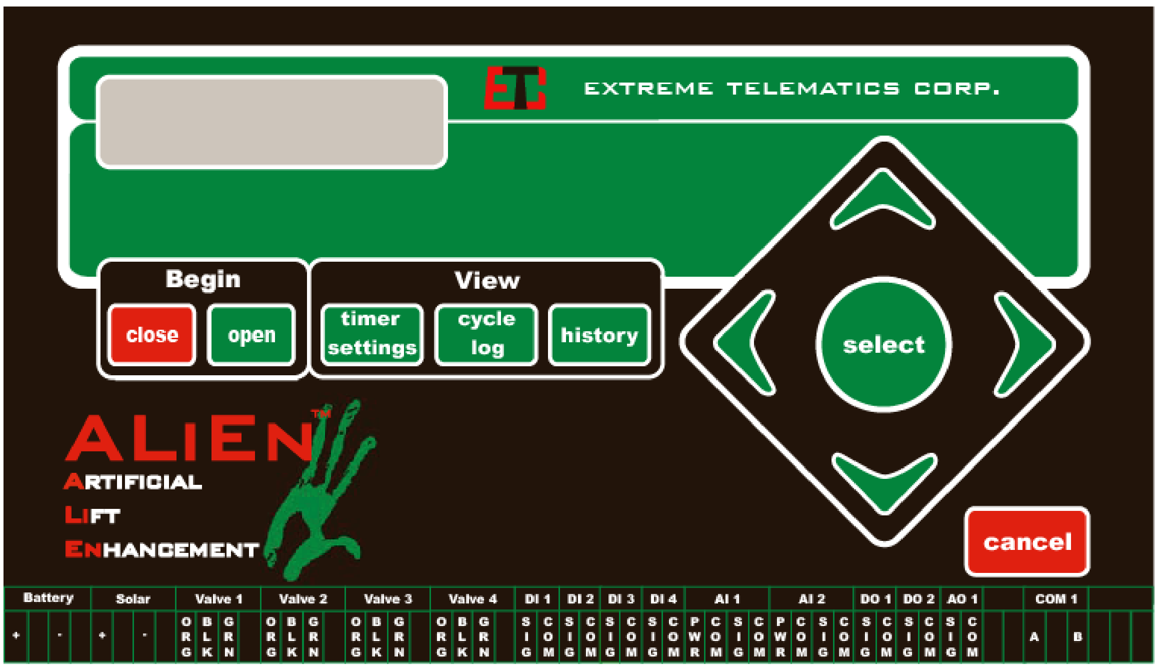
ALiEn Plunger Lift Controller

Installation and Operations Manual

Software Revision 6.5.3

8/12/2010



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Revision History

Revision	Date	Author	Changes
6.x.x	21/04/2008	Mark Scantlebury	Initial Version
6.5.0	15/01/2009	Mike Hughesman	Additions for Close Time Optimization
6.5.3	01/12/2010	Mark Scantlebury	Corrections to Timer Optimization and screen additions.

Acronyms

ADC	**Analog-to-Digital Converter**
AI	**Analog Input**
ALiEn	**Artificial Lift Enhancement**
CVC	**Configurable Valve Controller**
DAC	**Digital-to-Analog Converter**
DI	**Digital Input**
DO	**Digital Output**
ESD	**Emergency Shut Down**
N/C	**Normally Closed**
N/O	**Normally Open**
PSI	**Pounds per Square Inch**
R	**Read Permission**
RTU	**Remote Terminal Unit**
R/W	**Read/Write Permission**
SCADA	**Supervisory Control And Data Acquisition**
V	**Volts**
VFD	**Vacuum Fluorescent Display**
VI	**Virtual Input**

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1 Introduction

1.1 Purpose

This manual is intended to provide all of the information required to setup and operate the Alien Plunger Lift Controller. As well, it covers basic troubleshooting techniques and support information.

1.2 Overview

The Alien Plunger Lift Controller is a versatile gas well controller that can be used in a number of different configurations. It can function as a simple intermitter or with a plunger and can optimize a well based on pressures or plunger arrival times. In addition, the controller can be accessed remotely using the provided Modbus compatible RS485 communications port.

1.3 Assumptions

The following assumptions have been made when writing this manual:

- The reader has some knowledge of the operation of a gas well.
- A controller is available as a reference while reading this manual.

2 Controller Overview

2.1 Startup

On power up, the controller is initialized by performing the following operations:

- Set the outputs to a known state
- Close all valves
- Load all previously saved values
- Turn on the display
- Set the display to show the current controller state as the latest device status information.

The controller automatically enters the Close state when powering up.

2.2 Battery Monitor

The controller samples the battery every 10 minutes, monitoring the voltage in order to prevent unpredictable valve operation. The battery voltage is reported as one of the following:

- *Normal*: The controller behaves normally. If 6 successive battery samples are below 5.5 Volts, the controller closes all valves and enters the *Low* state. A low battery alarm condition is recorded, which is reported in the history.
- *Low*: If 6 successive samples are above 6.0 Volts, the controller enters the *Normal* state. When entering the *Normal* state, the controller will restart to the *Close* state for a duration specified by the *Close Time* parameter.

During power on or reset, and before any valves are opened, the battery voltage is sampled. The *Normal* or *Low* state is entered based upon this sample.

3 User Interface

3.1 Display

A Vacuum Fluorescent Display (VFD) is provided which consists of 2 lines x 16 characters. Each character is a 5x7 dot matrix with a full underline bar. The display is partitioned into 2 areas with an unused column between them for spacing.

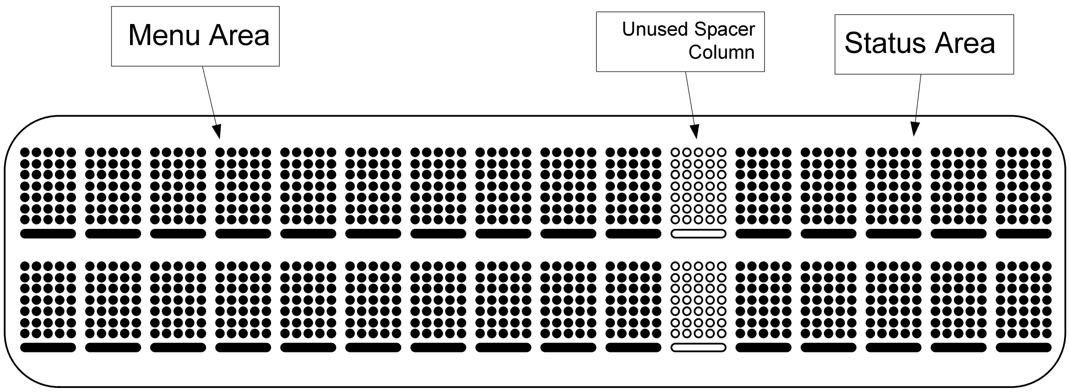


Figure 1 - Screen Layout

3.1.1 Menu Area

The content of the *Menu Area* (2 x 10 characters) shows the current state of the controller on startup. This area will change based on user keypad interaction. The current state information as well as the setup menu is available in this area.

3.1.2 Status Area

The *Status Area* (2 x 5 characters) constantly rotates through all enabled inputs and outputs. By default, this includes the battery voltage as well as the state of Valve A. As other options are enabled on the controller, additional information becomes available in this same area. For example, Valve B will be displayed if it has been enabled. If pressure devices such as line pressure and casing pressure are enabled, their current value will also be displayed.

3.1.3 Automatic Shut Off

The controller is constantly monitoring the input from the operator. If no keys have been pressed in the last 5 minutes, the controller will turn off the display in order to conserve battery power.

3.2 Keypad

An integrated keypad is included which allows the user to change settings, navigate through statistics, and control the well. The following sections discuss the various keys that are available.

3.2.1 Navigation Keys

The navigation keys are used to move through the menus in the controller and input new settings.

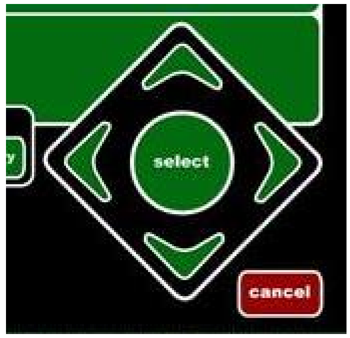


Figure 2 - Navigation Keys

3.2.1.1 Select

Select is used to enter a sub-menu, select a field to be edited, or save changes made while editing a field.

3.2.1.2 Cancel

Cancel is used to backup through the menu levels or cancel an edit.

3.2.1.3 Arrow Keys

The arrow keys allow the user to move up/down and left/right. If the display is on a line that has a sub menu associated with it, pressing "Right" will enter the sub menu. Conversely, pressing the "Left" arrow will go back one level of menu depth. If a field can be edited the "Right" arrow will put the controller into edit mode. Moving left and right while in edit mode will switch between different fields on the screen. If the user moves past the end of the screen to the left, the edit is cancelled. Move past the end of the screen to the right and the edited value is saved.

3.2.2 Hot Keys

The hot keys are provided to take the user to special menus or provide instant action.

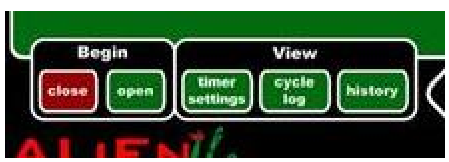


Figure 3 - Hot Keys

3.2.2.1 Close

Pressing *Close* will send the controller to the close state, closing all valves.

3.2.2.2 Open

Pressing *Open* will send the controller to the open portion of the cycle. The action that is taken depends on the number of valves configured, how they are set to operate, and if there are any special checks required, such as casing and/or line pressure. The normal mode of operation is to go to Rise, which opens Valve A and waits for a plunger arrival to occur.

3.2.2.3 Timer Settings

The *Timer Settings* hot key navigates to a special menu that contains all of the times that are used by the controller as well as the set points for pressure devices. The timers control how long the controller leaves the well open, waits for an arrival, or closes the well in. These settings give the installer/operator control over how the well behaves. The following is a list of the timers and settings that are available in this menu:

Table 1 - Timer Settings Screens

Screen	Description	Default Value
Close Time	This determines the normal duration of the Close portion of the cycle.	0h45m00s
Non-Arrival Close Time	This determines the duration of the Close portion of the cycle following a non-arrival. Not used if the *Arrival Sensor* is disabled.	1h00m00s
Extra Close Time	This timer shows the current amount of Extra Close. In Close Timer Based Optimization this timer will adjust automatically to help bring the plunger to surface at the time specified by the *Target Rise Time*.	0h00m00s
Max Close Time	The maximum amount of close time for any one cycle. This is used for Close Time Optimization.	8h00m00s
Rise Time	This time is used to indicate that the plunger is not likely to arrive at the surface unless special action is taken. If this time expires before the plunger arrives, the controller will bypass the Afterflow portion of the cycle and close the valves for the Extended Close Time, or possibly shutdown the well. The intent is to allow extra pressure to build in order to lift the plunger on the next cycle. The Rise Time may not be set to zero. If the *Arrival Sensor* is disabled, this defines the time spent in the Rise portion of the cycle. That is, the controller will advance to Afterflow when this time expires.	1h00m00s
Tank Delay Time	When Valve B is configured as a Tank Valve, the flow is switched from Valve A to Valve B during the Rise portion of the cycle if the Plunger does not arrive within this time. It must be less than the Rise Time. Not used if set to zero or if Valve B is disabled.	0h45m00s
AutoCatcher Delay Time	This parameter sets the amount of time to hold the plunger at surface after Valve A has been closed. This parameter is not used if the Autocatcher is disabled.	0h00m10s
Fast Trip Time	This time is used to indicate that the Plunger did not likely fall to the bottom of the well. The well will be shut-in if a number of consecutive fast trips have occurred. Not used if the *Arrival Sensor* is disabled.	0h02m30s

Screen	**Description**	**Default Value**
Target Rise Time	This is the time that the plunger is expected to arrive after the well has been opened. It is only used when running Timer Based Optimization. The controller will increase or decrease the *Extended Afterflow or Extra Close Time* in order to try and cause the plunger to arrive at this time. Not used if the *Arrival Sensor* or Timer Based Optimization is disabled.	0h03m00s
Afterflow Delay Time	When Valve B is enabled, this defines the amount of time the controller will wait following a plunger arrival before opening Valve A. This is done to ensure that the plunger has moved fully into the Lubricator following a plunger arrival sensor signal. It is also used to ensure that any liquids are flushed through the system. Not used if Valve B Is disabled or if set to zero.	0h00m00s
Afterflow Time	The Afterflow portion of the cycle is terminated when this time expires. When "extended-afterflow"[1] devices are enabled, the controller will advance to Extended-Afterflow instead of Close if none of the devices have already tripped.	1h00m00s
Extended Afterflow Time	This timer shows the current amount of Extended Afterflow. In Timer Based Optimization this timer will adjust automatically to help bring the plunger to surface at the time specified by the *Target Rise Time*. In Pressure Based Optimization, this timer simply counts down during the Extended Afterflow portion of the cycle. This time is not adjusted and cannot be set in this mode as it is simply derived from the time remaining before the *Max Open Time* expires.	0h00m00s
Trip Delay Time	This screen specifies the amount of time to delay before closing the well in when using Rate Drop Casing Pressure Optimization. Please refer to the Optimization screens for more information.	1h00m01s
Max Open Time	This is the maximum time that a valve will remain open in a given cycle. If non-zero, must be greater than the Rise time. Not used if set to zero or if the *Arrival Sensor* is disabled or extended flow devices are not enabled.	8h00m00s

[1] The "Extended-Afterflow" devices are:
- Casing Pressure Switch/Sensor
- Flow Differential Pressure Switch/Sensor
- Flow Switch/Sensor/Virtual

Screen	Description	Default Value
Line Pressure Trip Point	When the *Line Pressure Device Type* is *Sensor*, defines the pressure, above which, the well will be shut-in.	90.0 psi
Open Casing Pressure Trip Point	When the *Casing Pressure Device Type* is *Sensor*, and the *Line Pressure Device Type* is not Sensor, defines the casing pressure, below which, the well will stay shut-in.	90.0 psi
Open Casing Line Differential Trip Point	When the *Casing* and *Line Pressure Device Types* are both *Sensor*, defines the pressure difference, below which the well will stay shut-in.	50.0 psi
Close Casing Differential Trip Point	When the *Casing Pressure Device Type* is *Sensor*, defines the pressure difference, above the minimum Afterflow value, below which the well will stay flowing. This screen is only visible if the Close Casing Pressure Type is set as Low Rise.	30.0 psi
Close Casing Pressure Trip Point	When the *Casing Pressure Device Type* is *Sensor*, this defines the pressure above which the well will stay flowing. This screen is only visible if the *Casing Pressure Device Type* is set as *Absolute*.	150.0 psi
Flow Differential Pressure Trip Point	When the *Flow DP Device Type* is *Sensor*, this defines the pressure which will cause a trip condition to be reset.	20.0 "WC
Flow Rate Trip Point	When the *Flow DP and Line Pressure Device Types* are both *Sensor OR Flow is Sensor/Virtual*, this defines the rate above which the well will stay flowing.	18.0 e3m3/d

3.2.2.4 Cycle Log

The cycle log is a history of each cycle that the controller goes through. A log entry is written at the end of a cycle, which is defined as the point when the controller finishes the *Close Time*. Therefore, the controller will write the first cycle log entry after the controller starts and the initial *Close Time* expires. Each log entry is stored in persistent memory so that it is maintained through any power disruptions. A maximum of 20 log entries will be saved. Once this limit is reached, new entries are written over top of the oldest entry.

