

Gen7 Systems SCADASuite Plunger Lift and Gas Lift Application Note

1 Introduction

Gen7 Systems has developed a plunger lift application for Schneider Electric SCADAPack that allows you to safely increase production from your wells. Instead of control modes, it uses a sophisticated conditions-based approach that gives you precise control. The program includes an optimization feature that tunes setpoints automatically to try to force normal plunger arrival.

The program also includes an optional gas lift add on which allows you to safely inject gas down hole to further increase well production. The gas lift application supports both Plunger Assisted Gas Lift (PAGL) and Gas Assisted Plunger Lift (GAPL) modes.

The gas lift program can be used in an independent way, or it can coordinate with the plunger program to inject gas at certain parts of the plunger cycle. The gas lift program includes optimization features that automatically adjust setpoints to reduce the amount of gas that is injected to only the necessary amount, which allows for increased production without wasting injection gas.

This document provides a high-level overview of the SCADASuite Plunger Lift and Gas Lift applications. For additional details, please consult the resources below, or reach out to us directly.

- [The latest version of this document](#)
- [SCADASuite Plunger Lift and Gas Lift web page](#)
- [SCADASuite Resources web page](#)
- [Plunger Lift and Gas Lift in the SCADASuite Reference Manual](#)
- [Plunger Lift and Gas Lift in the SCADASuite Applications Manual](#)

2 Plunger Lift

Figure 1 shows a standard plunger cycle. For the sake of clarity, protection and other optional functionality, like control overrides, are not shown.

Note that a plunger does not actually need to be installed in the well. When a plunger is not installed, the program does not wait for plunger arrival, but instead moves immediately to the 'after flow delay' state once the sales valve is opened.

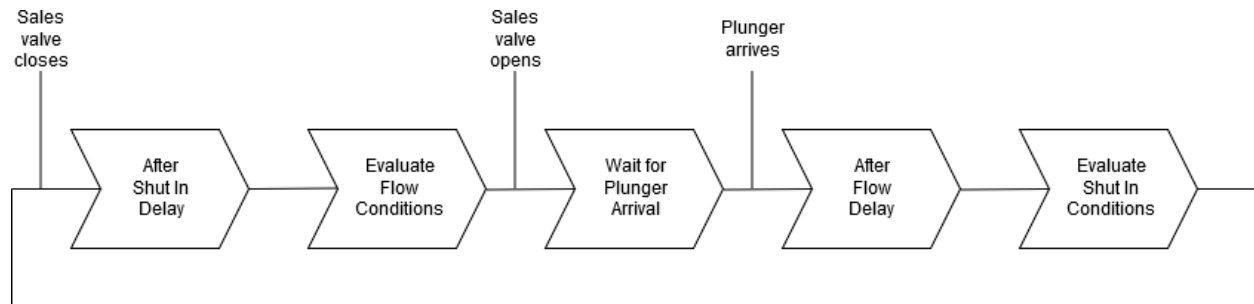


Figure 1 – Basic Plunger Lift Cycle

2.1 Conditions Based Approach

The SCADA Suite Plunger Lift application uses a conditions-based approach to determine when to open or close the sales valve and allow the well to flow or be shut in.

Each condition is enabled independently, and each condition also has a configurable delay between the time that the condition occurs and is accepted, which allows for rejection of fleeting changes.

2.2 Flow Conditions

All enabled flow conditions must be met before the sales valve is opened and the well can flow. This is unlike shut in conditions, where any single shut in condition being met will cause the well to shut in.

- **Minimum Off Time.** The minimum amount of time to wait after the well is shut in.
- **Maximum Load Ratio.** The calculated load ratio must be below this value.
- **Minimum Tubing Pressure.** The well's tubing pressure must be greater than this value.
- **Minimum Casing Pressure.** The well's casing pressure must be greater than this value.
- **Maximum Line Pressure.** The line pressure must be less than this value.
- **Minimum Tubing/Line Pressure Difference.** The difference between the tubing and line pressure must be greater than this value.
- **Minimum Casing/Line Pressure Difference.** The difference between the casing and line pressure must be greater than this value.
- **User Flow Condition.** Trigger a flow condition via a register based on your own ladder logic.

