccuFrac+ system, developed by Stewart & Stevenson, controls proppant and chemical delivery. Once blender functions have been pre-programmed into the computer, the system makes it possible for the blender to carry out the most complicated stimulation programs without operator assistance during the job. The basic function of the system is to create base fluid and proppant mixtures.

1.1 Understanding Blender Functions

The blender unit is a skid, truck or trailer-mounted assembly designed to blend the supply fracturing fluids to the fracturing unit. The blender is used to prepare the slurries and gels in stimulation or fracturing treatments onshore or offshore. The blender unit can handle a wide variety of complex fracturing tasks even in harsh oilfield conditions. Blenders are built to operate in temperature ranges of -10 °F to 115 °F (-23 °C to 46 °C) without auxiliary heating units. Auxiliary heating units are optional for Arctic climates.

Augers and hoppers are installed on the back of the blender unit. The hoppers can accept proppant from one or two trucks at a time. The auger and hopper assemblies are hydraulically positioned and can be raised and lowered. Dual auger units may have a split auger and hopper system to provide easier access to the hoppers for proppant supply trucks.

The blender tub, installed under the auger assembly discharges, can mix slurries at densities of up to 20 pounds of sand added (PSA) and rates up to 130+ barrels per minute. The tub delivers consistent blending of even high-density slurries. The tub uses a high surface area designed to minimize aeration, and a low volume capacity to prevent inconsistent slurry blending. This combination reduces the time the slurry stays in the tub, improving the accuracy of the unit's measuring, additive, and control systems. The tub has a paddle to aid the blending process. The paddle is hydraulically driven. The operator manually controls the paddle speed. Forward and reverse functions are also designed into the paddle drive.

Clear or pregelled fluid enters the tub from the side and follows a radial path within the outer fluid chamber. As the fluid circulates it flows over the lip of the chamber and into the inner slurry chamber. The high surface and inclined sides of the slurry chamber allow the fluid to mix with proppants being fed into the chamber without becoming unnecessarily aerated. Hydraulically driven, screw-type augers carry proppants from a hopper at the base of the augers into the blender tub. The mixture of fluid and proppant flows down the sides of the inner slurry chamber and into an agitating/mixing assembly installed in the base of the chamber. This hydraulically-driven assembly blends the slurry into a uniform consistency.

When the slurry leaves the agitating/mixing assembly, it passes through an open throat section of the inner radial slurry tub and enters the centrifugal discharge pump. The blender tub also features an automatic fluid level control system that works by adjusting an automated tub inlet valve or the speed of the suction pump to compensate for the level of fluid in the blender tub.

A typical frac set-up may have a hydrator which is often in-line between the fluid storage tanks and the blender. Fluid storage tanks or a reservoir at the job site store water used to mix chemicals and gelling agents. The hydrator takes "clean" water from the tanks and then sends the fluid to the blender, where additional chemicals may be added and proppant (sand) are blended together to form the slurry. The resulting slurry discharges to several manifolded together frac pumps. These frac pumps are used to pump the final slurry down hole.

1.2 System Access—Profiles

A user profile determines the access to screens in the system. Access to some screens requires a username and password. These screen icons appear with a padlock in the lower right corner.

While logged in, the user can access any screen allowed by the account profile. After a period of inactivity, the account is automatically logged out and the logo screen is launched.

1.3 Logo Screen

The logo screen is loaded each time the system is started (Figure 1). Touching the logo screen launches the Home screen.

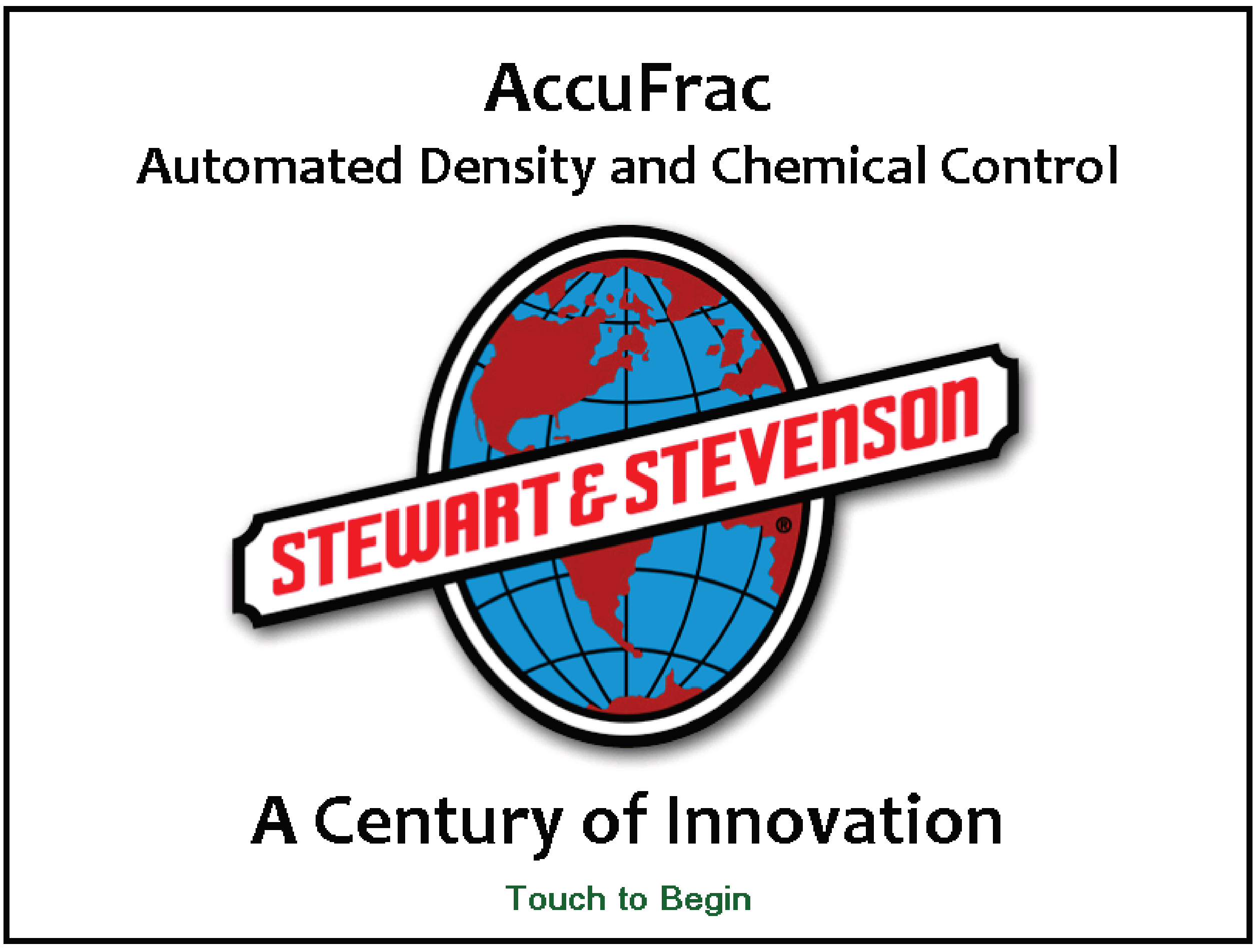
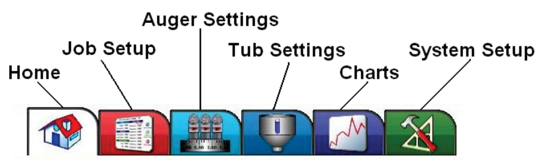


Figure 1, Logo Screen

1.4 System Navigation

Navigation through the system is controlled by touch areas shown in Table 1.

Table 1, System Navigation Touch Areas

SYSTEM NAVIGATION	
TOUCH AREA	**FUNCTION**
	A set of back and forward buttons navigate to the previous screen or forward to the next screen.
	The row of tabs across the top of the screen provides easy access to various screens. The active tab has a white background.
	The job control commands are available from any screen and are located in a column on the right side of the screen. Use of these buttons does not change the active screen.

1.5 Home Screen

The Home screen (Figure 2) is an informational display screen. The information displayed reflects the status of the job in real time.

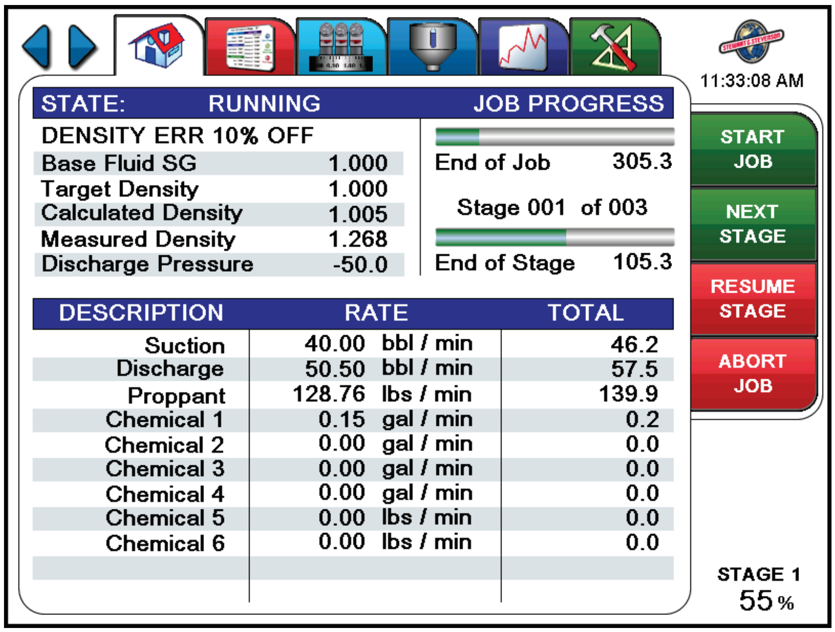


Figure 2, Home Screen

Table 2, Home Screen Fields

HOME SCREEN FIELDS		
FIELD NAME	**VALUE**	**DEFINITION**
State	Running	Currently running programmed job.
	Stopped	Job not running
Density Error	(1) Density Err < 2% (2) Density Err < 4% (3) Density Err 4% Off (4) Density Err 10% Off (5) Waiting For Discharge Flow (6) Waiting For Suction Flow (7) Job Complete (8) Job Not Set (9) Job Aborted (10) Running Remote Setpoint	This is a message field. The message is generated by the process controller.
Base Fluid SG		Represents the ratio of the density of the fracturing fluid to the density of water. The system uses the Base Fluid Specific Gravity, along with certain proppant characteristics, to convert between concentration and density.