The following information is saved for each cycle:

Table 2 - Cycle Log Screens

Screen	Description
Cycle Type and Start Time	This screen shows the type of cycle that occurred as well as the date and time that the cycle started. The cycle type will be one of: o Normal o Fast-trip o Non-Arrival o Max Open

	o Line Pressure Shut-In o Low Battery Shutdown o Operator Change o Startup
Rise Duration	This value shows the time that it took the plunger to come to surface once the well was opened. This screen is not displayed if the arrival sensor has been disabled.
Afterflow Duration	This is the total *Afterflow Time* for this cycle. It is the total of *Afterflow* and *Extended Afterflow Time*.
Close Duration	This is the amount of *Close Time* for the given cycle. It may be longer than the specified *Close Time* if the well is held in close by devices such as line pressure or casing pressure.
Minimum Afterflow Casing Pressure	This is the value of casing pressure that caused the well to go from open to close. This screen is only displayed if Pressure Based Optimization is being used and the Casing Pressure device is configured as a sensor.
Reset Log?	This clears all of the cycle log data.

3.2.2.5 History

The controller maintains production statistics which are written to persistent memory when the current time-of-day passes the *Day Start* parameter. The following information is available in the history menu:

Table 3 - History Screens

Screen	**Description**
Date and Total Cycles	Shows the date for the given history record as well as the total number of cycles that occurred during that day.
Volume	This shows the total volume for the given day. This is represented as e^3m^3.
Open/Close Time	Displays the total time that the well has been open and the total time the well has been closed for the day.
Cycle Counts	There are a number of screens that are used to display all of the cycle types for the current day.
Day Start	This defines the gas day cut off. When the controller passes this time each day, the history for the current day will stop and a new day will start.
Reset Log?	This clears all of the daily log data.

3.3 Top Level Menu

A menu is provided that allows the user to view current controller information as well as to access the more detailed settings of the controller. It is shown in the menu area on the left hand side of the screen.

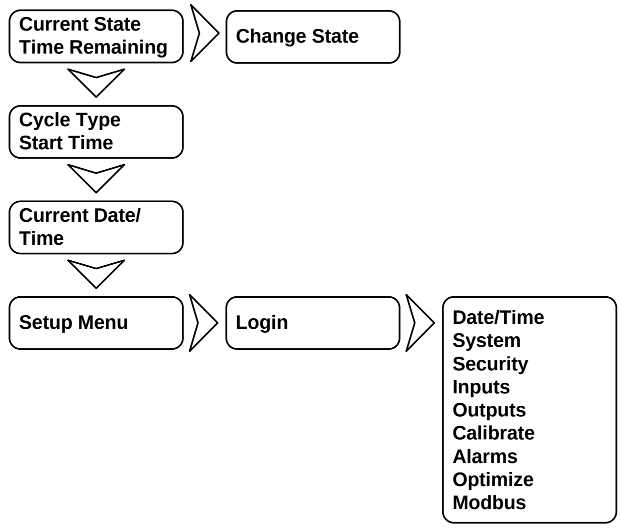


Figure 4 - Main Menu Structure

Scrolling down from the status screen that appears on startup will take you through the top level menu. Information such as the cycle type, start time, and the current date/time are displayed here. At the bottom of these menu items is a screen that reads "Setup". Selecting this item will enter the setup menu.

3.3.1 Current State

This screen is shown by default when the controller is powered up. It shows the current part of the cycle that the controller and a timer that indicates when the state will change.

3.3.2 Cycle Information

This screen shows the information for the last cycle. This includes the type of cycle (Ok, Fast Trip, Non Arrival, etc…) as well as the time that the cycle started.

3.3.3 Current Date/Time

This screen simply shows the current date and time. If this information is incorrect, the user must login and change the date and time in the Date/Time menu. The date and time is reset back to January 1, 2000 when the battery is disconnected.

3.3.4 Change State

The controller can be manually forced into the AfterFlow, Rise, or Close states by performing a manual state change. The controller will enter the selected state for a length of time set by the user in these screens.

3.4 Setup Menu

Users must log in here in order to see the menus below. The setup menu can be found in the top level menu by scrolling down. The default login is 000-0000. This can be changed in the security menu.

3.4.1 Date/Time

This menu allows the date and time to be configured. There is also a screen that allows daylight savings time to be enabled. The following is list of all of the available screens:

Table 4 - Date/Time Screens

Screen	Description	Default
Date	Allows the user to set the current date.	Jan 1, 2000
Day Confirm	This confirms the current day of the week when the date is set.	N/A
Time	Allows the user to set the current time. Please note that this is in 24 hr time (i.e. 1:00 pm is entered as 13:00)	00:00
DST Enable	If enabled, the controller will automatically adjust 2 times a year for daylight savings.	disabled

3.4.2 System

The System menu provides information specific to the given controller. This includes information such as the serial number and firmware version. Features can be enabled, the display brightness can be adjusted, and the controller settings can be reset to factory defaults. If any errors have been reported by the controller, they can be found at the end of this menu. The following is a list of the available screens:

Table 5 - System Screens

Screen	Description	Default
Display Brightness	Sets the screen brightness. Can be used to save power or adapt to different lighting conditions.	50%
Display Auto Off	This sets the amount of time after the last key press that the display will stay on.	1m00s
Serial Number	The serial number of the controller. This is required if features need to be enabled on the controller or it is to be returned for repair.	N/A
Firmware Version	This identifies the specific firmware version that is currently running on the controller. This is required if issues are reported to ETC. Please refer to the release notes for this version to see a list of known issues.	N/A
Valve B Option	This feature allows a second valve to be enabled and configured.	Disabled
Pressure Optimization Option	This feature allows the controller to optimize on one or more pressure devices. These devices include casing pressure, casing line differential pressure, flow differential pressure, or flow.	Disabled
Timer Optimization Option	This feature allows the controller to optimize the well based on plunger arrival time. The *Extended Afterflow or Extra Close Time* is manipulated in order to change the next arrival time of the plunger.	Disabled
Modbus Option	This feature allows the controller to communicate with a Modbus master. This feature is typically used as part of a Modbus network that is controlled by a central SCADA host.	Disabled

Screen	Description	Default
Restore Defaults	This will reset all controller settings back to the factory defaults. The user will be prompted to confirm this action before the settings are restored.	No
Error Log	This screen will only appear if a detectable error has occurred. Some errors will result in the controller restarting. This is the first place that should be checked if the controller is restarting itself.	N/A
Reset Error Log	If there are entries in the error log this screen will appear. It allows you to clear the error log. You will be prompted to confirm this action.	No

3.4.3 Security

The Security menu allows the currently logged in user to logout. Installers are able to view and change both the Operator and Installer login IDs.

Table 6 - Security Screens

Screen	Description	Default
Logout	This screen forces a log out. The screen will move back to the main status screen when the operator has logged out. The operator will be required to enter a password to regain entry to the Setup menu.	N/A
Auto Logout Time	The amount of time after the last key press that the user will remain logged in.	10m00s
Operator ID	This screen allows the Installer to set an *Operator ID*. This allows another user to have limited access to the Setup menu. This screen is only visible to a logged in Installer.	000-0000
Installer ID	This screen allows the Installer to change the current Installer ID. This screen is only visible to a logged in Installer. Note: If the Installer and Operator IDs are configured to be the same number, the user will be logged in as the Installer when using this code.	000-0000

3.4.4 Inputs

The Inputs menu lists all of the available inputs, such as arrival sensor and line pressure sensor. Other input devices will be available when the Pressure Optimization feature has been enabled. These devices include casing pressure, flow differential pressure, and flow.

Table 7 - Inputs Screens

Screen	Description	Default
Arrival Sensor	Informs the controller if an Arrival Sensor is connected. If disabled, the Rise cycle will run to completion and then switch to Afterflow.	*Enabled*

Screen	**Description**	**Default**
Arrival Switch Polarity	Allows the type of arrival sensor to be configured. The controller can detect an arrival on a close or open of a switch.	*Normally Open (Detects on a switch close)*
Line Pressure Device Type	Enables the use of a Line Pressure Switch or Sensor. Disabled = Device not installed or unused. Switch = Discrete Input Switch installed and enabled. Sensor = A Line Pressure Analog Sensor is installed.	*Disabled*
Line Pressure Range	When the *Line Pressure Device Type* is *sensor*, defines the range of the sensor.	500.0 psi
Line Pressure Switch Polarity	Configures the type of Line Pressure switch to use. The controller can detect a Line Pressure trip on a close or open of a switch.	*Normally Open (Detects on a switch close)*
Casing Pressure Device Type	Enables the use of a Casing Pressure Switch or Sensor. Disabled = Device not installed or unused. Switch = Discrete Input Switch installed and enabled. Sensor = A Casing Pressure Analog Sensor is installed.	*Disabled*
Casing Pressure Range	When the *Casing Pressure Device Type* is Sensor, defines the range of sensor.	500.0 psi
Casing Pressure Switch Polarity	Configures the type of Casing Pressure switch to use. The controller can detect a Casing Pressure trip on a close or open of a switch.	*Normally Open (Detects on a switch close)*
Flow Differential Pressure Device Type	Enables the use of a Flow Differential Pressure Switch or Sensor. Disabled = Device not installed or unused. Switch = Discrete Input Switch installed and enabled. Sensor = A Pressure Analog Sensor is installed.	*Disabled*
Flow Differential Pressure Range	When the *Flow Differential Pressure Device Type* is Sensor, defines the range of sensor.	150.0 “WC
Flow Differential Pressure Switch Polarity	Configures the type of Flow Differential Pressure switch to use. The controller can detect a Flow Differential Pressure trip on a close or open of a switch.	*Normally Open (Detects on a switch close)*

Screen	Description	Default
Flow Rate Device Type	Enables the use of a Flow Switch, Sensor, or Virtual. Disabled = Device not installed or unused. Switch = Discrete Input Switch installed and enabled. Sensor = A Pressure Analog Sensor is installed. This screen is disabled if the *Flow Differential Pressure Device Type* and the *Line Pressure Device Type* are both configured as *Sensor*. This configuration causes the Flow Rate to be calculated automatically.	*Disabled*
Flow Rate Range	When the *Flow Rate Device Type* is *Sensor*, defines the range of sensor.	10.0 e3m3/d
Flow Rate Switch Polarity	Configures the type of Flow Rate switch to use. The controller can detect a Flow Rate trip on a close or open of a switch.	*Normally Open (Detects on a switch close)*
Pressure Sensor Scan Time	Defines the rate at which all pressure sensors are read.	00m01s
Pressure Switch Scan Time	Defines the rate at which all pressure switches are read.	00m01s
Meter Run Size	When the *Flow Differential Pressure Device Type* and the *Line Pressure Device Type* are both *Sensor*, defines the meter run diameter used for flow rate calculations.	2 inches
Orifice Size	When *Flow Differential Pressure Device Type* and the *Line Pressure Device Type* are both *Sensor*, defines the orifice diameter used for flow rate calculations.	1.000 inches
Gas Temperature	When the *Flow Differential Pressure Device Type* and the *Line Pressure Device Type* are both *Sensor*, defines the gas temperature used for flow rate calculations.	60 °F
Gas Specific Gravity	When *Flow Differential Pressure Device Type* and the *Line Pressure Device Type* are both *Sensor*, defines the specific gravity (relative to air) used for flow rate calculations.	0.60

3.4.5 Outputs

The Outputs menu allows the installer to configure the behaviour of the Auto Catcher valve and the Digital Outputs (DOs). The Auto Catcher may be enabled or disabled. The DOs can be used to provide power for a 3 Wire Arrival Sensor, mimic a valve operation, operate an Auto Catcher, or signal an alarm condition.