2.3 Shut In Conditions

Once any single enabled shut in condition is met the well will be shut in. This is unlike flow conditions, where all the enabled flow conditions must be met to allow the well to flow.

- **Maximum On Time.** The maximum amount of time to wait after the well is flowing.
- **Minimum Well Flow.** The flow from the well must be less than this value.
- **Casing Pressure Rise.** The rise in casing pressure from the minimum measured value while the well is flowing must be greater than this value.
- **Critical Flow.** The actual flow from the well must be less than the calculated critical flow rate. This condition includes a multiplier so that the threshold can be set to some multiple of the critical flow rate. Both Turner and Coleman algorithms are supported for the critical velocity calculation.
- **User Shut In Condition.** Trigger a shut in condition via a register based on your own ladder logic.
- **Minimum Casing Pressure.** The casing pressure must be less than this value.
- **Minimum Tubing Pressure.** The tubing pressure must be less than this value.
- **Casing/Line Pressure Difference.** The difference between the casing and line pressure must be less than this value.

2.4 Control Overrides

The SCADASuite Plunger Lift application has the control overrides described below. Control overrides can be engaged or disengaged at any time during the plunger control cycle.

- **Sales Valve Manual Override.** This allows you to force the sales valve open or closed. When override is disengaged, plunger control will restart from the configured starting state.
- **Pause Control.** When pause is enabled, the plunger program will halt its counters and will not advance to a new state. The program will simply wait without doing anything except checking protection settings. When pause is disengaged, the program will pick up exactly where it left off. This feature lets you do maintenance on a well, or allow for some unexpected condition, without having to completely stop and start automatic control.
- **Advance to State.** This lets you advance to the After Shut In Delay or After Flow Delay states without passing through any other states. This feature gives you to option to bypass the application's internal control states to quickly move to a known state.

2.5 Automatic Optimization

When configured to do so, the SCADASuite Plunger Lift application will automatically adjust both flow condition and shut in condition set points to try to force normal plunger arrival. If the plunger arrival is early, the last flow condition that was met will be adjusted to make the well flow for longer on the next cycle. If the plunger arrival is late, the first shut in condition that was met will be adjusted to shut the well in for longer on the next cycle.

Conditions will only be adjusted within a user configurable range. Each condition has its own allowable range. This allows you to have complete control over how optimization works.

3 Gas Lift

The SCADASuite Gas Lift application allows you to inject gas down hole in a controlled fashion to increase production from your well. The application uses PID control to set the position of an injection valve to inject just the amount of gas that you want. The application supports multiple control modes, including a plunger mode where gas injection occurs at various times during the plunger cycle.

Control of the injection valve uses the same PID algorithm and code as is normally used in SCADAPack, which ensures that the closed loop control algorithm is robust and well tested. The gas lift application can be configured for just injection flow rate control, or for injection flow rate control with pressure override.

3.1 Control Modes

The SCADASuite Gas Lift application supports the control modes listed below.

3.1.1 Continuous Flow or Continuous Critical Flow

In the 'continuous flow' mode, gas is continuously injected down hole at a fixed rate. The injection flow rate set point is configured by the user.

In the 'continuous critical flow' mode, gas is continuously injected down hole at some rate to keep the well's flow rate above the well's calculated critical flow rate. The PID algorithm manipulates the position of the injection valve to control the well's flow rate. This requires very careful tuning of the PID loop to work.

3.1.1.1 Continuous Flow and Continuous Critical Flow Shut In Action

When in the 'continuous flow' or 'continuous critical flow' control mode, there is a configuration option to control what happens with gas injection when the plunger sales valve is closed. This isn't full coordination with the plunger control loop, like in the gas lift 'plunger' control mode, but it does allow for some smaller amount of coordination.

These actions are especially useful when the well does not have a plunger installed.