HOME SCREEN FIELDS		
FIELD NAME	**VALUE**	**DEFINITION**
Target SGU		Concentration (or density) value programmed into the job. The value displayed depends on where the system is in the job. The system calculates the required amount of sand and which augers to use and how fast, to achieve the target concentration based on the clean water inlet rate or the slurry output rate.
Calculated SGU		Value derived from the suction and/or discharge rate and auger sand delivery
Measured S		Value measured by the densometer.
Discharge psi		Pressure of the slurry after exiting the discharge pump
Job Progress	End of job	Measures remaining job volume
	Stage 1 of X	Displays the number of the stage currently running and the number of stages programmed for this job
	End of Stage	Measures remaining stage volume
Suction	Rate: gal kgal bbl m^3 L	Rate and Total for this stage
Discharge	Rate: gal kgal bbl m^3 L	Rate and Total for this stage
Proppant	Rate: lb kg	Rate and Total for this stage
Chemical 1-6	Rate: gal L	Rates and Totals for this stage
Stage Completion	Stage number	Displays the percentage completion of the stage currently running

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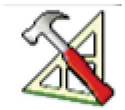
2. Using the System Setup Screen



Select the System Setup icon to select display options and access diagnostic information. The System Setup screen has several functions.

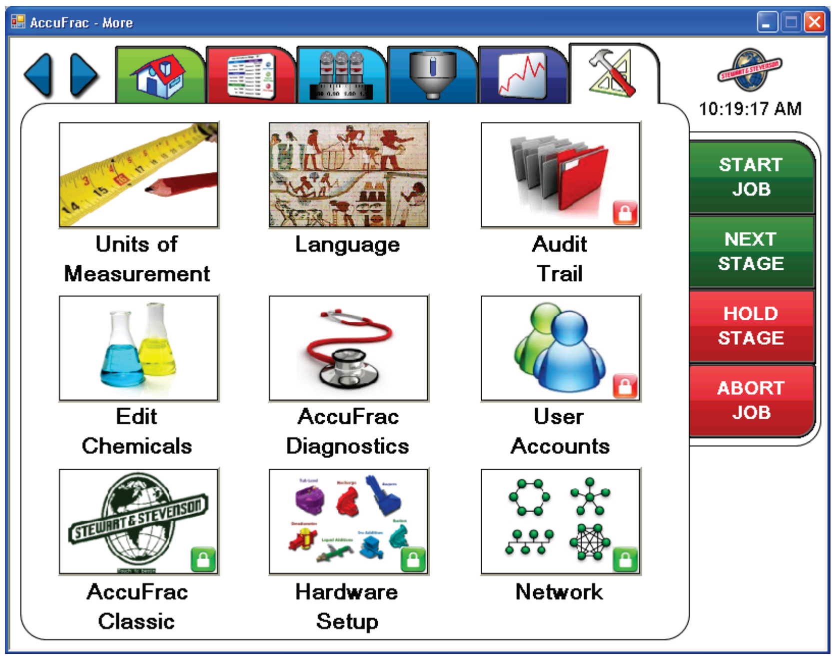


Figure 3, System Setup Screen

Table 3, System Setup Screen Icons

SETTING SCREEN ICONS	
ICON NAME	**FUNCTION**
Units of Measure	Allows choices of display units for suction/discharge, pressure, proppant, slurry density, liquid chemicals and dry chemicals
Language	Users can select the language used
Audit Trail	Password protected
Edit Chemicals	User entered chemical names, choice of base rates, bulk density, and control to auto or manual
AccuFrac+ Diagnostics	More detailed system information than shown on the Home screen; allows access to HMI diagnostics
User Accounts	Password protected
AccuFrac+ Classic	Password protected
Hardware Setup	Password protected
Network	Password protected

2.1 Select Units

Units of Measurement

Touch the Units of Measurement icon from the Settings screen to select the Units of Measurement screen. Next, choose the units for each data type by using the drop-down menus.

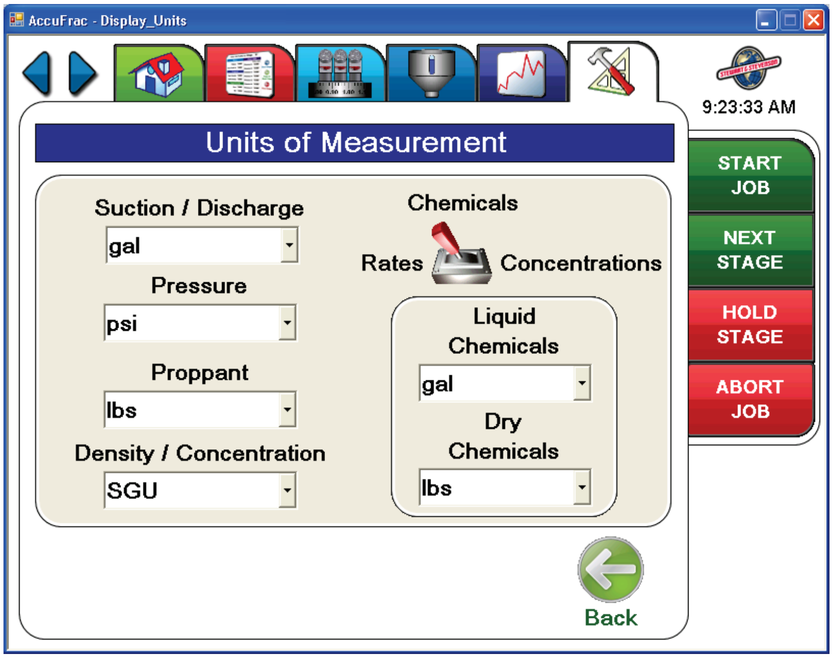


Figure 4, Units of Measurement

Table 4, Units of Measurement Fields

UNITS OF MEASUREMENT		
FIELD NAME	**VALUE**	**DEFINITION**
Suction / Discharge	gal	Gallon – one US gallon
	kgal	Kilogallon – 1,000 US gallons
	bbl	Barrels – 42 US gallons
	m^3	Cubic meters
	L	Liters
Pressure	psi	Pounds per square inch
	kPa	kilopascal; Pascal is the Standard International unit of pressure.
Proppant	lbs	Pounds
	kg	Kilogram
Density / Concentration	SGU	Ratio of the density of the slurry material (not counting air gaps between grains of sand) to water.
	PPG	Pounds per gallon of slurry
	PPA	Pounds proppant added per gallon of clean fluid. It is a concentration or ratio. It is NOT a bulk density.

UNITS OF MEASUREMENT		
FIELD NAME	**VALUE**	**DEFINITION**
	kg/m^3	Kilograms per cubic meter
Chemicals	Rates/ Concentrations	Toggle switch between rates and concentrations for Liquid Chemicals and Dry Chemicals
Liquid Chemicals	gal	US gallon
	L	Liter
Dry Chemicals	lbs	Pounds
	ft^3	Cubic feet
	kg	Kilograms
	m^3	Cubic meters

2.2 Alarms

If the system detects an error condition, the alarm indicator appears on the screen. Navigate directly to the Alarm Viewer (Figure 5) screen by touching the alarm indicator. An alarm can be active or inactive, indicating whether or not the error condition is still present. An alarm is acknowledged or unacknowledged indicating whether or not the user has acknowledged the alarm. Once an alarm is inactive and acknowledged, it no longer displays. A listing of alarms appears in Section 9, Error Conditions.

NOTE: The alarm screen can also be accessed by touching the Settings screen icon, AccuFrac+ Diagnostics, HMI Diagnostics, and then View Alarms.

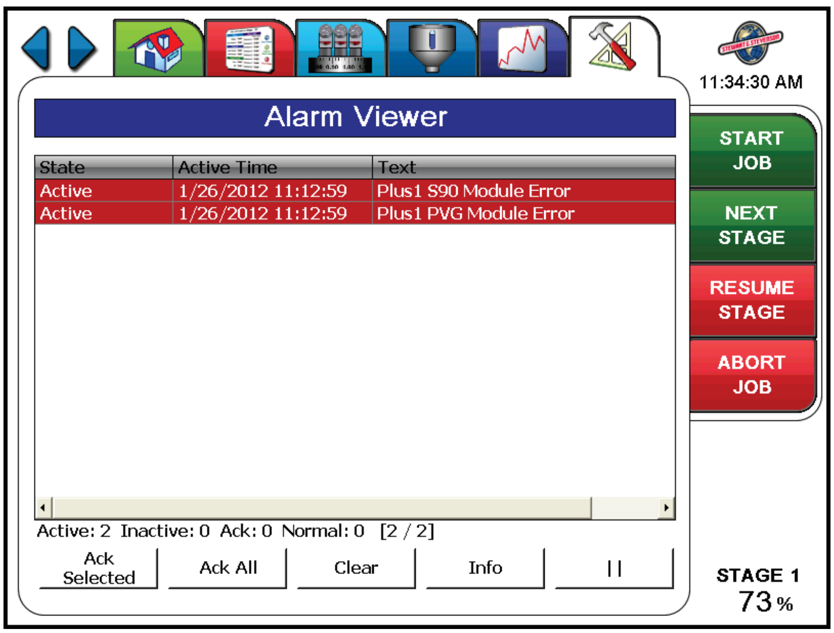


Figure 5, Alarm Viewer Screen

Table 5, Alarm Viewer Fields

ALARM VIEWER		
FIELD NAME	**VALUE**	**DEFINITION**
State	Active	Error condition currently exists and has not been acknowledged
	Inactive	Error condition no longer exists and has not been acknowledged
	Acknowledged	Error condition has been acknowledged but error still exists
	Normal	Alarm condition ended
Active Time	Month/Day/Year Hour/Minute/Second	Date and time State occurred
Text	System generated	Based on the error condition type. See Error Codes table
Ack Selected	Button activated	Acknowledge the selected alarm

ALARM VIEWER		
FIELD NAME	**VALUE**	**DEFINITION**
Ack All	Button activated	Acknowledge all active alarms
Clear	Button activated	Remove all inactive acknowledged alarms
| |	Button activated	Pause the screen

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3. Programming a Job

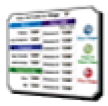
3.1 Stage Definition

A stage is defined by a volume (i.e. the length or duration of the stage), properties for the sand and other materials used during the stage, and targets or set-points for the sand rate and each chemical. The job ends when a zero length stage is reached.

3.2 Staging

Stage length can be entered as suction (the amount of clean water entering the unit) or as discharge (the total amount of sand, water, and chemicals leaving the unit).

3.3 *Entering Job Profile for Stages*



Touch the Job Profile icon to access the Enter Job Profile for Stage. Next, choose the units for each data type by using the drop-down menus.

Beginning with stage 1, enter the Volume, sand and fluid properties, and targets. The target density follows a linear ramp from the Start density to the End density over the volume of the stage. If the Start and End density are equal, the target is held throughout the stage.