Table 8 - Outputs Screens

Screen	Description	Default
Valve B Type	Defines Valve B operation: *Disabled*: Valve B not present or unused. The controller will only assert control on Valve A. *Line*: Valve B is connected to the Sales Line. It can be opened or closed during the Afterflow portion of the cycle based on the Afterflow Valve Configuration. *Tank*: Valve B is connected to a Tank. The Valve B feature must be enabled to have access to this parameter.	*Disabled*
Afterflow Valve Configuration	This parameter allows the user to configure which valves should be open during the Afterflow portion of the cycle when operating in dual valve mode. Valve B is open during Afterflow to keep the Plunger Catcher activated. It can be left closed during the Afterflow portion of the cycle for configurations where a Plunger Catcher is not installed. The Valve B feature must be enabled to have access to this parameter.	*A/B*
Auto Catcher	Turn the Auto Catcher valve on or off. The Auto Catcher is connected to Valve 4.	*Disabled*
Digital Output 1	Setup the digital output to do one of the following operations: - Provide power for a 3 wire arrival sensor - Pulse on an alarm condition - Mimic Valve 1 - Mimic Valve 2 - Mimic Auto Catcher (Valve 4)	*3 Wire*
Digital Output 2	Same as above, but for DO2.	*Disabled*
Analog Output 1	Setup the analog output to do one of the following operations: - Provide power for a 3 wire arrival sensor - Pulse on an alarm condition - Mimic Valve 1 - Mimic Valve 2 - Mimic Auto Catcher (Valve 4)	*Disabled*

3.4.6 Calibrate

The Calibrate menu is used to calibrate analog inputs. A low and high calibration value is set while affecting the connected transducer. This is typically achieved using a hand pump or available gauge. The controller will adjust the scaling for analog input values based on the calibration.

Table 9 - Calibrate Screens

Screen	Description	Default
Line Pressure Low Calibration	Use this screen to set a low calibration point. Select the value and change it to the current reading on the pressure gauge. Once both high and low points are calibrated, the scaling of the input will be modified to match the calibration.	N/A
Line Pressure High Calibration	Use this screen to set a low calibration point. Select the value and change it to the current reading on the pressure gauge. Once both high and low points are calibrated, the scaling of the input will be modified to match the calibration.	N/A
Casing Pressure Low Calibration	Use this screen to set a low calibration point. Select the value and change it to the current reading on the pressure gauge. Once both high and low points are calibrated, the scaling of the input will be modified to match the calibration.	N/A
Casing Pressure High Calibration	Use this screen to set a low calibration point. Select the value and change it to the current reading on the pressure gauge. Once both high and low points are calibrated, the scaling of the input will be modified to match the calibration.	N/A

3.4.7 Alarms

The alarms menu allows parameters such as the number of Fast Trips or Non-Arrivals that can occur before the controller shuts the well in. There are also settings that determine if the well is shut in or opened when an alarm condition occurs.

Table 10 - Alarms Screens

Screen	Description	Default
Non-Arrival Count	The controller will shutdown the well after "Non-Arrival Count" consecutive plunger non-arrivals. Not used if set to zero. Not used if the Arrival Sensor is disabled.	Disabled
Fast Trip Count	The controller will shutdown the well after "Fast Trip Count" consecutive fast trips. Not used if set to zero. Not used if the *Fast Trip Time* is set to 0. Not used if the Arrival Sensor is disabled.	2
Low Battery Fail Mode	This screen allows the user to configure the behaviour of the controller for this type of failure. The user can decide to have the controller fail Closed or Open.	Closed
Fast Trip Fail Mode	This screen allows the user to configure the behaviour of the controller for this type of failure. The user can decide to have the controller fail Closed or Open.	Closed
Non Arrival Fail Mode	This screen allows the user to configure the behaviour of the controller for this type of failure. The user can decide to have the controller fail Closed or Open.	Closed

3.4.8 Optimize

The optimize menu allows the optimization mode such as Timer or Pressure to be selected. The available optimization schemes depend on the features that have been enabled for a particular controller. Depending on the optimization scheme chosen, a number of additional screens become available.

Table 11 - Optimize Screens

Screen	Description	Default
Optimization Type	This screen is used to select the type of optimization. The selections that are available depend on the optimization modes that have been unlocked. Possible choices include AfterFlow Timer Optimization, Close Timer Optimization, Pressure Optimization, and Disabled.	Disabled
Timer Optimization Mode	The *Timer Optimization Mode* determines how aggressively the controller adjusts the *Extended Afterflow or Extra Close Time*. *Mode A* is the least aggressive and *Mode C* is the most aggressive.	Mode A (1%)
Line Pressure Trip Point	When the *Line Pressure Device Type* is *Sensor*, defines the pressure, above which, the well will be shut-in.	90.0 psi
Line Pressure Reset Point	When the *Line Pressure Device Type* is *Sensor*, defines the pressure, below which, a Line Pressure trip condition will be cleared.	85.0 psi
Line Pressure Stable Time	When the *Line Pressure Device Type* is enabled, defines the time required for the line pressure to stabilize above the *Line Pressure Trip Point*, or below the *Line Pressure Reset Point*, in order to declare a trip or reset condition.	0h01m00s
Open Casing Pressure Trip Point	When the *Casing Pressure Device Type* is *Sensor*, and the *Line Pressure Device Type* is not Sensor, defines the casing pressure, below which, the well will stay shut-in.	90.0 psi
Open Casing Pressure Reset Point	When the *Casing Pressure Device Type* is *Sensor*, and the *Line Pressure Device Type* is not *Sensor*, defines the pressure, above which, the well will be opened.	95.0 psi
Open Casing Pressure Stable Time	When the *Casing Pressure Device Type* is enabled, and the *Line Pressure Device Type* is not *Sensor*, defines the time required for the line pressure to stabilize above the *Open Casing Pressure Reset Point*, or below the *Open Casing Pressure Trip Point,* in order to declare a trip or reset condition.	0h01m00s
Open Casing/Line Differential Pressure Trip Point	When the *Casing* and *Line Pressure Device Types* are both *Sensor*, defines the pressure difference, below which the well will stay shut-in.	50.0 psi

Screen	**Description**	**Default**
Open Casing/Line Differential Pressure Reset Point	When the *Casing* and *Line Pressure Device Types* are both *Sensor*, defines the pressure difference, above which the well will be opened.	55.0 psi
Open Casing/Line Differential Pressure Stable Time	When the *Casing* and *Line Pressure Device Types* are both *Sensor*, defines the time required for the pressure difference to stabilize above the *Open Casing/Line Differential Pressure Reset Point*, or below the *Open Casing/Line Differential Pressure Trip Point*, in order to declare a reset or trip condition.	0h01m00s
Close Casing Pressure Type	This determines which algorithm to use for closing the well when the *Casing Pressure Device Type* is *Sensor*. The options are: - *Low Rise* - *Absolute* - *Rate Drop* These optimization algorithms are discussed further in the 4.1.4.1 Casing Pressure section.	Low Rise
Casing Pressure Rate Threshold	When the *Casing Pressure Device Type* is *Sensor*, defines the rate of change in pressure above which the well will stay flowing. The well will shut-in after the *Trip Delay Timer* expires. This screen is only visible if the *Close Casing Pressure Type* is set as *Rate Drop*.	5.0 psi/min
Close Casing Differential Pressure Trip Point	When the *Casing Pressure Device Type* is *Sensor*, defines the pressure difference, above the minimum Afterflow value, below which the well will stay flowing. This screen is only visible if the Close Casing Pressure Type is set as Low Rise.	30.0 psi
Close Casing Differential Pressure Reset Point	When the *Casing Pressure Device Type* is *Sensor*, defines the pressure, above the minimum Afterflow value, which will cause a trip condition to be reset. This screen is only visible if the Close Casing Pressure Type is set as Low Rise.	25.0 psi
Close Casing Differential Pressure Stable Time	When the *Casing Pressure Device Type* is *Sensor*, this defines the time required for the pressure to stabilize above the *Close Casing Differential Pressure Trip Point*, or below the *Close Casing Differential Pressure Reset Point*, in order to declare a trip or reset condition. This screen is only visible if the *Casing Pressure Device Type* is set as *Low Rise*.	0h01m00s

Screen	Description	Default
Close Casing Pressure Trip Point	When the *Casing Pressure Device Type* is *Sensor*, this defines the pressure above which the well will stay flowing. This screen is only visible if the *Casing Pressure Device Type* is set as *Absolute*.	150.0 psi
Close Casing Pressure Reset Point	When the *Casing Pressure Device Type* is *Sensor*, defines the pressure which will cause a trip condition to be reset. This screen is only visible if the *Close Casing Pressure Device Type* is set as *Absolute*.	155.0 psi
Close Casing Pressure Stable Time	When the *Casing Pressure Device Type* is *Sensor*, this defines the time required for the pressure to stabilize below the *Close Casing Pressure Trip Point*, or above the *Close Casing Pressure Reset Point*, in order to declare a trip or reset condition. This screen is only visible if the *Close Casing Pressure Device Type* is set as *Absolute*.	0h01m00s
Flow Differential Pressure Trip Point	When the *Flow DP Device Type* is *Sensor*, this defines the pressure which will cause a trip condition to be reset.	20.0 “WC
Flow Differential Pressure Reset Point	When the *Flow DP Device Type* is *Sensor*, this defines the pressure which will cause a trip condition to be reset.	22.0 “WC
Flow Differential Pressure Stable Time	When the *Flow DP Device Type* is enabled, this defines the time required for the pressure to stabilize below the *Flow Differential Pressure Trip Point*, or above the *Flow Differential Pressure Reset Point*, in order to declare a trip or reset condition.	0h01m00s
Flow Rate Trip Point	When the *Flow DP and Line Pressure Device Types* are both *Sensor OR Flow is Sensor/Virtual*, this defines the rate above which the well will stay flowing.	18.0 e3m3/d
Flow Rate Reset Point	When the *Flow DP and Line Pressure Device Types* are both *Sensor OR Flow is Sensor/Virtual*, this defines the rate which will cause a trip condition to be reset.	19.0 e3m3/d
Flow Rate Stable Time	When the *Flow DP and Line Pressure Device Types* are both *Sensor OR Flow is Sensor/Virtual*, this defines the time required for the rate to stabilize below the trip point, or above the reset point, in order to declare a trip or reset condition.	0h01m00s

3.4.9 Modbus

The Modbus menu will only appear if the Modbus feature has been enabled on the controller. This feature allows data to be retrieved by a SCADA host remotely. This menu contains all of the settings that are available for Modbus communications. These settings must match the settings that are used in the SCADA host.

Table 12 - Modbus Menus

Screen	Description	Default
Station Address	Defines the Modbus station. Valid values are 1 to 247. This setting must match the settings on your Modbus master.	1
Protocol	The specific Modbus protocol that is use. This can be set to either RTU or ASCII. This setting must match the settings on your Modbus master.	RTU
Baud Rate	The speed of the serial port. This setting must match the settings on your Modbus master.	9600
Character Format	This setting defines the character format used for the serial port. The number of data bits, the parity, and the stop bits are all defined within one selection. This setting must match the settings on your Modbus master.	8N1

4 Controller

The controller configuration can be accessed in two different ways:

- Through the menu using the display and keypad
- Using Modbus over the RS485 communications port.

The Alien Modbus Communications User's Guide discusses everything from physical connection to data format and access. As such, the Modbus communications interface will not be discussed further in this manual.

When the controller starts up, all valves are closed and the controller is put into the Close state. The close timer starts decrementing. Once this timer has expired, the controller decides what action to take based on the controller configuration.

4.1 Controller Configurations

The following sections describe the various ways that the controller can be configured. The configuration may be changed by modifying the parameters that are available through the user interface screens outlined in the preceding sections.

4.1.1 Intermitting

The plunger lift controller is designed to act as a well intermitter in the most basic configuration.

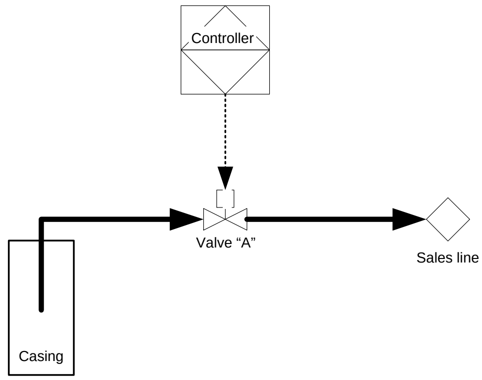


Figure 5 - Well Intermitting

In this configuration, Valve A is opened and closed based on a simple timer setup. The *Close, Rise*, and *Afterflow Times* are used to determine when to open and close the well. The *Arrival Sensor Device Type* must be *Disabled* for the controller to act as a simple well intermitter.

At the start of the cycle, Valve A is opened and the *Rise Time* is started. When the *Rise Time* expires the controller moves to Afterflow. Once this timer expires, the controller moves back to Close and the valve is closed.