When the plunger sales valve is closed, the gas lift application can:

- **Do Nothing.** Gas will continue to be injected and there is no coordination with the plunger program.
- **Close the Injection Valve.** The injection valve will be closed at the same time as the sales valve. Gas injection will resume when the plunger sales valve is opened.
- **Shut In Injection.** In this mode, gas will be injected if the well's casing pressure is below a configurable threshold and stop when the well's casing pressure exceeds a configurable threshold. This allows for gas only to be injected to bring the pressure in the well up. If the pressure in the well is above the starting threshold, then gas will not be injected, which saves gas.

3.1.2 Injection Steps

Gas is injected at various rates to unload a well. Each step has its own injection flow rate and pressure change settings. The system moves to the next step when the pressure in the well changes by a configured amount or a timeout occurs.

This control mode is designed to unload the well and is typically used with plunger control disabled. Once the initial unloading is complete, then plunger control can be enabled and another gas lift control mode can be selected.

3.1.3 Plunger

In this mode, the gas lift application is aware of the state of the plunger lift application and injects gas at various stages of the plunger cycle.

Figure 2 shows how the gas lift program works with the plunger lift program. Gas can optionally be injected at various times during the plunger cycle. Each phase is discussed in more detail below.

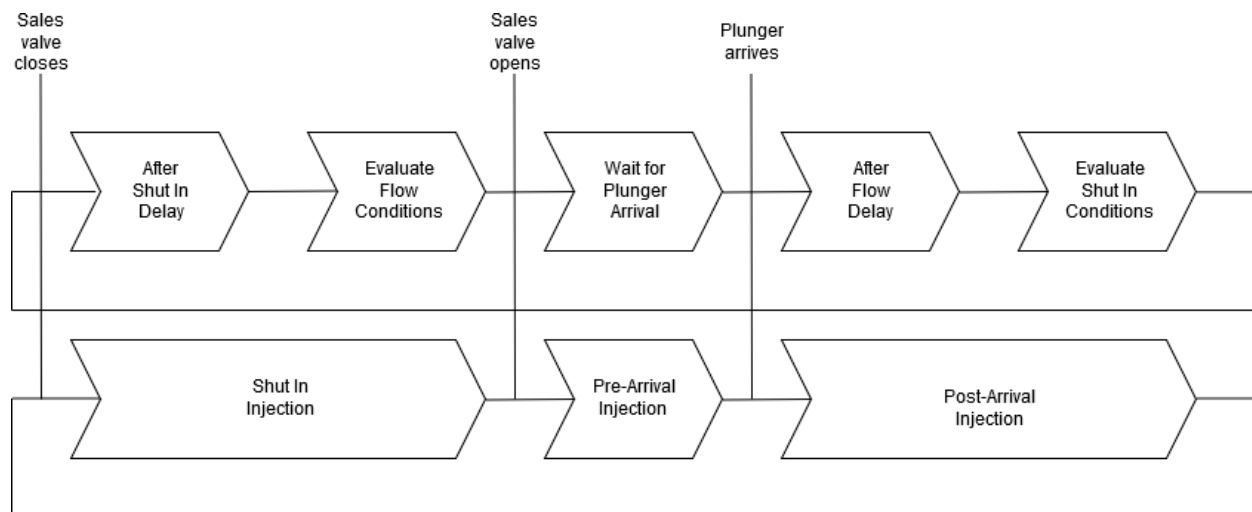


Figure 2 – Basic Plunger Lift and Gas Lift Cycle

3.1.3.1 Shut In Injection

When a shut in condition is accepted, and the plunger program closes the sales valve, the gas lift application can start shut in injection. Shut in injection is started if the well's casing pressure is below a configurable threshold, and stops when either a timeout occurs, or the well's casing pressure rises above a configurable threshold.

If the well's casing pressure is above the starting threshold, then gas won't be injected, which reduces the amount of gas that's used.

3.1.3.2 Pre-Arrival Injection

After flow conditions are met, and the sales valve is opened, but before the plunger arrives, gas can be injected. The gas injection flow rate is set depending on the type of the last plunger arrival. This lets you inject less gas (or no gas) if the plunger arrived early or normally in the previous cycle, or inject more gas if the plunger arrived late in the previous cycle.