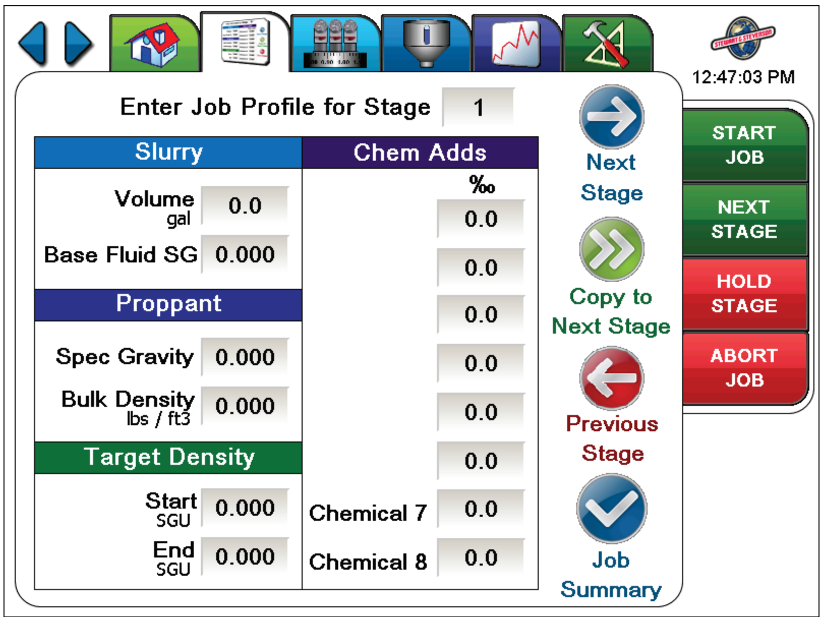


Figure 6, Enter Job Profile for Stage Screen

Table 6, Enter Job Profile Fields and Navigation

JOB PROFILE FIELDS		
FIELD NAME	**VALUE**	**DEFINITION**
Slurry	Volume	Expressed in the units selected in Units of Measurement
	Base Fluid SG	User-entered value that represents the ratio of the density of the fracturing fluid to the density of water
Proppant	Spec Gravity	User-entered value that represents the ratio of the density of the fracturing proppant to the density of water
	Bulk Density	Proppant mass per unit of volume. Can be expressed as lbs per cubic foot or kg per cubic meter
Target Density	Start	Target density of the slurry mixture at the beginning of this stage. Can also be expressed as a concentration.
	End	Target density of the slurry mixture at the end of this stage. Can also be expressed as a concentration.
Chemical Adds	Chem 1-8	Target concentration of each chemical during this stage

JOB PROFILE FIELDS		
FIELD NAME	**VALUE**	**DEFINITION**
Next Stage		Pressing the Next Stage button advances through the scheduled job stage-by-stage.
Copy to Next Stage		If you want to copy all of the current stage's settings to the next stage, touch the Copy to Next Stage button. You can then edit anything that needs to change and repeat until the final job stage as required.
Previous Stage		To back up one stage, touch the Previous Stage button.
Job Summary		You can review the programmed stage volumes and Start and End densities Job Summary.

NOTE: For programming, you can also touch the stage number to skip directly to a particular stage.

3.4 Job Summary

Touch the Job Summary button from the Enter Job Profile for Stage screen to access the Job Summary screen. This display only screen allows you to view the Job Volumes and Target Densities for the completed stages and current stage for the active job. To view totals for the job, touch the View Job Totals button.

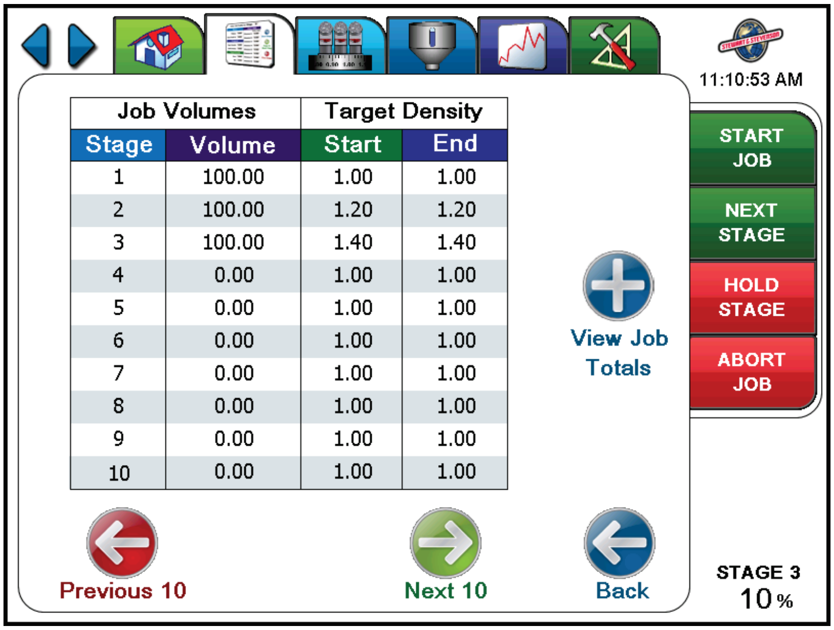


Figure 7, View Job Volumes Screen

Table 7, View Job Volumes

VIEW JOB VOLUMES	
ICON	**FUNCTION**
	Displays the Job Totals screen.
	Displays the previous 10 job volumes.
	Displays the next 10 job volumes.
	Returns the previous display screen.

3.5 View Job Totals

Touch the View Job Totals button from the View Job Volumes screen to access the Job Summary screen. The View Job Totals screen displays the planned and actual totals for the current job. To create a comparison of the programmed job to the actual usage, select the Reset Job Totals on the Start Job feature which automatically resets the totals when the job starts.

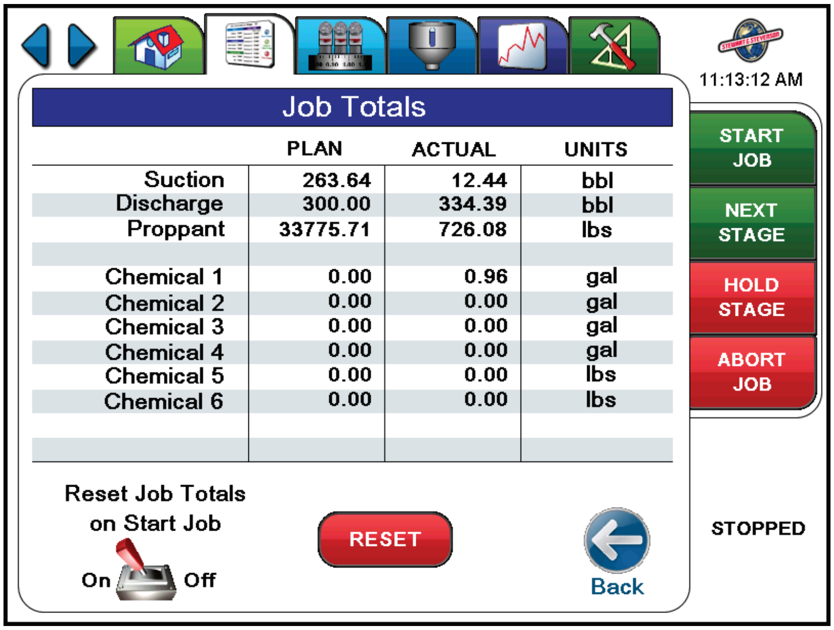


Figure 8, Job Totals

Table 8, Job Totals Fields

JOB TOTAL FIELDS	
FIELD NAME	**DEFINITION**
Plan	Shows the sum of each material required for the current job program
Actual	Total that can be reset at any time by the operator
Units	Expressed in the units selected in Units of Measurement
Reset Job Totals on Start Job	Automatically resets the totals when the job starts when toggled to the on position
RESET	Resets job totals
Back	Returns to Job Summary screen

NOTE: The totals displayed on the Job Totals screen are separate from the totals used by the system to control staging.

3.6 *Edit Chemicals*

Touch the Edit Chemicals icon from the Settings screen to access the Chemical Setup screen.

Touch the description field and enter the description for the Chemicals 1-6. The description has a 32 character limit.

The Base Rate can be selected from the drop down menu.

User-entered chemical descriptions help the operator by providing a consistent reference. The chemical additives can be labeled in whatever way makes the most sense to the operator. For example, the label can be "Dry Add 1" or "Breaker" or "Chem 5." The label will appear on all the applicable screens as well as on the individual panel-mounted displays.

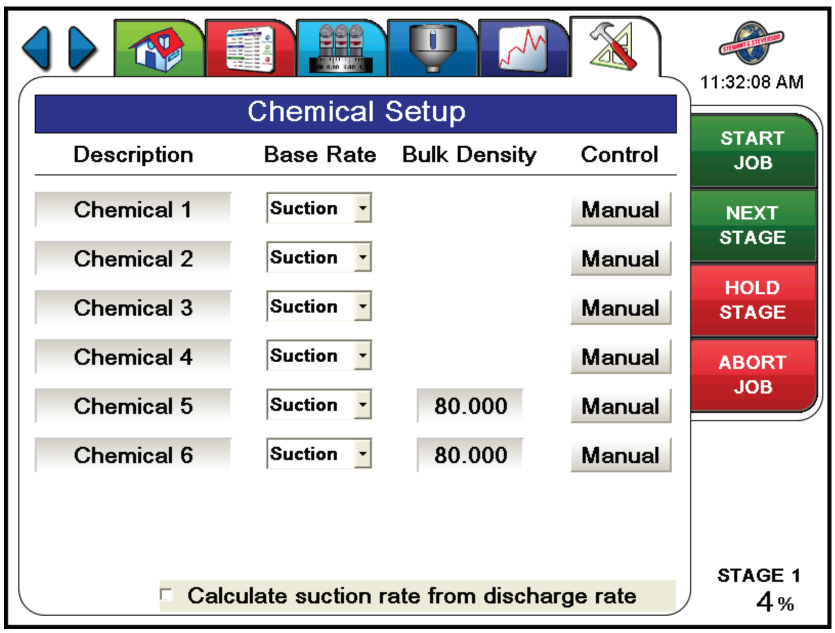


Figure 9, Chemical Setup Screen

Table 9, Chemical Setup Fields

CHEMICAL SETUP FIELDS	
FIELD NAME	**FUNCTION**
Description	Chemical 1-8; User entered chemical name or chemical description. Disabled chemicals do not display. Limit 32 characters.
Base Rate	Suction or External
Bulk Density	Only visible / necessary / meaningful for dry chemicals
Control	User selected; toggle from Manual to Auto Can also be selected from the smaller panel mounted displays
Calculate suction rate from discharge rate	Touch to check the box for calculation of the suction rate from the discharge rate (otherwise it is measured, not calculated)

4. Running a Job

4.1 Choosing Flow Meters

The blender can be equipped with up to 3 suction flow meters and up to 3 discharge flow meters. To select which flow meter signal is used, touch the FLOW METER button on the panel-mounted suction display or discharge display. The choices are Primary, Secondary, and Backup (see Section 10, Hardware Reference for complete description).