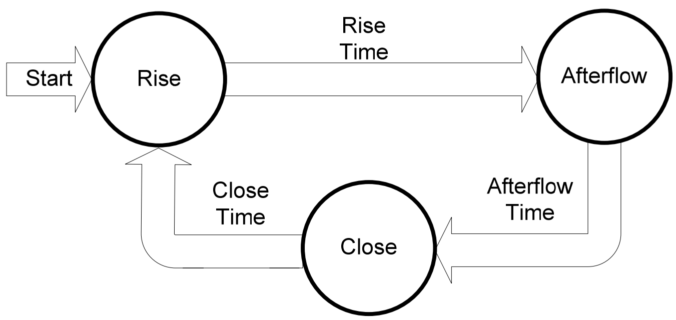


Figure 6 - Basic Controller States

4.1.2 Arrival Sensor Operation

The plunger lift controller is designed to operate primarily in the following plunger lift configuration:

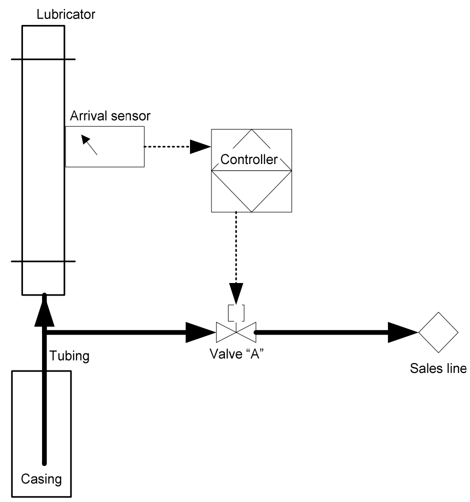


Figure 7 - Arrival Sensor Operation

In this application, a plunger travels between the bottom of the well tubing and the lubricator. The purpose of the plunger is to lift fluids which accumulate at the bottom of the well tubing. The lubricator acts as a trap for the plunger when it arrives at the surface and is fitted with an *Arrival Sensor*. The *Arrival Sensor* provides a pulse to the controller as the plunger moves past it in either direction.

When the valve is closed, the plunger falls to the bottom of the well tubing. At an appropriate time, Valve A is opened, and the pressure in the gas formation drives the plunger and any accumulated fluids to the top of the well tubing. A short time after plunger arrival, Valve A is closed and the cycle repeats.

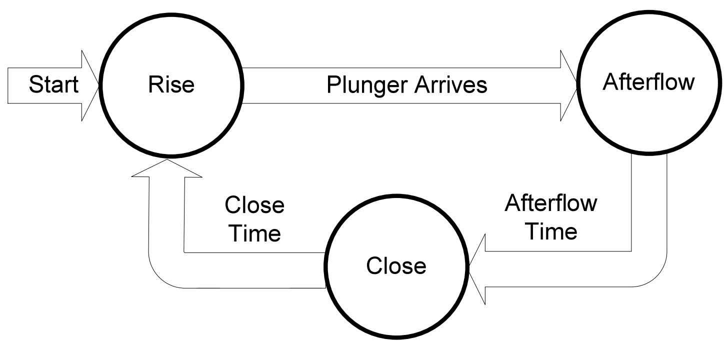


Figure 8 - Controller Operation with Arrival Sensor

4.1.2.1 Non-Arrival

If the plunger fails to arrive within the *Rise Time*, a non-arrival cycle is declared. In this case, Valve A is closed for an extended amount of time (*Extended Close Time*). After a pre-determined number of *Non-Arrivals* defined in the Alarms menu, the controller will move into a Stopped state and wait for operator intervention.

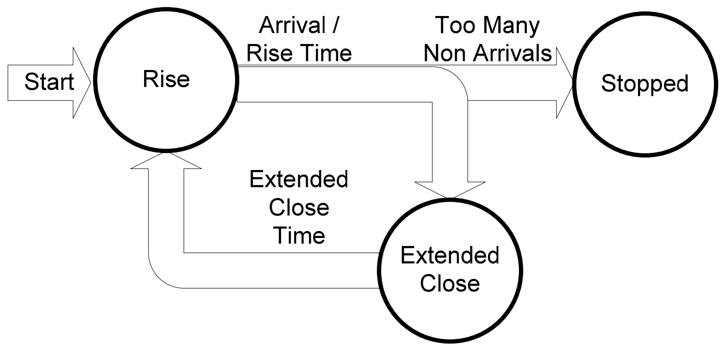


Figure 9 - Non-Arrival

4.1.2.2 Fast-Trip

If the plunger arrives within the *Fast-Trip Time*, a fast-trip cycle is declared. This may occur if the plunger did not fall to the bottom of the well during the Close portion of the last cycle and the plunger returns to the surface dry. When a fast trip occurs, the controller proceeds to the Afterflow portion of the cycle. After a predetermined number of fast trip occurrences, the controller will move to the Stopped state and wait for operator intervention to protect the well.

Any arrivals in the first 6 seconds of the *Rise Time* are ignored. This delay allows the controller to ignore power up glitches that occur when using arrival sensors from some vendors.

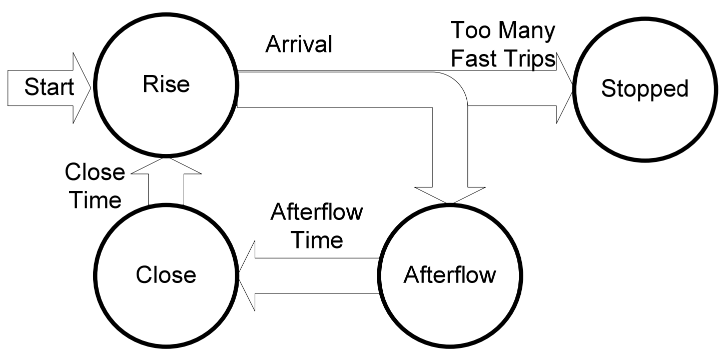


Figure 10 - Fast Trip

4.1.3 Line Pressure

The well may be equipped with a line pressure switch or sensor. This device is configured to be “tripped” when the pressure in the sales line exceeds a pre-determined threshold.

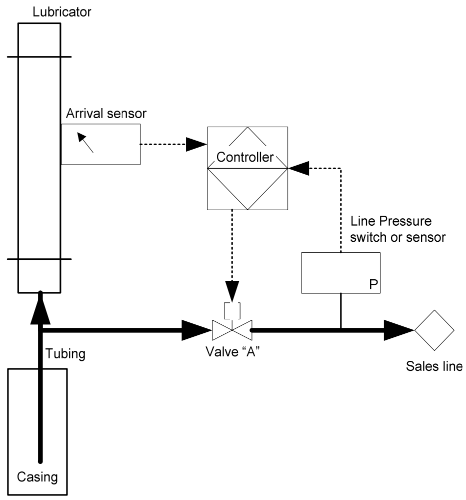


Figure 11 - Using Line Pressure

The controller monitors the state of the switch just before the Rise portion of the cycle. The cycle is delayed if the pressure is high. It is also monitored during the Afterflow portion of the cycle. The well is shut-in if the pressure is high.

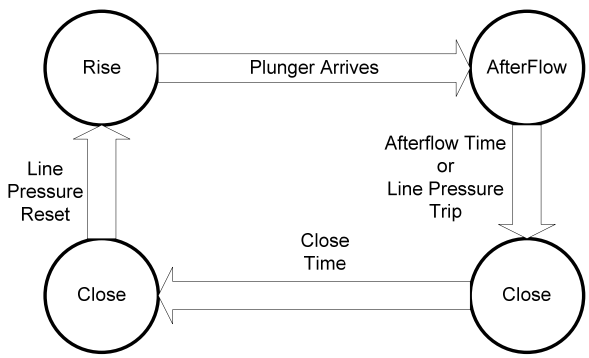


Figure 12 - Line Pressure Cycle

4.1.4 Pressure Optimization

In addition to the line pressure switch/sensor, the well may be equipped with a casing pressure switch/sensor and/or a flow differential pressure switch/sensor.

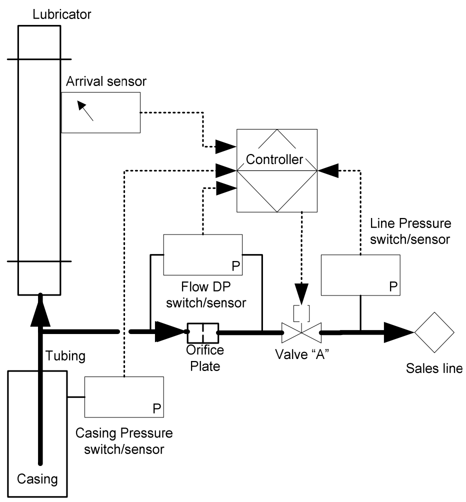


Figure 13 - Pressure Based Optimization

The following table describes the different optimization schemes that are used depending on the devices that are enabled.

Table 13 - Pressure Optimization Modes

Ref	Line Pressure	Casing Pressure	Flow DP	Optimization
1	disabled	disabled	disabled	none
2	disabled	disabled	switch	1
3	disabled	disabled	sensor	2
4	disabled	switch	disabled	3
5	disabled	switch	switch	1, 3
6	disabled	switch	sensor	2, 3
7	disabled	sensor	disabled	4
8	disabled	sensor	switch	1, 4
9	disabled	sensor	sensor	2, 4
10	switch	disabled	disabled	none
11	switch	disabled	switch	1
12	switch	disabled	sensor	2
13	switch	switch	disabled	3
14	switch	switch	switch	1, 3
15	switch	switch	sensor	2, 3
16	switch	sensor	disabled	4, 6
17	switch	sensor	switch	1, 4, 6
18	switch	sensor	sensor	2, 4, 6
19	sensor	disabled	disabled	none

Ref	Line Pressure	Casing Pressure	Flow DP	Optimization
20	sensor	disabled	switch	1
21	sensor	disabled	sensor	2, 5
22	sensor	switch	disabled	3
23	sensor	switch	switch	1, 3
24	sensor	switch	sensor	3, 5
25	sensor	sensor	disabled	6, 7
26	sensor	sensor	switch	1, 6, 7
27	sensor	sensor	sensor	5, 6, 7

1. Stay in Afterflow until the *Afterflow Time* expires AND: the *Max Open Time* expires or the Flow DP switch trips.
2. Stay in Afterflow until the *Afterflow Time* expires and: the *Max Open Time* expires or the Flow DP drops below an operator-entered threshold.
3. Monitor the Casing Pressure switch after the *Close Time* expires. Stay shut-in while the Casing Pressure switch is tripped.
4. Monitor the Casing Pressure sensor after the *Close Time* expires. Stay shut-in while the Casing Pressure is below an operator-entered set-point.
5. During Rise, Afterflow: Calculate the Flow Rate using a simplified orifice meter formula. Stay in Afterflow until the *Afterflow Time* expires. Stay in Afterflow until the *Max Open Time* expires or the Flow Rate drops below an operator-entered threshold. Calculate and save daily production volumes based on the calculated flow rate.
6. During Afterflow: Monitor the Casing Pressure to find its “minimum value”.[2] Keep the well flowing until the *Afterflow Time* expires AND: the *Max Open Time* expires or the Casing Pressure exceeds the “minimum value” by an operator-entered set-point. See diagram below. Other algorithms are also available to monitor Casing Pressure in the Afterflow portion of the cycle.
7. During Close: After the *Close* or *Extended Close Time* expires, monitor the Casing/Line differential pressure. Start a new cycle when the Casing/Line pressure difference exceeds an operator-entered threshold.

[2] Do not monitor Casing and Line pressure sensors within the *Arrival Guard* time of plunger arrival.

The following diagram illustrates the controller behaviour when using various extended flow devices.

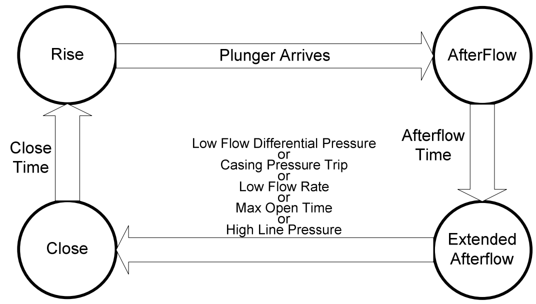


Figure 14 - Extended Afterflow Optimization

4.1.4.1 Casing Pressure

Casing Pressure can be used on its own or in combination with Line Pressure. This section discusses how Casing Pressure can be used on its own. Some of the optimization schemes behave the same when line pressure is turned on, while others will cause the controller to switch to using Casing Line Differential Pressure. The following controller actions will only take place if a Casing Pressure device has been enabled.

4.1.4.1.1 Close

The Casing Pressure is not monitored until the end of the Close portion of the cycle. Once the *Close Time* has expired, the well will be held closed until the Casing Pressure device has been reset.

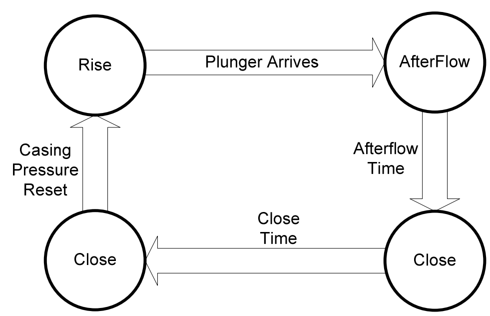


Figure 15 - Casing Pressure Close Cycle

If a switch is used, it must be in the reset position and must stay there for at least the stable time. If the *Casing Pressure Device Type* is configured as a sensor, then the sensor value must exceed the *Open Casing Pressure Reset Point* and stay there for at least the *Open Casing Pressure Stable Time*.