3.1.3.2.1 Pre-Arrival Injection Optimization

The gas lift program can automatically adjust the pre-arrival injection flow rate depending on the previous plunger arrival types. You can configure both the number of consecutive arrivals that cause an adjustment, and the size of the adjustment.

For example, if the previous 3 plunger arrivals were late, you could increase the injection flow rate by a configurable amount. If the previous 5 plunger arrivals were early, you could reduce the injection flow rate by a configurable amount. The injection flow rate can be adjusted all the way down to 0, in which case no gas would be injected, which saves gas.

It's also possible to adjust the injection rate setpoint immediately, in the same cycle, when the plunger arrival is late. This can help a plunger arrive in the same cycle, instead of having to wait for a consecutive number of no-arrivals before an adjustment.

3.1.3.3 Post Arrival Injection

After the plunger arrives, the gas lift program can inject gas. Gas is injected until a timeout occurs or a shut in condition is accepted and the sales valve is closed.

3.2 Control Overrides

The SCADASuite Gas Lift application has the control overrides described below. Control overrides can be engaged at any time.

- **Injection Flow Rate Clamp.** When enabled, the injection flow rate will never be allowed to exceed the clamp value. This clamp is addition to other limitations that are available in the various gas lift control modes. This provides a global clamp that can be easily enabled to prevent too much gas from being injected downhole.
- **Injection Valve Override.** When enabled, the injection valve will be positioned to an operator selected value.
- **Control Mode Override.** When enabled, the gas lift program will either close the injection valve or undertake shut in injection. When disabled, the gas lift program will move back to whatever the previously selected control mode was.

Shut in injection is started if the well's casing pressure is below a configurable threshold, and stops when either a timeout occurs, or the well's casing pressure rises above a configurable threshold. When using the control mode override, it's the operators responsibility to position the plunger sales valve appropriately.

4 Other Features

4.1 Diagnostic Logging

The SCADASuite Plunger Lift and Gas Lift application includes a detailed diagnostic log to understand how the application is working. The log shows timestamped state changes, overrides and set point changes, as well as other detailed information.

This makes it easy to understand how the application is working, especially when something unexpected happens.

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■ 599 11/20/2019 8:28:07 AM [RTU] [INFO] Diagnostic Log: App Plunger Lift, config v1.1.7, app v1.0.0 for Controller ID A946612