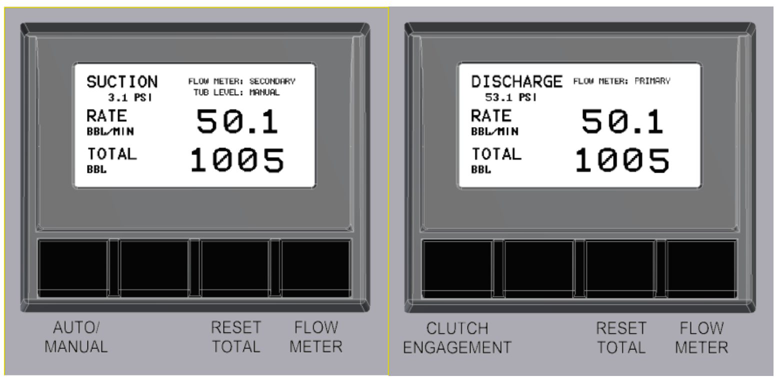


Figure 10, Flow Meter Screens

Table 10, Flow Meter Fields

SUCTION METER FIELDS	
BUTTON	**FUNCTION**
Auto/Manual	Press to toggle the Suction to either Manual or Auto
Reset Total	Resets the total anytime during the job—only affects total on this display
Flow Meter	Press to select meter: Primary, Secondary, or Backup

DISCHARGE METER FIELDS	
BUTTON	**FUNCTION**
Clutch Engagement	Engages the clutch to spin the discharge pump
Reset Total	Resets the total anytime during the job; only affects total on this display
Flow Meter	Press to select meter: Primary, Secondary, or Backup

4.2 Tub Control

Touch the icon to access the Tub Level Control screen from the Navigation Bar.

The operator can touch the Tub Level Target Bar for quick adjustments or the up and down arrows for incremental adjustments. The lower half of the screen is display only, with the exception that the tub level target can be entered directly by touching the numeric field.

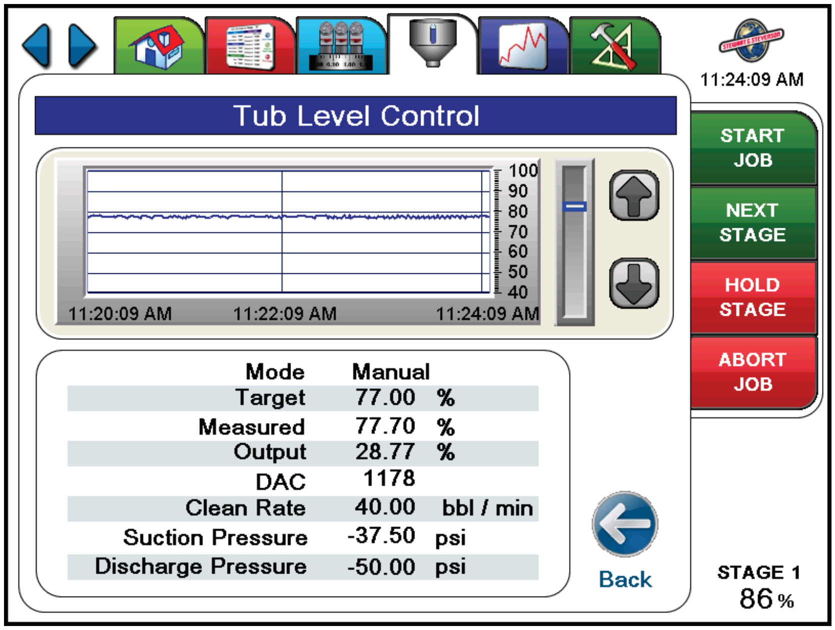


Figure 11, Tub Level Control Screen

Table 11, Tub Level Control Fields

TUB LEVEL CONTROL FIELDS	
FIELD NAME	**DEFINITION**
Mode	Manual or Auto; determined by the selection from the small panel mounted display
Target	Target Percentage of the level of fluid in the tub, 0 – 100 %
Output	Suction pump speed, 0 – 100%
DAC	Digital-to-Analog-Converter – controller output to suction pump, 0 - 4095
Clean Rate	Rate of water being introduced as determined by suction pump speed
Suction Pressure	Pressure in between the suction pump and the tub-inlet valve in units selected from the Units of Measurement screen
Discharge Pressure	Pressure of the discharge slurry after the discharge pump in units selected from the Units of Measurement screen

4.2.1 Tub Level Control

Good tub level control is essential for a successful job. In practice, a blender has no control over its discharge rate. The blender provides charge pressure to the fracturing pumps, but the fracturing pumps set the flow rate. The blender then controls the level in the mixing tub by controlling the suction rate.

In Manual mode, the suction rate (and therefore the tub level) is controlled by the operator through a potentiometer. It is completely up to the operator to monitor the level in the tub and adjust the potentiometer accordingly.

In Automatic mode, the control system monitors the tub level via the level sensor and speeds up or slows down the suction pump in order to maintain the target level. The operator sets the target in the Tub Level Control screen.

4.2.2 Suction Pressure

The Suction pressure is measured in between the suction pump and the tub-inlet valve. When rates are low, the control system has a tendency to surge because even a small output can result in too much suction flow. The higher the suction supply level (water tanks or hydration unit) is above the blender tub, the more pronounced this problem becomes. One common solution is to partially close the tub-inlet valve to create a small amount of back pressure for the suction pump. The optimal pressure can depend on several variables, but in general 5 to 10 PSI is enough to maintain steady flow.

4.2.3 Suction Hoses

For the control system to work properly, the suction pump must have adequate supply pressure (also known as Net Positive Suction Head or NPSH). A general rule-of-thumb is that under ideal conditions each 10'x 4" hose can supply about 8 barrels per minute. Conditions such as longer hose lengths or bends in the hoses can significantly reduce this number.

4.2.4 Tub Paddles

The tub paddles are an essential element of the tub's mixing energy. The operator can adjust and monitor the paddle speed using the panel-mounted display. The system maintains the paddle speed even when the viscosity and proppant concentration increases.

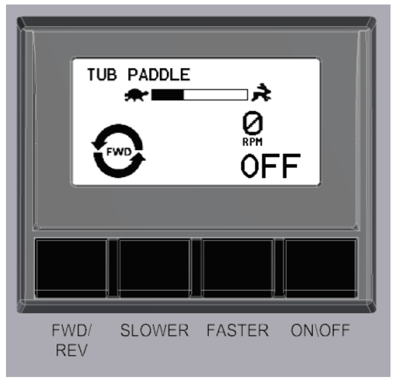


Figure 12, Tub Paddle Screen

Table 12, Tub Paddle Fields

FLOW METER FIELDS	
BUTTON	**FUNCTION**
Fwd/Rev	Press to toggle to either Forward or Reverse.
Slower	Press to reduce the speed of the Tub paddles.
Faster	Press to increase the speed of the Tub paddles.
On/Off	Press to toggle to either On or Off.

5. Auger Control

Touch the icon to access the Auger Control screen from the Navigation Bar. Auger assemblies deliver proppant from the hopper to the blender mixing tub.

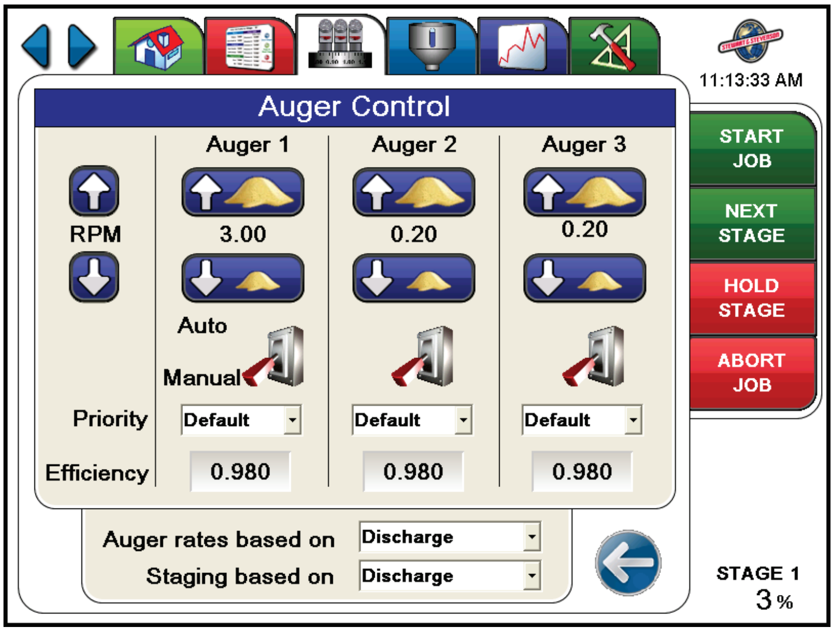
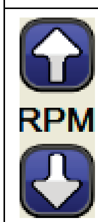


Figure 13, Auger Control Screen

Table 13, Auger Control Fields

TUB LEVEL CONTROL FIELDS	
FIELD NAME	**DEFINITION**
	The RPM up and down arrows adjust the efficiency of all three augers at once.
	Incrementally decreases the efficiency; thereby increasing the sand rate for a particular auger. Can be toggled from Auto to Manual
	Incrementally increases the efficiency; thereby, decreasing the sand rate for a particular auger. Can be toggled from Auto to Manual
Priority	Allows the operator to control which augers are used during a job either default or explicit

TUB LEVEL CONTROL FIELDS	
FIELD NAME	**DEFINITION**
Efficiency	To fine-tune the actual delivery rate, the system includes an efficiency which is a number that is multiplied by the final calculated delivery. Setting the efficiency to 1.0 causes the system to use table values without adjustment.
Auger rates based on	Suction Control- the system calculates the amount of sand required based on the current suction rate as measured by the suction flow meter. Discharge Control-the system calculates the amount of sand required based on the current discharge rate as measured by the discharge flow meter.
Staging based on	Dual Discharge-discharge from two blenders to equal the total of the sum of the discharges from the two blenders

5.1 Manual, Auto, and Load Modes for Augers

Manual

In Manual mode, an auger is controlled by a potentiometer on the operator panel. The system does not make any adjustments to the auger speed based on feedback nor does the system subtract the manual sand rate from any other augers that are running in Auto (i.e., any auger that is set to Manual is ignored by the automatic system). Any sand that is delivered in Manual mode *is* counted toward a job sand total.

Auto

When an auger is set to Auto mode, the auger is available for the system to use during a job. The system selects augers according to the operator-entered priority and the total target sand rate is divided among the selected augers.

Load

When sand is first loaded into the hopper, the auger tubes are empty. It can take 20 to 30 revolutions before sand begins to fall into the tub. To avoid this delay, many operators pre-load the auger tube with sand during the pad stage by manually turning the auger until sand appears at the discharge chute. Load mode is used to pre-load an auger tube with sand without counting the "empty" revolutions toward the sand total.

If the auger is in Auto mode when load mode is selected, the system switches the auger to manual. While in Load mode, the sand rate is displayed normally but the sand total for that auger does not accumulate or register until the "load" toggle switch is released.