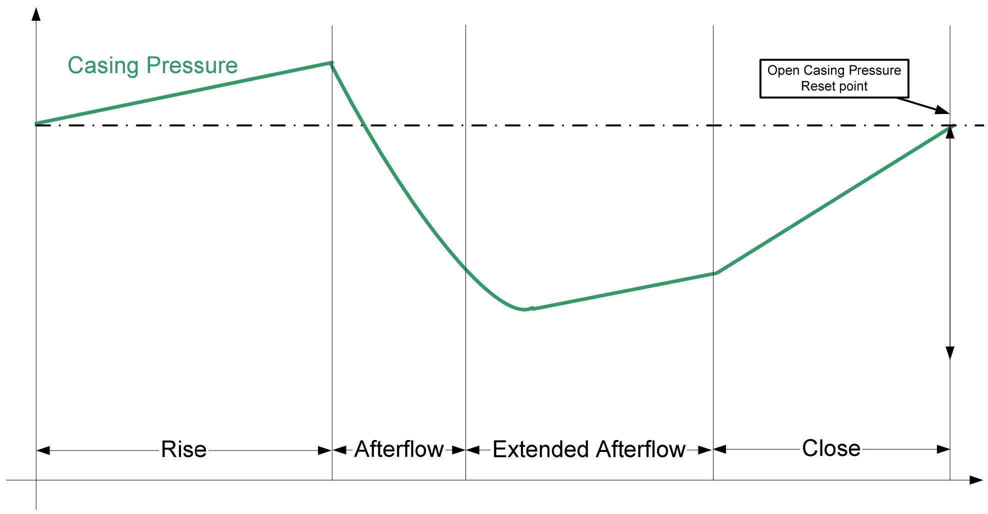


Figure 16 - Open Casing Pressure Reset Point

4.1.4.1.2 Afterflow/ Extended Afterflow

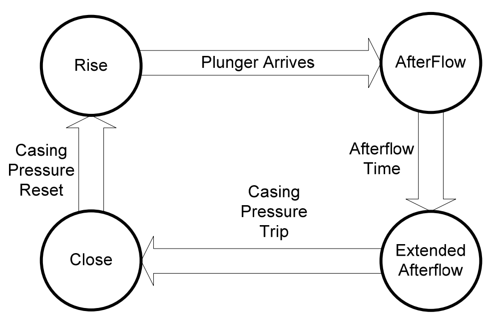


Figure 17 - Afterflow/Extended Afterflow Casing Pressure

During the Afterflow portion of the cycle, the Casing Pressure is monitored one of three different ways if the *Casing Pressure Device Type* has been configured as a sensor. If the Casing Pressure trips during Afterflow, the well is closed as soon as the *Afterflow Time* expires. If the Casing Pressure has not tripped by the end of the *Afterflow Time*, then the Casing Pressure will continue to be monitored during the Extended Afterflow portion of the cycle. A trip during the Extended Afterflow portion of the cycle will cause the well to be closed once the applicable *Stable Time* has been met. The following sections describe the different Casing Pressure monitors that can be configured.

4.1.4.1.2.1 Low Rise

The Low Rise method monitors the down slope of the Casing Pressure. Once the Casing Pressure stops decreasing, the current value is saved. This is used to determine how much the Casing Pressure has risen when the well begins to water in. Once the Casing Pressure has risen greater than the *Close Casing Differential Pressure Trip Point* and stays there for at least the time defined by the *Close Casing Differential Pressure Stable Time*, the well will be shut-in.

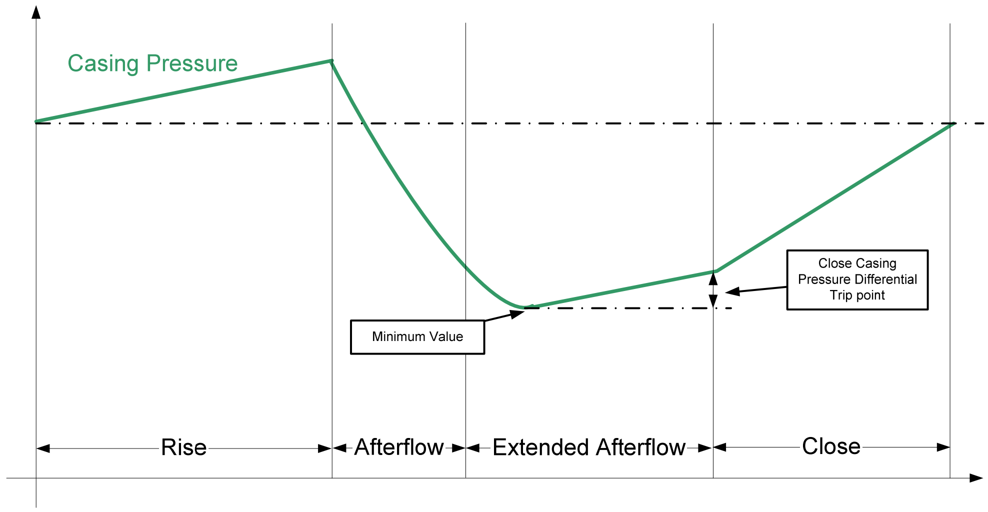


Figure 18 - Casing Pressure Low Rise Method

4.1.4.1.2.2 Absolute

This method simply looks for a drop in the Casing Pressure. Once the Casing Pressure drops below the *Close Casing Pressure Trip Point* and stays there for at least the time defined by the *Close Casing Pressure Stable Time*, the well will be shut in.

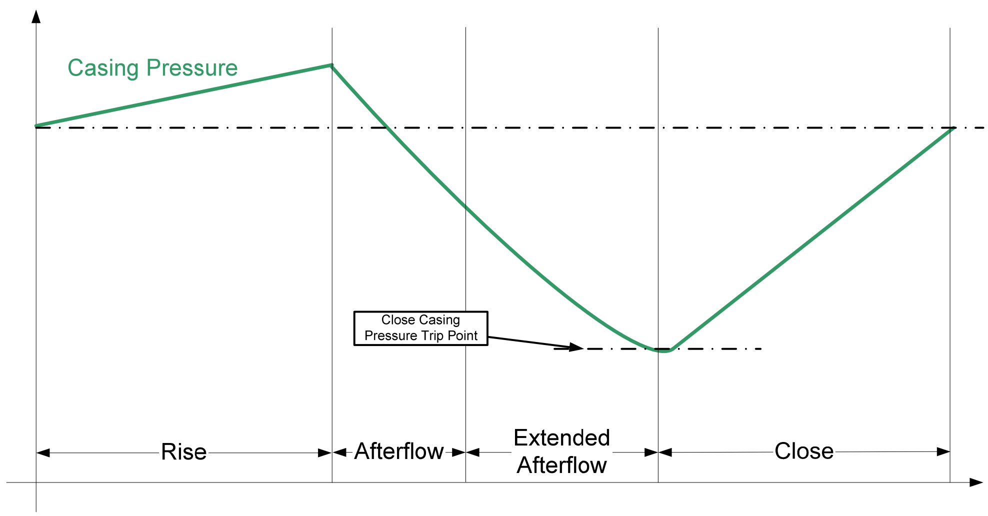


Figure 19 - Casing Pressure Absolute Method

4.1.4.1.2.3 Rate Drop

The Rate Drop method monitors the change in the Casing Pressure over time. As the rate of change slows and becomes lower than the *Casing Pressure Rate Threshold*, the *Trip Delay Time* is started. When this timer expires the well will be shut-in.

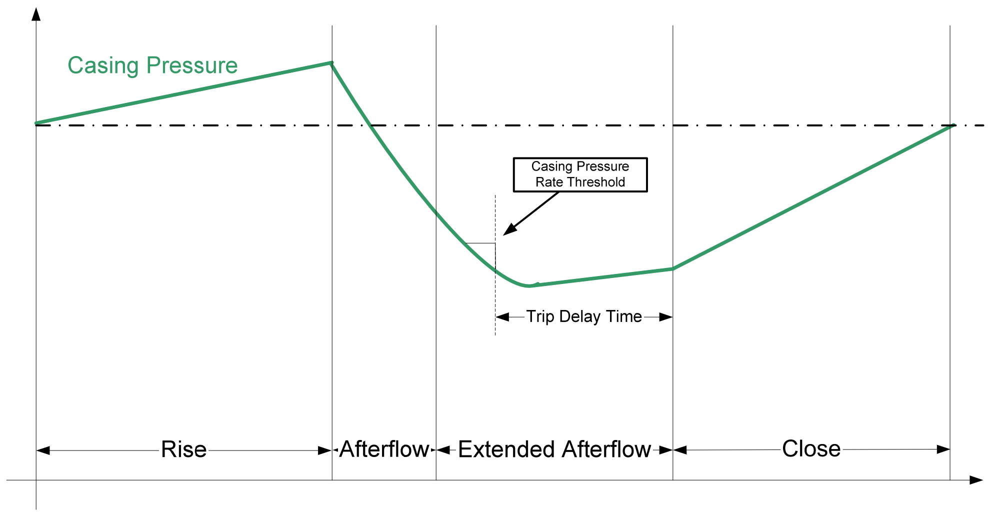


Figure 20 - Casing Pressure Rate Drop Method

4.1.4.2 Casing Line Differential Pressure

If a Casing Pressure Sensor and a Line Pressure Sensor are both enabled, Casing Line Differential Pressure will be used to determine when the controller can move from Close to Open. The difference will be taken between these two values and then compared to the *Open Casing Line Differential Pressure Reset Point*. Once the differential exceeds the reset point and stays above it for at least the *Open Casing Line Differential Pressure Stable Time*, the well will open. Please note that casing pressure alone is used when determining when to go from open to close.

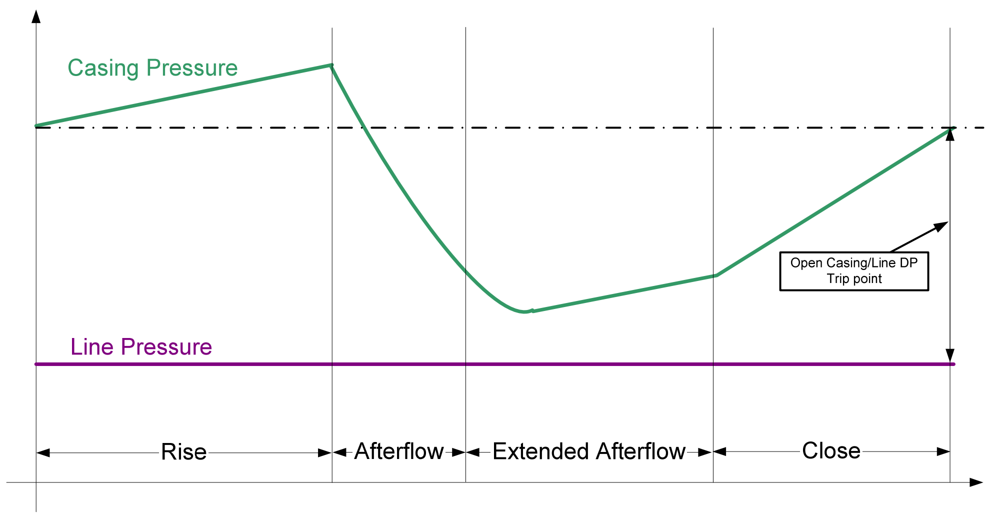


Figure 21 - Open Casing Line Differential Trip

4.1.4.3 Flow Differential Pressure

Flow DP Device Type can be configured as either a switch or sensor. When it is configured as a switch, it will automatically drop out of Extended Afterflow when the switch trips. A trip indicates that the differential is below a trip point set externally. The differential is proportional to the flow. A drop in flow is represented as a drop in differential. As the well begins to water in, the differential will decrease.

When the *Flow DP Device Type* is enabled as sensor, the controller will behave in the same manner. The difference is that the *Flow Differential Pressure Trip Point* and *Flow Differential Pressure Reset Point* must be configured to tell the controller when to shut in the well. If a Line Pressure sensor is used in conjunction with a Flow Differential Pressure Sensor, then a flow rate can be estimated. Please refer to the Flow Rate section below.

4.1.4.4 Flow Rate

There are several ways to obtain a Flow Rate for optimization. They are discussed in detail in the sections below.

When the Flow Rate is available, the *Extended Afterflow Time* of the controller is optimized. If the Flow Rate is a numerical value, the well is shut-in when the Flow Rate drops below the *Flow Rate Trip Point* and remains there for at least the *Flow Rate Stable Time*.

The Flow Rate value is also used to provide an estimated daily production. The flow is summed over time and the resultant production numbers are shown in the daily logs, which can be viewed by pressing the History hot key.

4.1.4.4.1 Calculated

The flow rate can be calculated if a Line Pressure sensor and a Flow Differential Pressure Sensor are used. This method will require a set of orifice plate parameters to be entered in the Inputs menu. A Meter Factor is derived from a look up table using the *Meter Run Size* and *Orifice Plate Size*. The Gas Temperature and *Gas Specific Gravity* are entered by the installer and are NOT updated real time. This calculation will provide an estimated flow that can be used for optimization. Please note that the production values that are derived from the calculation are not suitable for custody transfer.

4.1.4.4.2 Switch

The *Flow Rate Device Type* can also be configured as a switch. This allows the well to be shut in when the switch trips. Since there is no value associated with the Flow Rate, production numbers will not be provided.

4.1.4.4.3 Virtual

This configuration for Flow Rate allows the well to be optimized based on a Flow Rate from another system. This mode of operation requires a Flow Rate to be written to a Modbus register. This incoming value is then compared against the *Flow Rate Trip Point* to determine when to shut-in the well. Since a value is available for Flow Rate, the production numbers are calculated and displayed in the daily logs.

4.1.4.4.4 Sensor

The *Flow Rate Device Type* can also be set to sensor which uses an analog input. This input value is scaled to provide a flow value. This option is currently available, but has not been tailored to match any specific flow sensor at this point. Development would be required to fully implement this solution.

4.1.5 Timer Optimization

Timer Optimization allows the well to be optimized based on the arrival time of the plunger, which can be derived from the plunger velocity and well depth. The actual plunger arrival time is compared to a *Target Rise Time* and adjustments are made to the flow or shut-in time of the well in order to optimize the performance of the well. The objective of this optimization is to cause the plunger to arrive at the *Target Rise Time*.

The algorithm uses a set of parameters to determine the percentage of time late or early that the plunger arrived. This percentage is then scaled and added to or subtracted from the *Extended*

Afterflow Time or Extra Close Time, depending on which optimization mode has been selected. Please note that these timers starts at 0h00m00s. They can be configured to a higher value to allow the well to adjust the time up or down

In Afterflow Time Optimization, if the *Extended Afterflow Tim*e it is left at 0h00m00s, the well will only be able to flow longer, not shorter. This means that no adjustments can be made if the plunger arrives late. The *Afterflow Time* should be configured appropriately in this case so that the *Extended Afterflow Time* moves up over time (i.e. Afterflow Time is set to the minimum you ever want the well to flow for after the plunger arrives).

In Close Time Optimization, if the *Extra Close Time* is left at 0h00m00s, the well will only be able to shut in for longer, not shorter. This means that no adjustments can be made if the plunger arrives early. The *Close Time* should be configured appropriately in this case so that the Extra Close Time moves up over time (i.e. Close Time is set to the minimum you ever want the well closed for).

4.1.5.1 Timer Optimization Parameters

There are a number of parameters that are used for the Timer Optimization algorithm. They control the response that is generated to an early or late plunger arrival. The following sections outline the relationship between these parameters.

4.1.5.1.1 Rise Time (R_{Time})

The *Rise Time* is the window that the controller will wait for a plunger arrival to occur. An arrival after this window will be ignored. The *Rise Time* is used as part of the plunger late arrival window.

4.1.5.1.2 Target Rise Time (TR_{Time})

The *Target Rise Time* is the time that the plunger is expected to arrive when the well is producing most efficiently. This time should be calculated from the well depth and the desired average velocity of the plunger. If the plunger arrives on target, no adjustments are made. The *Target Rise Time* is used for both the early and late plunger arrival windows.

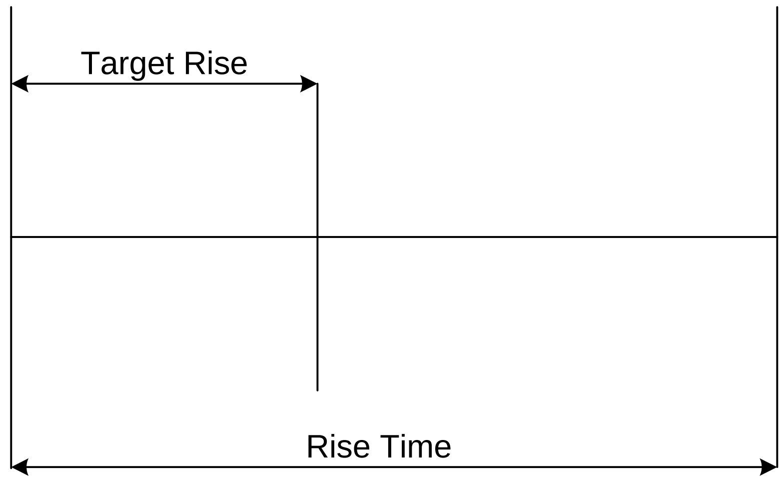


Figure 22 – Target Rise Time

4.1.5.1.3 Actual Rise Time (AR_{Time})

The *Actual Rise Time* is the time that the plunger took to rise to surface from the time that the controller opened the well. This time will always be less than the *Rise Time*. It is compared to the Target Rise Time to determine if we arrived early or late, and by how much.

4.1.5.1.4 Miss Percentage ($M_{\%}$)

The Miss Percentage is determined by taking the amount of time the Target Rise Time is missed by and dividing it by the arrival window (early or late). The following shows the difference between a late arrival and an early arrival.

4.1.5.1.4.1 Early Arrival

An early arrival occurs when the plunger arrives before the *Target Rise Time*.

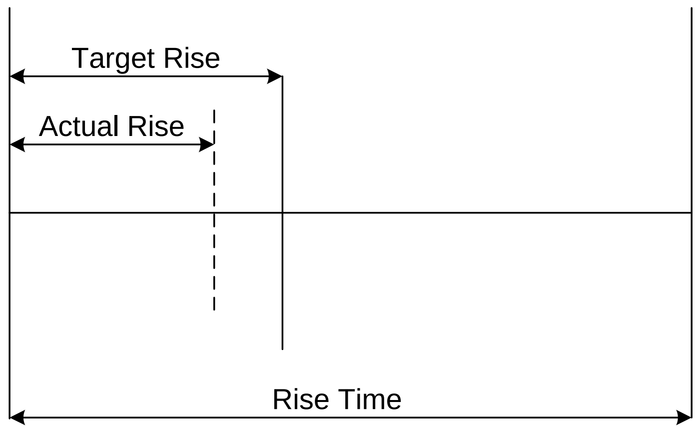


Figure 23 - Early Arrival

The *Miss Percentage* is calculated by taking the difference between the *Target Rise Time* and *Actual Rise Time* and dividing by the *Target Rise Time*. This number will be a **NEGATIVE** number since the *Actual Rise Time* is less than the *Target Rise Time*.

$$M_{\%} = \left[\frac{AR_{Time} - TR_{Time}}{TR_{Time}}\right] x100\%$$

Where:

$M_{\%}$ = Miss Percentage
TR_{Time} = Target Rise Time
AR_{Time} = Actual Rise Time

For example, if the *Target Rise Time* is 10 minutes and the *Actual Rise Time* is 9 minutes, the plunger arrived 1 minute early out of 10 minutes, which is a -10% miss.

$$M_{\%} = \left[\frac{9-10}{10}\right] x100\% = -10\%$$

4.1.5.1.4.2 Late Arrival

A late arrival occurs when the plunger arrives after the *Target Rise Time*.

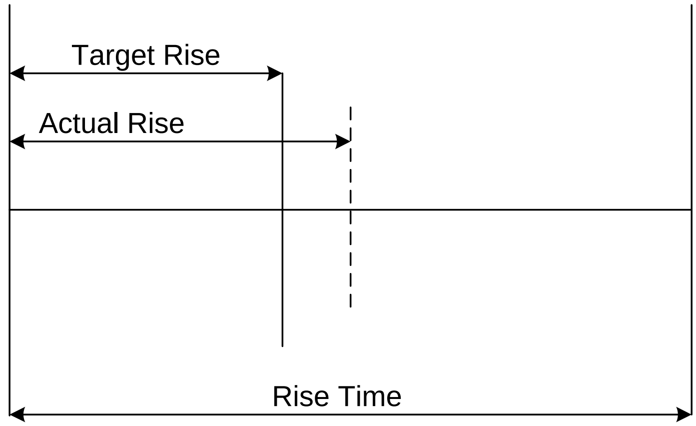


Figure 24 - Late Arrival

The percentage late is calculated by taking the difference between the *Actual Rise Time* and *Target Rise Time* and dividing by the late window, which is the difference between the *Rise Time* and the *Target Rise Time*.

$$M_{\%} = \left[\frac{AR_{Time} - TR_{Time}}{R_{Time} - TR_{Time}} \right] x100\%$$

Where:

$M_{\%}$ = Miss Percentage
TR_{Time} = Target Rise Time
AR_{Time} = Actual Rise Time
R_{Time} = Rise Time

For example, if the *Rise Time* is 20 minutes, the *Target Rise Time* is 10 minutes and the *Actual Rise Time* is 11 minutes, the plunger arrived 1 minute late out of 10 minutes, which is a 10% miss.

$$M_{\%} = \left[\frac{11-10}{20-10} \right] x100\% = 10\%$$

4.1.5.1.5 Timer Mode (TM)

The *Timer Mode* parameter lets you adjust the magnitude of response to an early or late arrival. There are three different modes: A, B, and C. Mode A is the least aggressive and will substantially dampen the amount of flow time that is added or subtracted. This will make more stable, smaller adjustments, but the well will take longer to reach to the *Target Rise Time*. Mode C is the most aggressive and will provide less dampening. This will make larger adjustments, but may cause more swings in the plunger arrival time.

The following table shows the amount of the *Miss Percentage* that is applied to the *Extended Afterflow Percentage* or the *Extra Close Percentage*.

Table 14 - Timer Modes

Timer Mode	Scale
A	1%
B	5%
C	10%

4.1.5.2 Afterflow Time Optimization

The goal of Afterflow Optimization is to modify the amount of flow time in order to get the plunger to arrive at the *Target Rise Time*. The *Afterflow Time* acts as a minimum amount of flow time, while the *Extended Afterflow Time* will increase and decrease automatically based on the arrival time of the plunger.

If the plunger arrives late, the well will shut-in earlier in to send the plunger down sooner (makes more trips). If the plunger arrives early, the well will be allowed to flow longer (makes less trips). The amount of additional flow time that we are currently using is stored as *Extended Afterflow Percentage* ($EAF_{\%}$).

The following parameters summarize the calculations that are done to get the current *Extended Afterflow Time*.

4.1.5.2.1 Afterflow Time (AF_{Time})

The *Afterflow Time* is configured as part of the normal setup of the controller. The *Afterflow Time* is used to flow the well for a **MINIMUM** amount of time after the plunger has arrived. Changes in devices or timer optimization settings will not affect the *Afterflow Time*.

4.1.5.2.2 Max Open Time (MO_{Time})

The *Max Open Time* defines the maximum amount of time that the well is allowed to stay open including *Actual Rise, Afterflow* and *Extended Afterflow Time*. In Afterflow Time Optimization, the *Max Open Time* is used to find the *Remaining Flow Time*.

4.1.5.2.3 Remaining Flow Time (RF_{Time})

The *Remaining Flow Time* is the amount of flow time that is left after the plunger arrives and *Afterflow* is complete, but before the *Max Open Time* expires.

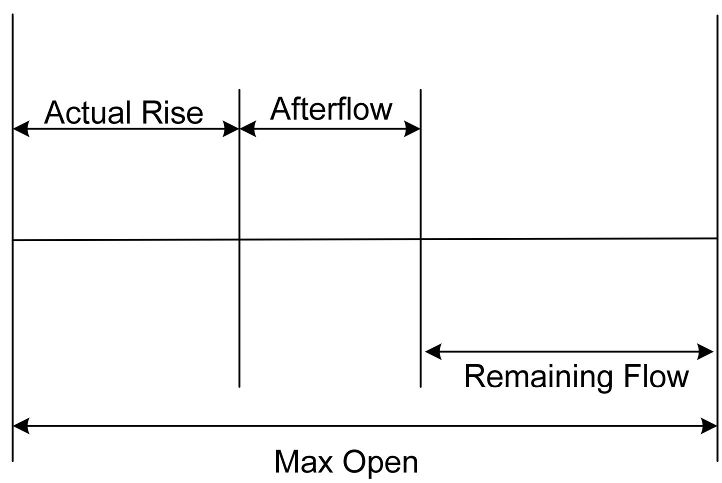


Figure 25 – Remaining Flow Time

This time is used in conjunction with the *Extended Afterflow Percentage* to give us *Extended Afterflow Time*.

$$RF_{Time} = MO_{Time} - AR_{Time} - AF_{Time}$$

Where:
RF_{Time} = Remaining Flow Time
MO_{Time} = Max Open Time

AR_{Time} = Actual Rise Time
AF_{Time} = Afterflow Time

4.1.5.2.4 Extended Afterflow Percentage ($EAF_{\%}$)

The *Extended Afterflow Percentage* keeps track of how much of the *Remaining Flow Time* to make use of. This percentage is adjusted after each plunger arrival. The percentage is decreased for each late arrival and is increased for each early arrival. The minimum for this parameter is 0.0% and the maximum is 100.0%.

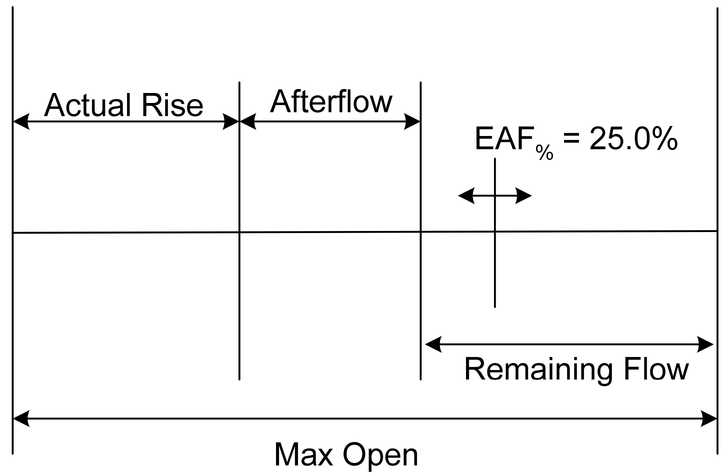


Figure 26 - EAF%

The amount of change is proportional to the *Miss Percentage* as defined earlier. The *Miss Percentage* is scaled by the *Timer Mode* and subtracted from the *Extended Afterflow Percentage*.

$$EAF_{\%} = EAF_{\%} - (M_{\%} \times TM)$$

Where:
$EAF_{\%}$ = Extended Afterflow Percentage
$M_{\%}$ = Miss Percentage
TM = Timer Mode

For example, if the *Miss Percentage* was -10% (arrived 10% early) and the Timer Mode was set to A (1%), then 0.1% would be added to the *Extended Afterflow Percentage*.

$$EAF_{\%} = EAF_{\%} - (-10\% \times 1\%)$$

$$EAF_{\%} = EAF_{\%} + 0.1\%$$

Conversely, if the *Miss Percentage* was 10% (arrived 10% late) and the Timer Mode was set to A (1%), then 0.1% would be subtracted from the *Extended Afterflow Percentage*.

$$EAF_{\%} = EAF_{\%} - (10\% \times 1\%)$$

$$EAF_{\%} = EAF_{\%} - 0.1\%$$

4.1.5.2.5 Extended Afterflow Time (EAF_{Time})

To get the current *Extended Afterflow Time*, the *Extended Afterflow Percentage* is multiplied by the Remaining Flow Time.

$$EA_{Time} = EAF_{\%} \times RF_{Time}$$

Where:
EAF_{Time} = Extended Afterflow Time
$EAF_{\%}$ = Extended Afterflow Percentage
RF_{Time} = Remaining Flow Time

4.1.5.3 Close Time Optimization

Close Optimization is used to modify the amount of time the well is closed in order to get the plunger to arrive at the *Target Rise Time*. The *Close Time* acts as a minimum amount of close, while the *Extra Close Time* is an additional controller state that is used to shut-in the well for a variable amount of time. The amount of additional close time that we are currently using is stored as *Extra Close Percentage* ($EC_{\%}$).