5.2 Auger Efficiency

Each auger's delivery is calculated using an empirically derived table that converts the auger's speed into a volumetric proppant rate. To fine-tune the actual delivery rate, the system includes an efficiency which is a number that is multiplied by the final calculated delivery. Setting the efficiency to 1.0 causes the system to use the table values without adjustment.

An efficiency of less than 1.0 causes the control system to increase the auger's speed. The lower the efficiency the faster the system has to spin the auger to get a given amount of sand.

An efficiency of greater than 1.0 causes the system to decrease the auger's speed. The higher the efficiency the slower the system has to spin the auger to get a given amount of sand.

The RPM buttons control the efficiency of the auger. The efficiency can also be entered directly by touching the efficiency field.

5.3 Auger Priority

Auger priority allows the operator to control which augers are used during a job. The system only selects from augers that are in Auto mode. Each auger has a minimum and maximum speed and therefore each auger has a minimum and maximum sand rate. The control system will not assign a target sand rate to an auger outside of its range.

5.3.1 Default Priority

When the auger priority is set to Default, the system automatically selects which augers to use in a way that minimizes the number of transitions from one set of selected augers to another.

5.3.2 Explicit Priority

When the auger priorities are set to a specific number, the system chooses the auger with the lowest number first. Other augers are added in according to their priority only if the target sand rate exceeds the high limit of the first auger. If two or more augers are set to the same priority, they are treated as a single auger with the minimum and maximum sand rates equal to the sum of the individual limits.

5.4 Auger Control Rate

5.4.1 Auger Rates Based on Suction

When the control mode is set to Suction Control, the system calculates the amount of sand required based on the current suction rate as measured by the suction flow meter. The tub-level system manages the mixing tub level by adjusting the suction rate. The effect is that sand entering the mixing tub displaces water, thereby reducing the suction rate (i.e., as the sand rate increases the water rate decreases). The control system automatically adjusts the sand rate to match the instantaneous suction rate.

5.4.2 Auger Rates Based on Discharge

If the control mode is set to Discharge Control, the system calculates the amount of sand required based on the current discharge rate as measured by the discharge flow meter. Since the discharge rate does not change as a function of the sand rate, the initial target sand rate does not change when sand begins entering the mixing tub.

5.4.3 Considerations for Choosing Control Mode

Over the course of the job, Suction Control mode and Discharge Control mode accomplish the same results; however, in the short run there are some important differences. Suction Control mode reacts more quickly to changes and will generally reach the target concentration more quickly. The suction flow meter tends to be cleaner and more reliable due to the difficulties in measuring a suspension of solids in liquid. Discharge Control mode tends to produce steadier sand rates but depends on user-entered sand parameters to calculate the target sand rate.

5.5 Manual and Auto Chemical Control Mode

5.5.1 Manual

In Manual mode, each chemical additive system is controlled by a potentiometer on the operator panel. The system does not make any adjustments to the chemical rate based on feedback nor does the system adjust if the clean rate changes. Any chemical that is delivered in Manual mode *is* counted toward a job total for that chemical.

5.5.2 Auto

When a chemical additive system is set to Auto mode, the system sets the chemical rate according to the programmed recipe. The system monitors the appropriate base rate and adjusts the chemical rate so that the dosing matches the target.

5.5.3 Base Rates

Each chemical additive system allows for two different base rates by which to control the recipe. These are the local suction rate as measured (on the unit on which the chemical pumps or dry add hoppers are mounted), or an external rate originating from other equipment (such as a hydrator).

5.6 *Job Controls*

5.6.1 Start Job

The Start Job command is used to begin processing the pre-programmed job. If the rate used to control staging is zero, the controller immediately enters a waiting state. As soon as flow is detected, the controller begins controlling to the programmed targets.

5.6.2 Hold Stage and Resume

The Hold Stage command will cause the system to hold the current target until the Resume button is pushed. While the job is held, the length of the current stage grows at the same rate as the control volume. The end of job volume is pushed back accordingly.

Figure 14 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 the hold button is pressed. During the time while the stage is held, the end of the stage and end of job are continuously pushed back. The operator presses the Resume button 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.

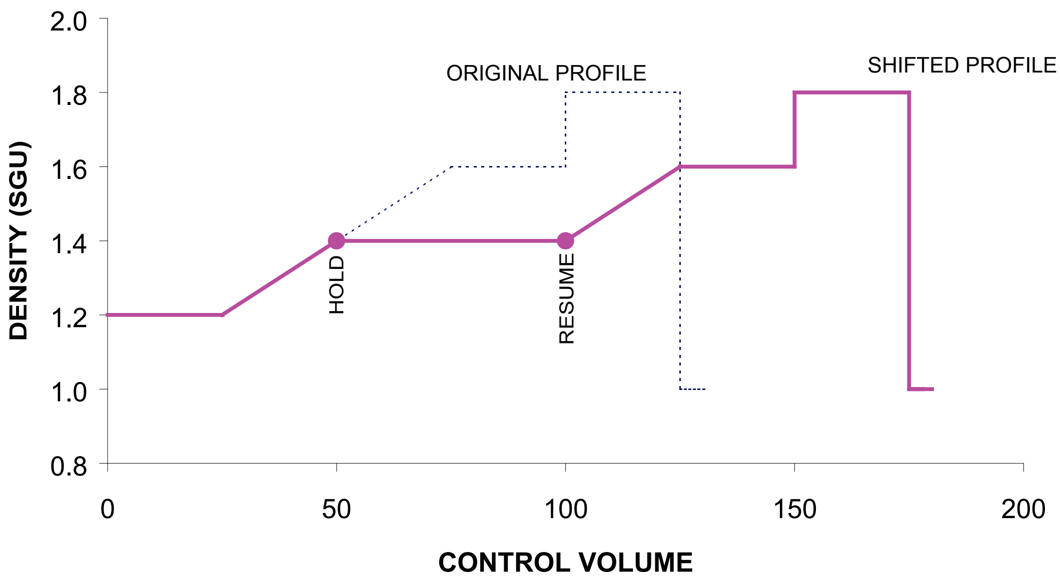


Figure 14, Hold Function Effect on Ramp

In this example, stage two was originally programmed for a volume of 50 units; but when the job is over, stage two is programmed for 100 units.

5.6.3 Abort Job

The Abort Job button stops the current job. The augers are stopped, but the programmed job is not affected. Subsequently pushing START JOB will begin the job again from the beginning. There is no way to **resume** an aborted job.

5.6.4 Next Stage

The Next Stage function causes the system to immediately advance to the next stage. The remainder of the current stage is discarded and the operator-programmed value for the length of the current stage is set to the current stage volume. In the example illustrated in Figure 15, stage two 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.

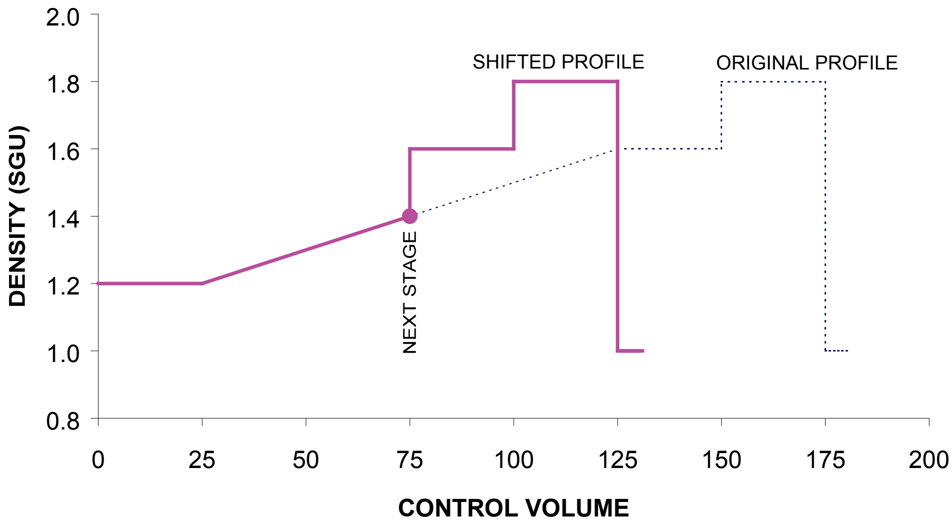


Figure 15, Effect of Next Stage Function on Ramp

5.6.5 Modifying a Running Job

Changes can be made to a job currently executing. Changes to stages not yet run take effect when the stage runs. If the length of a stage is changed, it will affect the end of job value. Changes to the current stage 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 job been programmed that way originally.

The slope is recalculated as a straight line from the original beginning point to the new ending point.

In the example shown in Figure 16, 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, where it would have been had the job been programmed for 200 units originally. Changing the beginning and ending density for the stage has a similar effect.

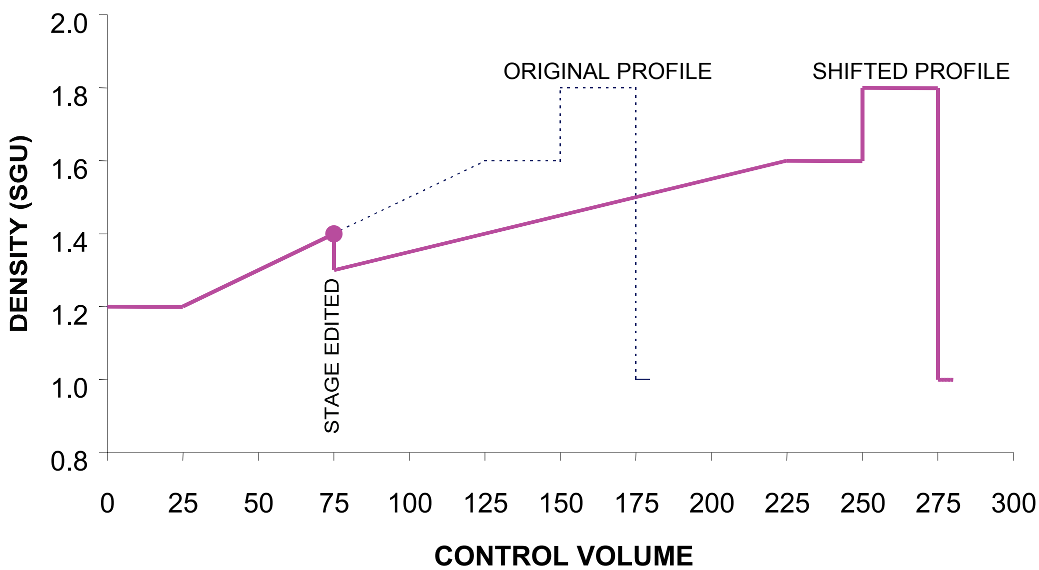


Figure 16, Effect of Lengthening a Ramp Stage during Execution

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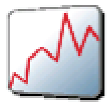
6. Monitoring Trends



Touch the icon to access the Monitoring Trends screen from the Navigation Bar.
The Monitoring Trends screen allows the operator to view the trends of a job over time.