The following parameters summarize the calculations that are done to get the current *Extra Close Time*.

4.1.5.3.1 Close Time (C_{Time})

The *Close Time* is configured as part of the normal setup of the controller. The *Close Time* is used to shut-in the well for a **MINIMUM** amount of time. Changes in timer optimization settings will not affect the *Close Time*, but devices such as Line Pressure and Casing Pressure can hold the controller in close.

4.1.5.3.2 Max Close Time (MC_{Time})

The *Max Close Time* defines the maximum amount of time that the well is allowed to stay closed including *Close*, *Non-Arrival Close*, and *Extra Close Time*. In Close Time Optimization, the *Max Close Time* is used to find the *Remaining Close Time.* Please note that the well may stay closed longer due to devices such as Line Pressure or Casing Pressure.

4.1.5.3.3 Remaining Close Time (RC_{Time})

The Remaining Close Time is the amount of shut-in time that is left after the *Close Time* has expired and before the *Max Close Time* is reached.

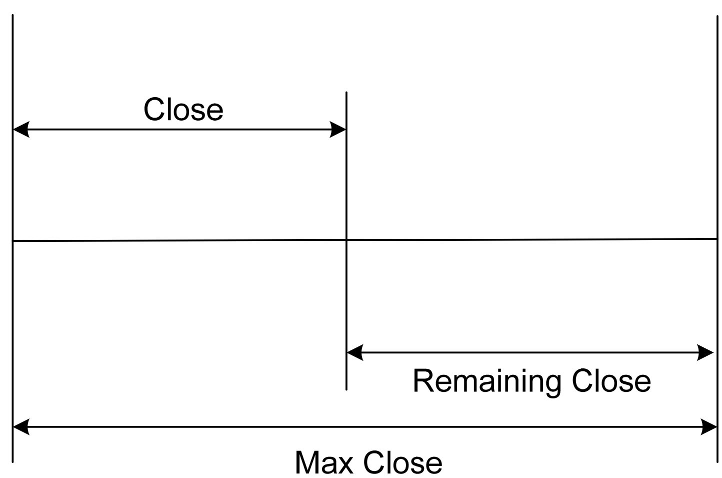


Figure 27 – Remaining Close Time

This time is used in conjunction with the *Extra Close Percentage* to give us *Extra Close Time*.

$$RC_{Time} = MC_{Time} - C_{Time}$$

Where:
RC_{Time} = Remaining Close Time

MC_{Time} = Max Close Time
C_{Time} = Close Time

4.1.5.3.4 Extra Close Percentage ($EC_{\%}$)

The *Extra Close Percentage* keeps track of how much of the Remaining Close Time to make use of. This percentage is adjusted after each plunger arrival. If the plunger arrives late, the well will be shut-in longer. If the plunger arrives early, the well will be shut-in less. The minimum for this parameter is 0% and the maximum is 100%.

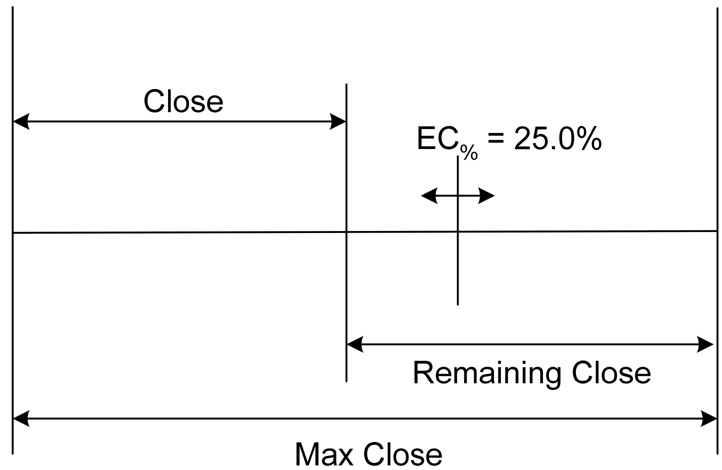


Figure 28 - EC%

The amount of change that is made is proportional to the *Miss Percentage* as defined earlier. The *Miss Percentage* is scaled by the *Timer Mode* and added to the *Extra Close Percentage*.

$$EC_{\%} = EC_{\%} + (M_{\%} \times TM)$$

Where:
$EC_{\%}$ = Extra Close Percentage
$M_{\%}$ = Miss Percentage
TM = Timer Mode

For example, if the *Miss Percentage* was -10% (arrived 10% early) and the Timer Mode was set to A (1%), then 0.1% would be subtracted from the *Extra Close Percentage*.

$$EC_{\%} = EC_{\%} + (-10\% \times 1\%)$$

$$EC_{\%} = EC_{\%} - 0.1\%$$

Conversely, if the *Miss Percentage* was 10% (arrived 10% late) and the Timer Mode was set to A (1%), then 0.1% would be added to the *Extra Close Percentage*.

$$EC_{\%} = EC_{\%} + (10\% \times 1\%)$$

$$EC_{\%} = EC_{\%} + 0.1\%$$

4.1.5.3.5 Extra Close Time (EC_{Time})

To get the current *Extra Close Time*, the *Extra Close Percentage* is multiplied by the *Remaining Close Time*.

$$EC_{Time} = EC_{\%} \times RC_{Time}$$

Where:
EC_{Time} = Extra Close Time
$EC_{\%}$ = Extra Close Percentage
RC_{Time} = Remaining Close Time

4.1.6 Dual Valve

The well may also be equipped with a second valve (Valve B). This valve may be installed in one of 3 configurations. These configurations are illustrated and described below.

4.1.6.1 Top Valve

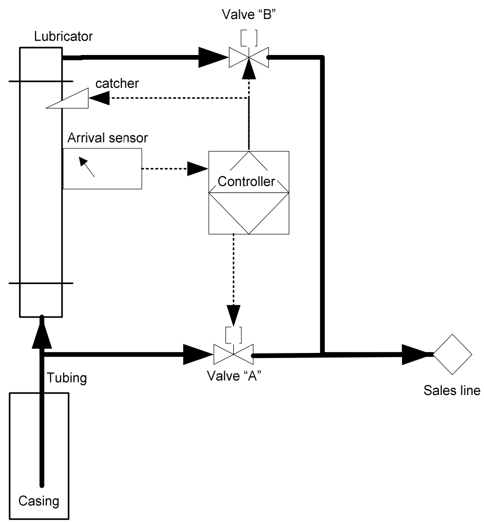


Figure 29 - Top Valve Well Configuration

The *Valve B Type* must be set to line and the *Afterflow Valve Configuration* must be set to A in order to operate the controller in a Top Valve configuration.

During the Rise portion of the cycle, Valve B is open and Valve A is closed. The location of Valve B is such that the plunger will be driven fully into the lubricator upon arrival without requiring excessive (i.e. sub-optimal) velocity. A short time after the plunger arrival, Valve A is opened and Valve B is closed. The location of Valve A causes the Plunger to be held within the Lubricator while gas is flowing with sufficient pressure. In this configuration, the well may be equipped with an auto-catcher which is driven from the Valve B gas supply line.

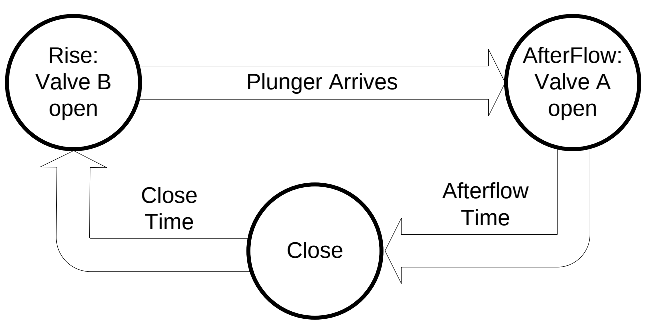


Figure 30 - Top Valve Operation

4.1.6.2 Flow Tee

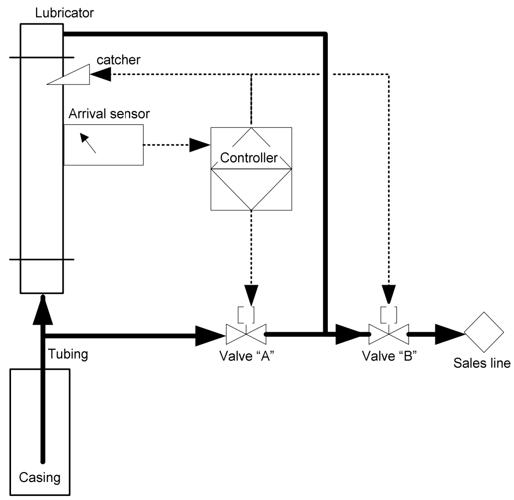


Figure 31 - Flow Tee Well Configuration

The Top Valve configuration has the disadvantage of requiring that a valve gas control line be installed between the separator shack and well-head. To avoid this, a Flow Tee configuration is often used. Operation is the same as for the *Top* valve except that, in the Afterflow portion of the cycle, both valves are left open.

To achieve this configuration, the *Valve B Type* must be set to line and the *Afterflow Valve Configuration* must be set to A/B.

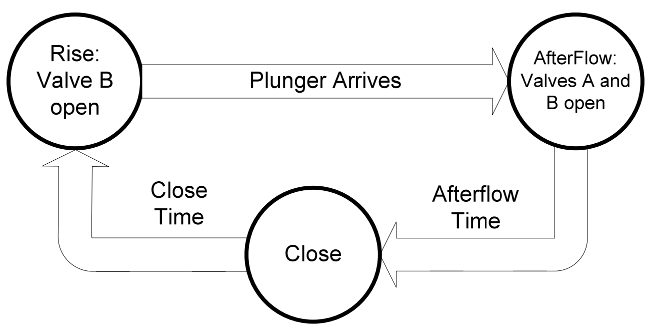


Figure 32 - Flow Tee Operation

4.1.6.3 Tank Valve

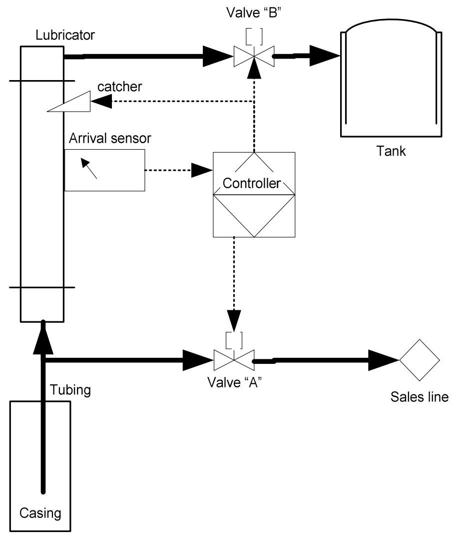
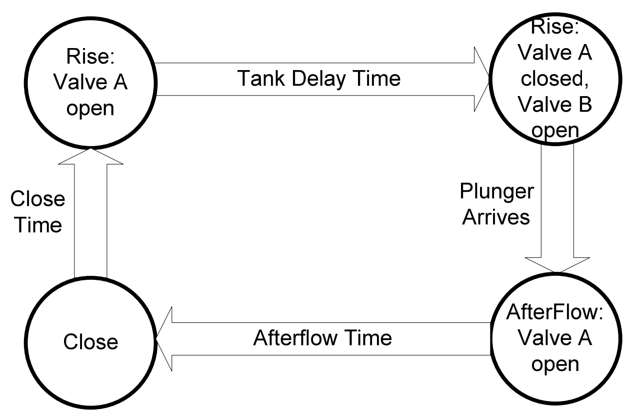


Figure 33 - Tank Valve Well Configuration

If Valve B is connected to a Tank, Valve A is opened at the start of the Rise portion of the cycle. If the plunger does not arrive within a specified time, then the valves are toggled (i.e. simultaneously open Valve B and close Valve A). When the plunger arrives, the valves may be toggled again. The purpose of the tank is to assist in plunger lift by exerting less back pressure on the well tubing than that exerted from the sales Line.

For each valve, the controller is equipped with a solenoid which directs the flow of low pressure gas to either an "open" or "close" line connected to a valve. This, in turn, controls the flow of higher pressure gas which actuates the valve position. The controller emits separate open and close pulse for each valve.



4.1.7 Low Battery

The controller is designed to handle a number of failure conditions, most of which have already been discussed. If the controller senses that the battery is low, it will take action to ensure that the valve(s) are left in a known state. When a low battery condition has occurred, the controller will actuate the valve(s) and then go into a Stopped state. The controller will remain in this state until the battery has recovered or an operator has intervened.

The state that the valve is placed in when a low battery condition occurs is based on the *Low Battery Fail Mode* parameter that is found in the Alarms menu.