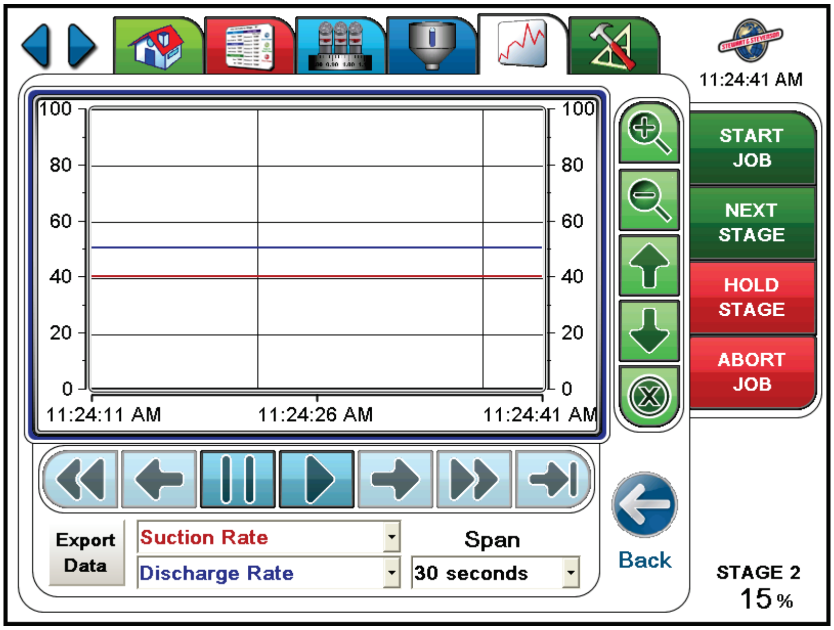
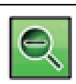
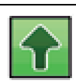
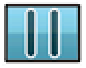
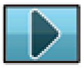
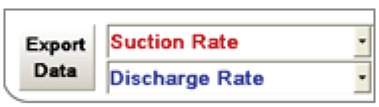


Figure 17, Trends Screen

Table 14, Trend Fields

TUB LEVEL CONTROL FIELDS	
FIELD NAME	**DEFINITION**
	Zoom in
	Zoom out
	Scroll Up
	Scroll Down
	Stop Scrolling
	Scroll right
	Scroll incrementally to the left

TUB LEVEL CONTROL FIELDS	
FIELD NAME	**DEFINITION**
	Pause
	Resume
	Scroll incrementally to the right
	Scroll right
	Scroll to the current time
	Return to the previous screen
	Exports last hour of data for each of the each variables available for trending by the red or blue pen
Data Point-Red	Selects which variable trended by the red pen from the top drop down box Values: Chemical 1 Target Density Chemical 2 Calculated Density Chemical 3 Discharge Pressure Chemical 4 Suction Rate Chemical 5 Discharge Rate Chemical 6 Proppant Rate Chemical 7 Tub Level Chemical 8
Data Point-Blue	Selects which variable trended by the blue pen from the bottom drop down box Values: Chemical 1 Target Density Chemical 2 Calculated Density Chemical 3 Discharge Pressure Chemical 4 Suction Rate Chemical 5 Discharge Rate Chemical 6 Proppant Rate Chemical 7 Tub Level Chemical 8

TUB LEVEL CONTROL FIELDS	
FIELD NAME	**DEFINITION**
Span	Increment to show on the time line Values: 30 Seconds 1 minute 4 minutes 10 minutes 30 minutes

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7. Diagnostics

7.1 AccuFrac+ Diagnostics

AccuFrac Diagnostics

Touch the icon to access the AccuFrac+ Diagnostics screen from the System Setup screen. The AccuFrac+ Diagnostics screen allows the operator to view the job status in more detail than the Home Screen.

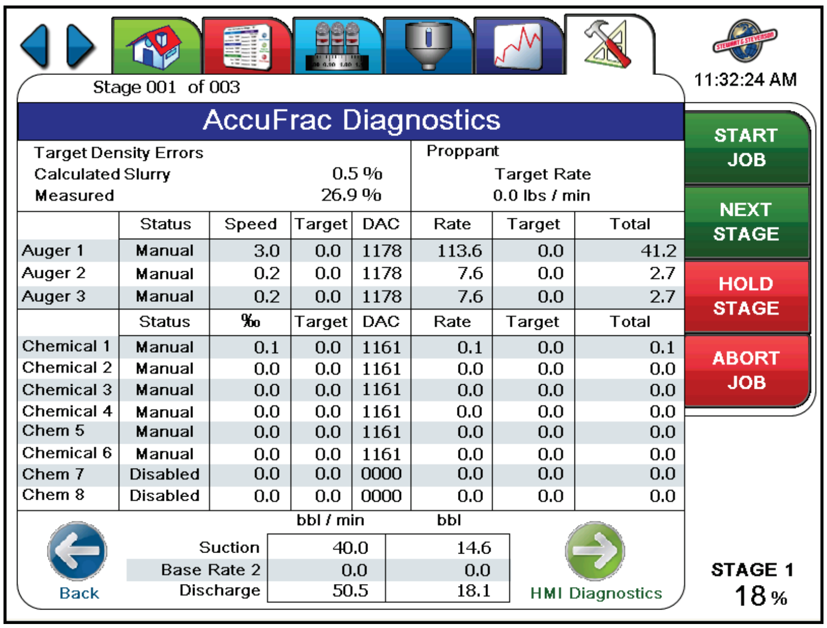

Figure 18, AccuFrac+ Diagnostics Screen

Table 15, AccuFrac+ Diagnostic Fields

ACCUFRAC+ DIAGNOSTICS		
FIELD NAME	**VALUE**	**DEFINITION**
Stage X of Y	X Current Stage Y Number of Programmed Stages	The current stage running of the total programmed stages
Target Density Errors	Calculated Slurry	Percentage error rate of actual delivery rate as compared to the desired target rate of the chemical pump
	Measured	
Auger 1-3	Status	Indicates whether the auger is in manual or automatic mode
	Speed	Actual delivery rate of the chemical pump
	Target	Target delivery rate of the chemical pump
	DAC	Digital to Analog converter count

ACCUFRAC+ DIAGNOSTICS		
FIELD NAME	**VALUE**	**DEFINITION**
Chemical 1-8	Status	Auto or Manual or Disabled
	‰	Symbol used to denote concentration. It is equivalent to parts-per-thousand or tenths of a percent. For liquid chemicals it means the units of chemical added to each 1000 units of clean water (i.e., gallons/1000 gallons, liters/m^3). For dry chemicals the units are lbs/1000 gallons or kg/m^3.
	Target	Target Concentration
	DAC	Digital to Analog Converter count
Proppant	Target Rate	Target combined proppant delivery rate
	Rate	Measured proppant delivery rate for each auger
	Target	Target proppant delivery rate for each auger
	Total	Measured proppant total
Suction		Suction rate and total
Base Rate 2		Base rate 2 rate and total
Discharge		Discharge rate and total
		Return to the previous display screen
		Proceed to the HMI Diagnostics screen

7.2 HMI Diagnostics

Touch the HMI Diagnostics button to access the HMI Diagnostics screen from the AccuFrac+ Diagnostics screen. The HMI Diagnostics screen allows the operator to view the status of the computer interface with the blender and also allows access to the View Alarms screen.

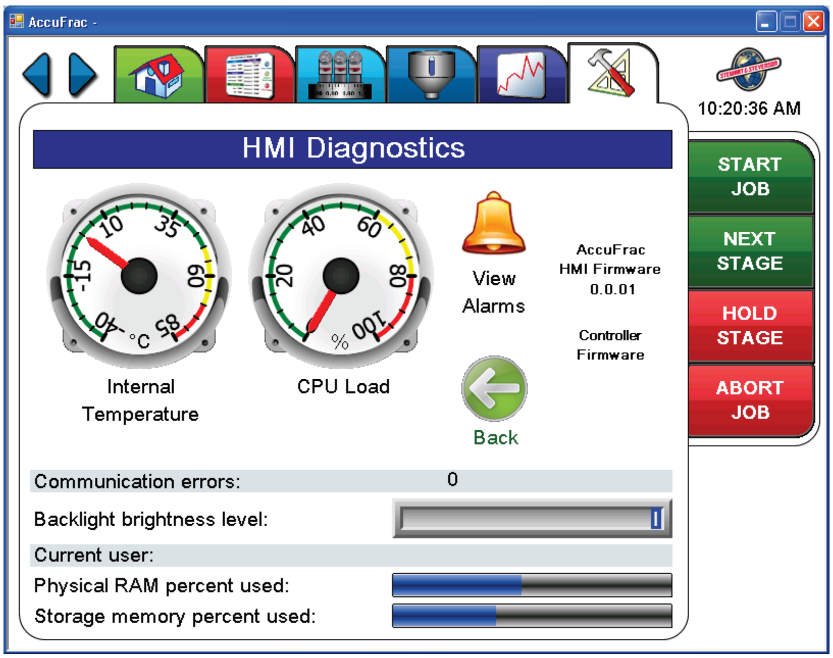

Figure 19, HMI Diagnostics

Table 16, HMI Diagnostic Fields

ACCUFRAC+ DIAGNOSTICS		
FIELD NAME	**VALUE**	**DEFINITION**
Internal Temperature Gauge	0-85 °C	Internal temperature of the display
CPU Load	0-100	Usage of the CPU expressed as a percentage of the total available
View Alarms		Touch to display the Alarm screen
AccuFrac+ HMI Firmware	0.0.01	Display firmware version
Controller Firmware	3.73	Controller firmware version
Communication Error		0 represents no communication errors. 1 represents a communication error between the display and the AccuFrac+ controller
Backlight brightness level	0-100%	Backlight strength of the screen
Current User		Login ID for the operator currently logged into to the system

ACCUFRAC+ DIAGNOSTICS		
FIELD NAME	**VALUE**	**DEFINITION**
Physical RAM percent used	0-100%	Amount of Random Access Memory currently in use expressed as a percentage of the total available
Storage memory percent used	0-100%	Amount of storage memory currently in use expressed as a percentage of the total available

8. Language

8.1 Select Language

Language

To access the Language screen, press the icon on the System Setup screen. The Select Language screen displays with flags representing the language choices. Press the appropriate flag to select the desired language.

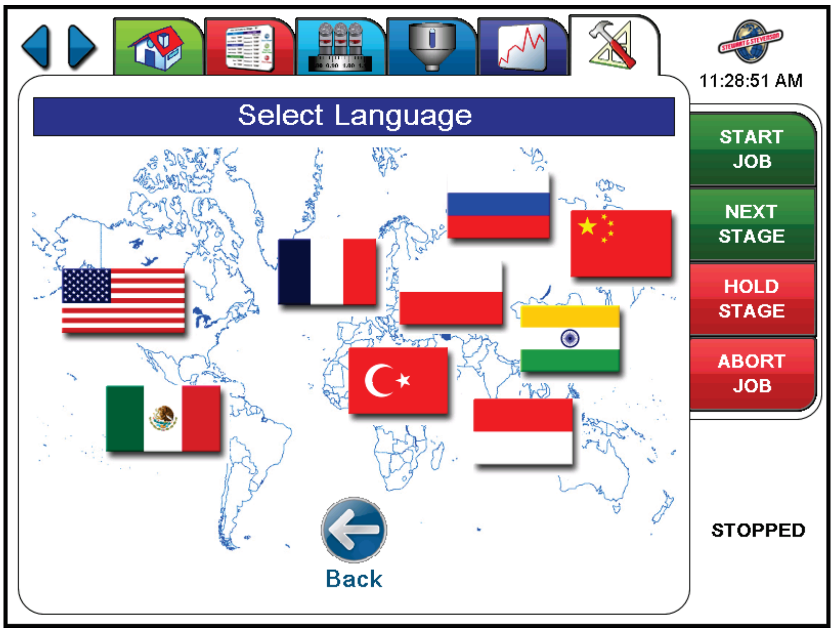

Figure 20, Language Screen

 Chinese

 English

 French

 Hindi

 Indonesian

 Polish

 Russian

 Spanish

 Turkish

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9. Error Conditions

9.1 Panel Display Alarms

Table 17, Panel Display Alarms

PANEL DISPLAY ALARMS		
SYMBOL	**NAME OF ALARM**	**DEFINITIION**
	Target under range	The target is too low. The controller is programmed to run below its low limit.
	Target over range	The target is too high. The controller is programmed to run above its high limit.
	Sensor calibration error	The system has detected that the feedback sensor is not properly calibrated.
	Output calibration error	The system has detected that the control output is not properly calibrated.
	Output on, no feedback	The controller is trying to drive the device but not seeing any feedback. The device may be stuck or otherwise non-functioning or the feedback sensor may be malfunctioning.
	PID not set	The closed-loop control parameters are not properly set.
	High limit set to zero	The device is effectively disabled because the high limit is set to zero.
	Analog output not set	The output used to control this device is not set up properly.

9.2 System Alarms

An alarm is activated and stored in the display's alarm database if communication to a network device is disrupted or cannot be established. The list shows the possible alarm messages.

I/O Expansion Module #1 Error

I/O Expansion Module #2 Error

Analog Control Module Error

Open-Loop Control Module Error

Closed-Loop Control Module Error

Main Control Module Communication Error

Auger MicroDisplay Communication Error

Chemical 1 MicroDisplay Communication Error

Chemical 2 MicroDisplay Communication Error

Chemical 3 MicroDisplay Communication Error

Chemical 4 MicroDisplay Communication Error

Chemical 5 MicroDisplay Communication Error

Chemical 6 MicroDisplay Communication Error

Chemical 7 MicroDisplay Communication Error

Chemical 8 MicroDisplay Communication Error

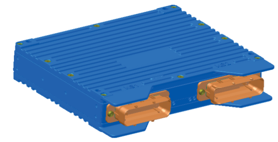
System MicroDisplay Communication Error

Tub Paddle MicroDisplay Communication Error

Suction MicroDisplay Communication Error

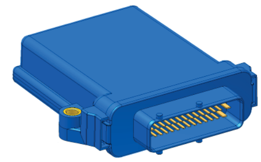
Discharge MicroDisplay Communication Error

10. Hardware Reference



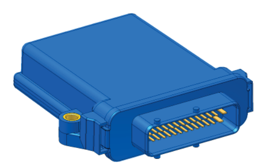
10.1 Signal Reference Main Control Module

Function	Signal	Connector	Pin	Standard
Suction Flow meter (Primary)	Frequency	KS1	11	Magnetic Flow Meter
Suction Flow meter (Secondary)	Frequency	KS2	65	Low Rate Turbine Flow Meter
Suction Flow meter (Backup)	Frequency	KS2	27	Turbine Flow Meter
Discharge Flow meter (Primary)	Frequency	KS1	69	Magnetic Flow Meter
Discharge Flow meter (Secondary)	Frequency	KS1	28	Low Rate Turbine Flow Meter
Discharge Flow meter (Backup)	Frequency	KS2	46	Turbine Flow Meter
Paddle Speed Feedback	Frequency	KS2	66	Encoder (300 pulses/rev)
Auger 1 Feedback	Frequency	KS1	70	Encoder (300 pulses/rev)
Auger 2 Feedback	Frequency	KS1	12	Encoder (300 pulses/rev)
Auger 3 Feedback	Frequency	KS1	31	Encoder (300 pulses/rev)
Chemical 1 Feedback	Frequency	KS1	30	Coriolis Flow Meter or Encoder (360 pulses/rev)
Chemical 2 Feedback	Frequency	KS1	49	Coriolis Flow Meter or Encoder (360 pulses/rev)
Chemical 3 Feedback	Frequency	KS1	68	Coriolis Flow Meter or Encoder (360 pulses/rev)
Chemical 4 Feedback	Frequency	KS1	10	Coriolis Flow Meter or Encoder (360 pulses/rev)
Chemical 5 Feedback	Frequency	KS1	29	Coriolis Flow Meter or Encoder (360 pulses/rev)
Chemical 6 Feedback	Frequency	KS1	48	Coriolis Flow Meter or Encoder (360 pulses/rev)
Chemical 7 Feedback	Frequency	KS1	67	Coriolis Flow Meter or Encoder (360 pulses/rev)
Chemical 8 Feedback	Frequency	KS1	9	Coriolis Flow Meter or Encoder (360 pulses/rev)
Bulkhead 1- 2nd discharge	Frequency	KS1	50	
Bulkhead 2 (placeholder)	Frequency	KS2	8	
Density Feedback	4-20mA	KS2	47	
Tub Level Feedback	4-20mA	KS2	28	
Clutch	Digital Output	KS1	32	
RS485 D+	RS-485	KS1	59	
RS485 D-	RS-485	KS1	58	
TX+	Ethernet	KS1	61	
TX-	Ethernet	KS1	62	
RX+	Ethernet	KS1	80	
RX-	Ethernet	KS1	81	
CAN1_H	CAN BUS	KS1	7	
CAN1_L	CAN BUS	KS1	26	
CAN2_H	CAN BUS	KS1	45	
CAN2_L	CAN BUS	KS1	64	
CAN3_H	CAN BUS	KS2	63	
CAN3_L	CAN BUS	KS2	44	
CAN4_H	CAN BUS	KS2	25	
CAN4_L	CAN BUS	KS2	6	
TX	RS-232	KS1	44	
RX	RS-232	KS1	63	



10.2 Signal Reference ESX-IOX I/O Module 1

Function	Signal	Connector	Pin	Standard
Chemical 1 Potentiometer	0-32VDC	ESX-IOX 1	13	
Chemical 2 Potentiometer	0-32VDC	ESX-IOX 1	3	
Chemical 3 Potentiometer	0-32VDC	ESX-IOX 1	4	
Chemical 4 Potentiometer	0-32VDC	ESX-IOX 1	5	
Chemical 5 Potentiometer	0-32VDC	ESX-IOX 1	6	
Chemical 6 Potentiometer	0-32VDC	ESX-IOX 1	7	
Chemical 7 Potentiometer	0-32VDC	ESX-IOX 1	8	
Chemical 8 Potentiometer	0-32VDC	ESX-IOX 1	9	
Battery Voltage	0-32VDC	ESX-IOX 1	10	
Self Test	Wired to Pin32	ESX-IOX 1	21	
CANopen NodeID	Left float	ESX-IOX 1	22	
pH input	4-20mA	ESX-IOX 1	24	
System Air Pressure	4-20mA	ESX-IOX 1	25	
Hydraulic Temperature	4-20mA	ESX-IOX 1	26	
Viscosity	4-20mA	ESX-IOX 1	27	
Tachometer	RPM	ESX-IOX 1	33	
Calculated/Actual Clean Rate	DIN	ESX-IOX 1	35	
CANopen NodeID	Left float	ESX-IOX 1	36	
Base Rate 1	4-20mA	ESX-IOX 1	38	

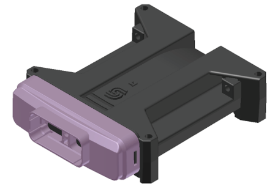


10.3 Signal Reference ESX-IOX I/O Module 2

Function	Signal	Connector	Pin	Standard
Auger 1 Potentiometer	0-32VDC	ESX-IOX 2	13	
Auger 2 Potentiometer	0-32VDC	ESX-IOX 2	3	
Auger 3 Potentiometer	0-32VDC	ESX-IOX 2	4	
Suction Potentiometer	0-32VDC	ESX-IOX 2	5	
Discharge Potentiometer	0-32VDC	ESX-IOX 2	6	
Tub Inlet Potentiometer	0-32VDC	ESX-IOX 2	7	
Auger 1 Load	DIN	ESX-IOX 2	9	
Auger 2 Load	DIN	ESX-IOX 2	10	
Auger 3 Load	DIN	ESX-IOX 2	11	
Self Test	Wired to Pin32	ESX-IOX 2	21	
CANopen NodeID	Left float	ESX-IOX 2	22	
Suction Pressure	4-20mA	ESX-IOX 2	24	
Discharge Pressure	4-20mA	ESX-IOX 2	25	
Bulkhead Pressure 1	4-20mA	ESX-IOX 2	26	
Bulkhead Pressure 2	4-20mA	ESX-IOX 2	27	
CANopen NodeID	Connect to GND	ESX-IOX 2	36	
Tub Inlet Valve Feedback	4-20mA	ESX-IOX 2	38	
Base Rate 2	4-20mA	ESX-IOX 2	39	

10.4 Signal Reference Closed-loop Control Module

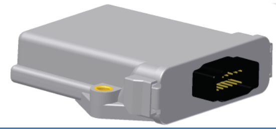
Function	Signal	Connector	Pin	Standard
Power Gnd -	GND	22200470-01	P1	
Power Supply +	12/24 VDC +	22200470-01	P2	
CAN +	CAN BUS 4	22200470-01	P3	
CAN -	CAN BUS 4	22200470-01	P4	
AIN/CAN0 Shield	AIN/CAN0 Shield	22200470-01	P5	
Address Input A	Connect to Power	22200470-01	P10	
Address Input B	Connect to GND	22200470-01	P11	
Address Input C	Connect to GND	22200470-01	P12	
S90 #1 Pin A, Ground B	PWMOUT	22200470-01	P37	
S90 #1 Pin D, Ground C	PWMOUT	22200470-01	P38	
S90 #2 Pin A, Ground B	PWMOUT	22200470-01	P39	
S90 #2 Pin D, Ground C	PWMOUT	22200470-01	P40	
S90 #3 Pin A, Ground B	PWMOUT	22200470-01	P42	
S90 #3 Pin D, Ground C	PWMOUT	22200470-01	P43	
S90 #4 Pin A, Ground B	PWMOUT	22200470-01	P44	
S90 #4 Pin D, Ground C	PWMOUT	22200470-01	P45	
Power Supply +	12/24 VDC +	22200470-01	P47	
Power Supply +	12/24 VDC +	22200470-01	P48	
Power Supply +	12/24 VDC +	22200470-01	P49	
Power Supply +	12/24 VDC +	22200470-01	P50	