5 Modbus Communications

The controller is equipped with an RS-485 port which is designed primarily to provide communications to a SCADA system. This port provides most of the functions available from the front panel user interface using the Modbus protocol. The Modbus Communications User's Guide discusses the physical connections, communications settings, and the available registers.

6 Installation

6.1 Physical Connections

The following is an outline of the locations that input devices can be wired to:

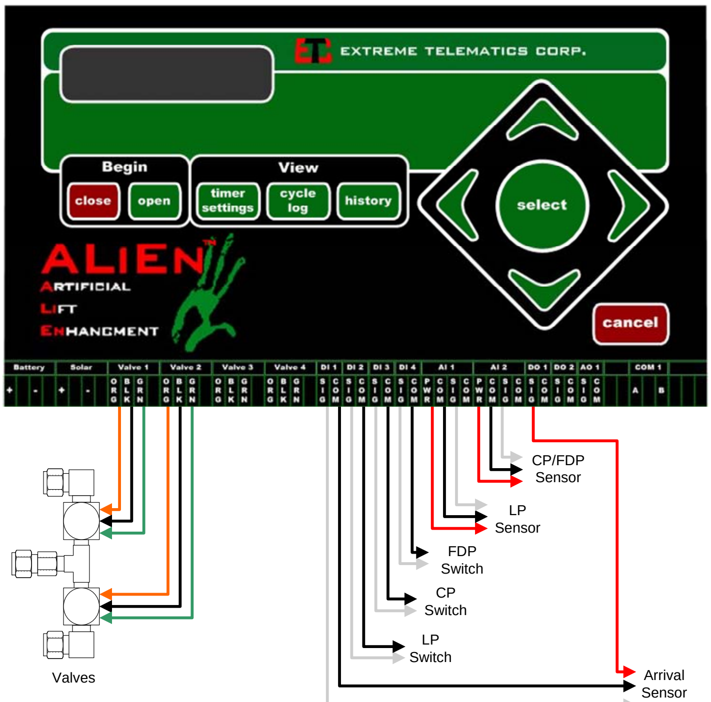


Figure 34 - Alien Wiring Diagram

Location	Devices To Connect	Description
Battery	6V Battery	Only use a 6V intrinsically safe ETC battery.
Solar	Solar Panel	Use a 3W ETC Solar Panel
Valve 1	Valve A Solenoid	Only use an intrinsically safe ETC approved valve solenoid.
Valve 2	Valve B Solenoid	Only use an intrinsically safe ETC approved valve solenoid.
Valve 3	Valve C Solenoid	Only use an intrinsically safe ETC approved valve solenoid.
Valve 4	Valve D Solenoid (Auto Catcher Valve)	Only use an intrinsically safe ETC approved valve solenoid.

Location	Devices To Connect	Description
DI 1	Arrival Sensor	Connect signal and ground of a 2 or 3 wire plunger arrival sensor.
DI 2	Line Pressure Switch	Switch contacts that can be configured to cause a trip on a switch closing or opening.
DI 3	Casing Pressure Switch	Switch contacts that can be configured to cause a trip on a switch closing or opening.
DI 4	Flow/Flow DP Switch	Switch contacts that can be configured to cause a trip on a switch closing or opening.
AI 1	Line Pressure Sensor	Use AST intrinsically safe, low power pressure transducer provided by ETC
AI 2	Casing Pressure	Use AST intrinsically safe, low power pressure transducer provided by ETC
	Flow Differential Pressure	Use low power Rosemount 1151 differential pressure transmitter.
	Flow Sensor	This feature is currently not fully implemented and requires customer input.
DO 1	Arrival Sensor Power or Field Connectable	Configure this output to power the arrival sensor or to mimic a valve. This is field connectable, but must meet the entity parameters found in the ETC Gas Valve Controller Installation Manual.
DO 2	Arrival Sensor Power or Field Connectable	Configure this output to power the arrival sensor or to mimic a valve. This is field connectable, but must meet the entity parameters found in the ETC Gas Valve Controller Installation Manual.
AO 1	Not currently implemented	Provides a 4 – 20 mA output signal.
COM 1	Differential RS485 device	Field connectable to a 2 wire RS485 interface. The connected device must meet the entity parameters found in the ETC Gas Valve Controller Installation Manual.

Note: support for a 3 wire arrival sensor has been included but must be configured through the Outputs menu. By default, the power for the 3 wire sensor is provided through the DO1>SIG connection.

6.2 Connecting Power

The following steps must be performed in the specified order to ensure that the battery properly charges:

1. Connect the Battery to the +/- Battery terminals on the left hand side of the controller
2. Connect the solar panel to the +/- Solar terminals

Note: If the controller is not hooked up to power in this order, the battery will not charge.

7 Troubleshooting

The following outlines a number of common issues that may be encountered.

Table 15 - Troubleshooting Guide

Issue	Cause	Resolution
The display won't come on when the battery is plugged in.	The fuse is blown on the battery	Return to ETC to be repaired. To avoid this issue, make sure to avoid shorting the battery connections.
	Battery is unplugged or there is a loose connection	Plug in the battery and check all connections
	Battery is dead	Charge the battery as per the directions on the side of the battery. If it does not hold a charge, contact ETC to purchase a new battery.
	Software has been erased	Reprogram the software using the software upgrade procedure.
Pressing a button does not produce the desired response.	A key is stuck on the keypad	The keypad will need to be replaced. Please call ETC to arrange for the controller to be repaired.
	The main core of the controller has been shocked	The controller core must be replaced. Please call ETC to arrange for the controller to be repaired. To avoid this, always transport the controller board in a static protection bag and avoid touching any exposed connections along the back of the controller without appropriate grounding.
Cannot Log in to the Setup Menu	You have forgotten your operator/installer ID.	If the Operator ID has been forgotten, use the Installer ID. If the Installer ID has been forgotten, ETC can generate a new ID on a per controller basis.

Issue	Cause	Resolution
Cannot see the Optimization menu item	No optimization schemes are enabled on this controller	Contact ETC to purchase an optimization feature key.
Cannot see the Modbus menu item	Modbus communications has not been enabled on this controller	Contact ETC to purchase a Modbus communications feature key.
Cannot turn on Valve B	Valve B operation has not been enabled on this controller.	Contact ETC to obtain a Valve B feature key.
Timer Optimization adjustments are too large	The algorithm is setup to be too aggressive.	Try using a different Timer Optimization mode. Mode A is the least aggressive.
Timer Optimization takes too long to adjust to the right value	The algorithm is not setup to be aggressive enough.	Try using a different Timer Optimization mode. Mode B and C are more aggressive than the default, A.
Fast Trips do not shut in the well	Fast Trips are disabled	Set the Fast Trips in the Alarms menu to something other than disabled.
	The fast trip alarm mode is set to fail open	Change the Fast Trip Fail Mode to Closed in the Alarms menu.
Non-Arrivals do not shut in the well	Non-Arrivals are disabled	Set the Non-Arrivals in the Alarms menu to something other than disabled.
	The non-arrival alarm mode is set to fail open	Change the Non-Arrival Fail Mode to Closed in the Alarms menu.
Controller is sitting in the stopped state	The battery is low	Replace the battery and ensure that the solar panel is connected and positioned correctly.
	Too many fast trips have occurred	Correct the issue with the well and set the controller to resume normal operation.
	Too many non-arrivals have occurred	Correct the issue with the well and set the controller to resume normal operation.

8 Support

8.1 Software Upgrade

On occasion, software upgrades are made available. These releases will contain new features as well as resolutions to issues found in the product. The release notes describe the changes that are available in each release. The new software can be downloaded through the communications port whether the Modbus option is enabled or not.

It is recommended that the controller be removed from the well before the upgrade is performed as the valve operation cannot be trusted during the upgrade.

8.1.1 Prerequisites

The following equipment is required to upgrade the controller:

- Battery
- Laptop with a USB port
- USB to RS485 converter
- Latest Firmware file from Extreme Telematics Corp.

8.1.2 Setup

1. Ensure that the USB to RS485 adapter is configured in 2 wire mode.
2. Wire the RDA(-) to COM1 B and RDB(+) to COM1 A. The GND can be wired to the unlabelled connection on COM1 between A and B, but is not necessary.
3. Plug adapter into an available USB port
4. Install the drivers that were provided with the USB to RS485 converter

8.1.3 Upgrade Procedure

1. Hold the ***Cycle Log*** button down
2. Plug the battery into the controller
3. Release the ***Cycle Log*** button
4. If the controller does not enter the upgrade program, the previous software that was installed may not include this program. Please contact ETC.
5. Follow the prompts on the screen to erase the current firmware. To abort the upgrade process at this point, unplug the battery.
6. When prompted to do so, download the firmware
    a. Open the ETC Upgrade Utility
    b. Browse to the latest ETC file that was provided by Extreme Telematics Corp.
    c. Select the appropriate COM port from the drop down list.
    d. Click the Connect button
    e. Select Download
7. The display on the controller should change to show the status of the download and a progress bar should appear on the screen, showing how much code has been downloaded.
8. When the download is complete, the controller should start normally.

8.1.4 Upgrade Errors

During the download of a firmware image, errors may occasionally occur. If this does happen, simply repeat the procedure again, making sure to erase the current firmware. If an error occurs multiple times in a row, contact Extreme Telematics Corp.

The following is a list of errors that may be seen:

- **Err 1 – Invalid file format.** The Bootloader found information in the serial stream that did not match the expected format. This could be a transmission error or an error with the file.
- **Err 2 – Dropped Characters.** While parsing the incoming stream, extra characters were detected. This typically means that some data was lost.
- **Err 3 – Character Buffer Overrun.** Incoming characters were lost because the controller was too busy processing to service the incoming data. Please contact ETC if this occurs.
- **Err 4 – Flash Buffer Overrun.** This means that there is a back log saving to the controller. Please contact ETC if this occurs.
- **Err 5 – Character Buffer Underrun.** The controller was expecting to parse more incoming characters, but there are none available. Please contact ETC if this occurs.

8.2 Replacement Parts and Accessories

Several replacement parts or accessories are available for purchase. These items are listed in the table below with their associated part numbers. Please contact sales for the current price list.

Table 16 - Available Replacement Parts and Accessories

Part Number	Name	Description
ET-10000-1007-0001	Single Valve Assembly	Includes a pneumatic valve solenoid, 2 3/8" NPT elbows, an O Ring, and Nylon Lock Nut
ET-10000-1007-0002	Dual Valve Assembly	Includes 2 pneumatic valve solenoids, 2 3/8" NPT elbows, a Tee, a 3/8" NPT connector, 2 O Rings, and 2 Nylon Lock Nuts
ET-10000-1007-0005	Dual Valve Upgrade Kit	Includes a pneumatic valve solenoid, a Tee, a 3/8" NPT connector, an O Ring, and Nylon Lock Nut
ET-00000-0000-0230	Valve Solenoid Core	Includes the plastic molded solenoid core and wires
ET-00000-0000-0231	Valve Piston and Spring	Includes the internal valve piston and attached spring assembly
ET-00000-0000-0225	Solar Panel	6V, 3W CSA Class 1 Div 1 Intrinsically safe solar panel
ET-10000-1011-0000	6V Battery	CSA approved replacement battery with intrinsically safe protection.
Coming Soon	Arrival Sensor	Use with the Alien controller to detect a plunger arrival.
ET-00000-0000-0070	4 Pin Connector	4 Pin Weidmuller connector
ET-00000-0000-0009	8 Pin Connector	8 Pin Weidmuller connector
ET-00000-0000-0180	Captive Screw	Small screws that are used to attach the controller to the enclosure.
S0000001	Timer Optimization License Key	Allows the Extended Afterflow or Extra Close times to be modified based on the arrival time of the plunger.
S0000002	Pressure Optimization License Key	Allows pressure devices to be used to optimize both the close and extended Afterflow portions of the cycle.
S0000003	Modbus Communications License Key	Allows for remote communications via Modbus.

8.3 Technical Support

8.3.1 Contacting Support

Support is available from your current service company. If an issue does arise, they should be the first point of contact. Service companies that are currently authorized distributors of the Alien can contact us in the following ways:

8.3.1.1 Web

Please visit our website at http://www.ETCorp.ca.

8.3.1.2 Phone

ETC support can be contacted via phone at our office in Calgary, AB at (403) 290-6300 Mon – Fri, 9:00 am to 5:00 pm MST. Authorized distributors will be provided information on how to contact someone outside the normal business hours listed above.

8.3.2 Identifying the Issue

Please take the time to identify the issue that is being experienced. Many issues can be resolved by simply upgrading the controller to the latest software. If the issue still persists, please try and determine if there is an issue with the software or hardware. Here are some common indications of each type of issue:

8.3.2.1 Hardware

- Battery is not charging
- Some display pixels do not power up
- The controller display does not come up and the controller does not draw any current
- A key is stuck

8.3.2.2 Firmware

- The controller restarts itself (goes back to close at an incorrect time)
- There are entries in the error log (Located in the System menu)
- Controller behaviour is erratic
- The same issue happens across multiple controllers

8.3.3 Reporting Software Issues

We strive to provide the best software possible that is free of defects. As with any controller, there may be issues. When issues do arise, please do the following:

- Copy down any errors that are found in the error log
- Note the controller configuration
- Note what was being done on the controller when the issue occurred
- Note the serial number and version number of the controller that experienced the issue
- Detail instructions on how to repeat the issue if possible

8.3.4 Repair Process

Please contact ETC and arrange to have the controller repaired. Please be ready to explain the issues that are being experienced. A detailed account of the problem will be required so that the issue can addressed in a timely fashion. Returned controllers will take approximately 4 – 6 weeks to be diagnosed and resolved.