10.5 Signal Reference Open-loop Control Module

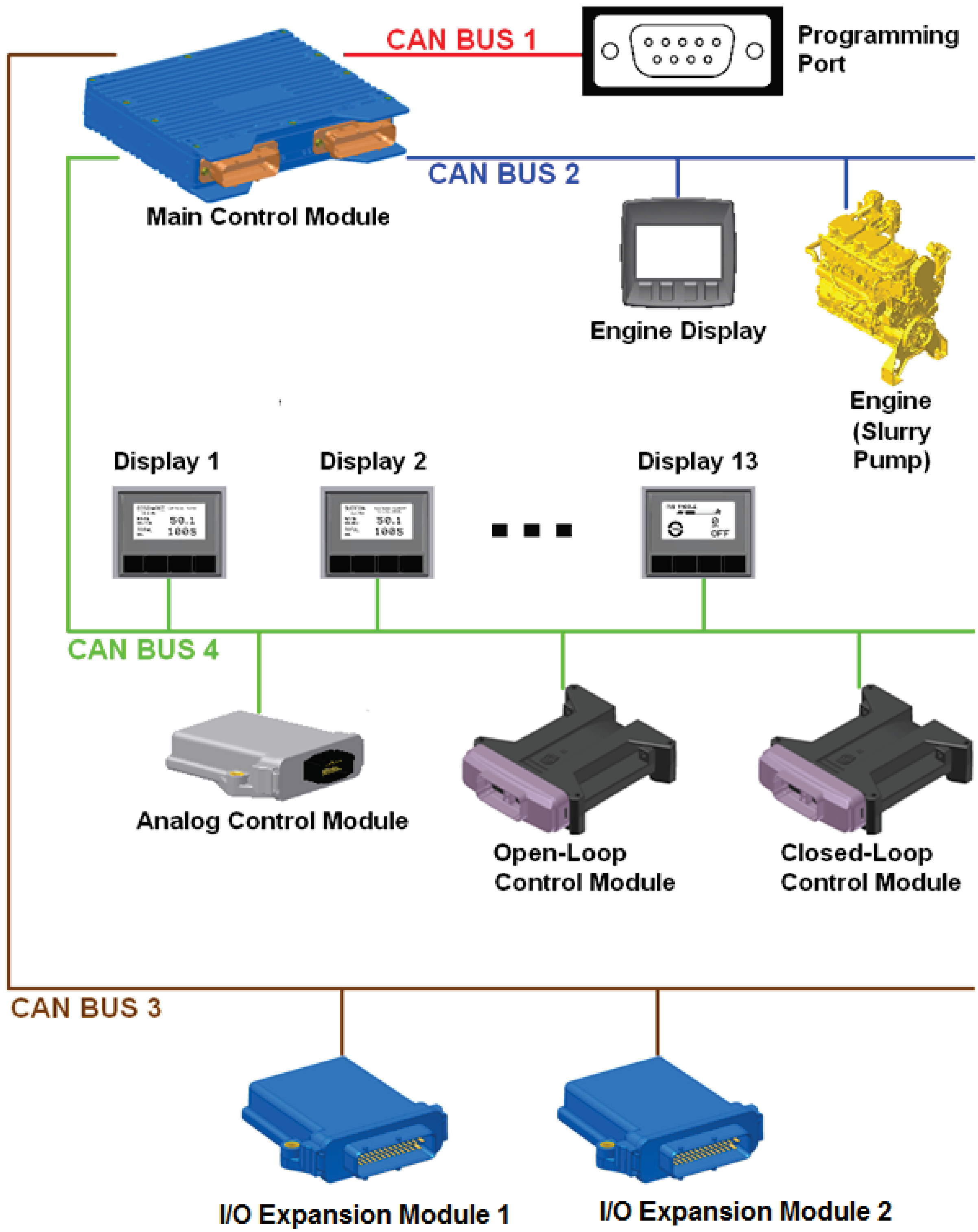
Function	Signal	Connector	Pin	Standard
Power Gnd -	GND	22200470-02	P1	
Power Supply +	12/24 VDC +	22200470-02	P2	
CAN +	CAN BUS 4	22200470-02	P3	
CAN -	CAN BUS 4	22200470-02	P4	
AIN/CAN0 Shield	AIN/CAN0 Shield	22200470-02	P5	
Address Input A	Connect to GND	22200470-02	P10	
Address Input B	Connect to GND	22200470-02	P11	
Address Input C	Connect to GND	22200470-02	P12	
PVG/PVEH Coil 1 Error Pin	DIN	22200470-02	P14	
PVG/PVEH Coil 2 Error Pin	DIN	22200470-02	P15	
PVG/PVEH Coil 3 Error Pin	DIN	22200470-02	P16	
PVG/PVEH Coil 4 Error Pin	DIN	22200470-02	P17	
PVG/PVEH Coil 5 Error Pin	DIN	22200470-02	P18	
PVG/PVEH Coil 6 Error Pin	DIN	22200470-02	P19	
PVG/PVEH Coil 7 Error Pin	DIN	22200470-02	P23	
PVG/PVEH Coil 8 Error Pin	DIN	22200470-02	P24	
PVG/PVEH Coil 9 Error Pin	DIN	22200470-02	P25	
PVG/PVEH Coil 10 Error Pin	DIN	22200470-02	P26	
PVG/PVEH Coils 1&2 Power	DOUT	22200470-02	P32	
PVG/PVEH Coils 3&4 Power	DOUT	22200470-02	P33	
PVG/PVEH Coils 5&6 Power	PVG pwr	22200470-02	P34	
PVG/PVEH Coils 7&8 Power	PVG pwr	22200470-02	P35	
PVG/PVEH Coils 9&10 Power	PVG pwr	22200470-02	P36	
Chemical 1 Control Signal	PVGOUT	22200470-02	P37	
Chemical 2 Control Signal	PVGOUT	22200470-02	P38	
Chemical 3 Control Signal	PVGOUT	22200470-02	P39	
Chemical 4 Control Signal	PVGOUT	22200470-02	P40	
Chemical 5 Control Signal	PVGOUT	22200470-02	P41	
Chemical 6 Control Signal	PVGOUT	22200470-02	P42	
Chemical 7 Control Signal	PVGOUT	22200470-02	P43	
Chemical 8 Control Signal	PVGOUT	22200470-02	P44	
Tub Paddle	PVGOUT	22200470-02	P45	
Power Supply +	12/24 VDC +	22200470-02	P47	
Power Supply +	12/24 VDC +	22200470-02	P48	
Power Supply +	12/24 VDC +	22200470-02	P49	
Power Supply +	12/24 VDC +	22200470-02	P50	

10.6 Signal Reference Analog Control Module



Function	Signal	Connector	Pin	Standard
CAN +	CAN BUS 4	ACM 1	10	
CAN -	CAN BUS 4	ACM 1	11	
CAN SHIELD	CAN BUS 4	ACM 1	9	
Calculated Clean Rate Output	4-20 mA	ACM 1	2	

10.7 Can Bus Utilization



11. Glossary

Base Fluid SG

The Base Fluid SG (specific gravity) is a user-entered value that represents the ratio of the density of the fracturing fluid to the density of water. As a ratio, specific gravity is dimensionless (i.e., it has no units). Because the reference fluid (water) has a density of 1.0 gram/milliliter at standard temperature and pressure, it is easy and common to treat specific gravity as equivalent to density measured in grams/milliliter.

The system uses the Base Fluid SG, along with certain proppant characteristics, to convert between concentration and density.

Calculated Clean Rate

Stewart & Stevenson blenders control the fluid level in the mixing tub by varying the fluid inlet (suction or clean) rate. For this reason, the clean rate can be a “noisy” signal even when the fluid outlet (discharge or slurry) rate is steady. The chemical controller adds chemicals in proportion to the clean rate, so any fluctuations in the clean rate are mirrored in the chemical rates.

To allow the chemicals to run smoothly, we calculate a theoretical clean rate by subtracting the current proppant rate (as measured by the densometer) from the current slurry rate (as measured by the discharge flow meter).

The controller on a chemical additive unit can add chemicals in proportion to the blender’s calculated clean rate. To do so, select *Base Rate 2* in the chemical setup screen. If *Base Rate 1* is selected, the chemical is added in proportion to the hydration unit’s measured suction rate.

Concentration (or Density), Calculated

The calculated concentration (or density) is a value derived from the auger and fluid rates.

Concentration (or Density), Measured

The measured concentration (or density) is the value measured by the densometer.

Concentration (or Density), Target

Target concentration is the concentration (or density) value programmed into the job by the user. The value displayed depends on where the system is in the job. The system calculates how much sand is required (and therefore which augers to use and how fast) to achieve the target concentration based on the clean water inlet rate or the slurry output rate.

DAC

Digital-to-Analog-Converter – A device that converts a number in a computer to a voltage.

Per mille or parts-per-thousand (‰)

The "per mille" symbol is used to denote concentration. It is equivalent to parts-per-thousand or tenths of a percent. For liquid chemicals it means the units of chemical added to each 1000 units of clean water (i.e., gallons/1000 gallons, liters/m^3). For dry chemicals the units are lbs/1000 gallons or kg/m^3.

PPA

PPA stands for pounds proppant added per gallon of clean fluid. It is a concentration or ratio. It is NOT a bulk density.

Proppant Bulk Density

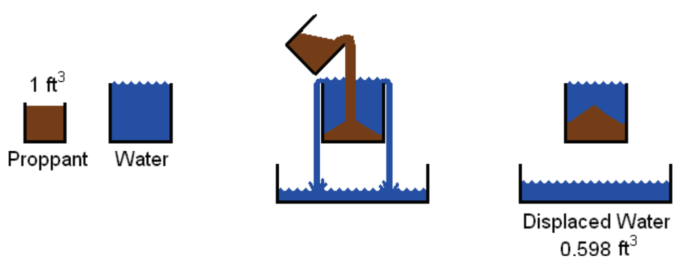
Proppant bulk density is the weight of 1 ft^3 of proppant. 20/40 fracturing sand is approximately 100 lbs/ft^3.

Proppant Specific Gravity

Proppant SGU is the ratio of the density of the proppant material (not counting the air gaps between grains of sand) to water. If you take 1 ft^3 of proppant, and pour it into a container that is full of water, the sand will displace a certain amount of water (less than 1 ft^3). Proppant SGU equals the weight of the sand in pounds divided by the volume of the displaced water in gallons divided by 8.3454 (the weight of 1 gal of water).

$$PropSGU = \frac{ProppantMass}{DisplacedWater \times 8.3454}$$

SGU is the relative density of the sand with all of the air gaps between grains removed.



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