Message Details: (01) 2019-Nov-20 08:01:36.600 [INFO] Plunger 0, exit 'after shut in delay' state. Time in state 0, limit 0 (minutes) [1944]
(02) 2019-Nov-20 08:04:46.600 [INFO] Plunger 0, valve controlled. Old state 0, new state -1, reason 2 [1948]
(03) 2019-Nov-20 08:04:46.600 [INFO] Plunger/Gas Lift 0, pre-arrival injection start, last arrival type 'normal' [2175]
(04) 2019-Nov-20 08:04:46.600 [INFO] Plunger 0, exit 'wait for flow' state. Reason 'minimum off time', time in state 3 (minutes). Limit 3, actual value 3 [1958]
(05) 2019-Nov-20 08:08:06.610 [INFO] Plunger/Gas Lift 0, pre-arrival injection stop, total time in state 199(seconds), delay 0(seconds), max time 600seconds [2176]
(06) 2019-Nov-20 08:08:06.610 [INFO] Plunger 0, plunger arrival, total 243, normal 236, early 5, late 2, no arrival 0, consecutive very early 0, consecutive no arrival 0, arrival time 3 (min
(07) 2019-Nov-20 08:08:11.610 [INFO] Plunger 0, exit 'after flow delay' state. Time in state 0, limit 0 (minutes) [1946]
(08) 2019-Nov-20 08:13:26.610 [INFO] Plunger 0, valve controlled. Old state -1, new state 0, reason 3 [1948]
(09) 2019-Nov-20 08:13:26.610 [INFO] Plunger 0, exit 'wait for shut in' state. Reason 'maximum on time', time in state 5 (minutes). Limit 5, actual value 5 [1947]
(10) 2019-Nov-20 08:13:36.630 [INFO] Plunger 0, exit 'after shut in delay' state. Time in state 0, limit 0 (minutes) [1944]
(11) 2019-Nov-20 08:16:46.800 [INFO] Plunger/Gas Lift 0, pre-arrival injection start, last arrival type 'normal' [2175]
(12) 2019-Nov-20 08:16:46.800 [INFO] Plunger 0, exit 'wait for flow' state. Reason 'minimum off time', time in state 3 (minutes). Limit 3, actual value 3 [1958]
(13) 2019-Nov-20 08:16:46.810 [INFO] Plunger 0, valve controlled. Old state 0, new state -1, reason 2 [1948]
(14) 2019-Nov-20 08:19:11.630 [INFO] Plunger/Gas Lift 0, pre-arrival injection stop, total time in state 145(seconds), delay 0(seconds), max time 600seconds [2176]
(15) 2019-Nov-20 08:19:11.630 [INFO] Plunger 0, plunger arrival, total 244, normal 237, early 5, late 2, no arrival 0, consecutive very early 0, consecutive no arrival 0, arrival time 2 (min
(16) 2019-Nov-20 08:19:16.650 [INFO] Plunger 0, exit 'after flow delay' state. Time in state 0, limit 0 (minutes) [1946]
(17) 2019-Nov-20 08:24:31.730 [INFO] Plunger 0, valve controlled. Old state -1, new state 0, reason 3 [1948]
(18) 2019-Nov-20 08:24:31.730 [INFO] Plunger 0, exit 'wait for shut in' state. Reason 'maximum on time', time in state 5 (minutes). Limit 5, actual value 5 [1947]
(19) 2019-Nov-20 08:24:46.640 [INFO] Plunger 0, exit 'after shut in delay' state. Time in state 0, limit 0 (minutes) [1944]
(20) 2019-Nov-20 08:27:56.640 [INFO] Plunger 0, valve controlled. Old state 0, new state -1, reason 2 [1948]
(21) 2019-Nov-20 08:27:56.640 [INFO] Plunger/Gas Lift 0, pre-arrival injection start, last arrival type 'normal' [2175]
(22) 2019-Nov-20 08:27:56.640 [INFO] Plunger 0, exit 'wait for flow' state. Reason 'minimum off time', time in state 3 (minutes). Limit 3, actual value 3 [1958]
(23) 2019-Nov-20 08:30:06.700 [INFO] Plunger/Gas Lift 0, pre-arrival injection stop, total time in state 129(seconds), delay 0(seconds), max time 600seconds [2176]
(24) 2019-Nov-20 08:30:06.700 [INFO] Plunger 0, plunger arrival, total 245, normal 238, early 5, late 2, no arrival 0, consecutive very early 0, consecutive no arrival 0, arrival time 2 (min
(25) 2019-Nov-20 08:30:11.650 [INFO] Plunger 0, exit 'after flow delay' state. Time in state 0, limit 0 (minutes) [1946]
(26) 2019-Nov-20 08:35:21.690 [INFO] Plunger 0, valve controlled. Old state -1, new state 0, reason 3 [1948]
(27) 2019-Nov-20 08:35:21.690 [INFO] Plunger 0, exit 'wait for shut in' state. Reason 'maximum on time', time in state 5 (minutes). Limit 5, actual value 5 [1947]
(28) 2019-Nov-20 08:35:36.660 [INFO] Plunger 0, exit 'after shut in delay' state. Time in state 0, limit 0 (minutes) [1944]
(29) 2019-Nov-20 08:38:51.670 [INFO] Plunger 0, valve controlled. Old state 0, new state -1, reason 2 [1948]
(30) 2019-Nov-20 08:38:51.670 [INFO] Plunger/Gas Lift 0, pre-arrival injection start, last arrival type 'normal' [2175]
(31) 2019-Nov-20 08:38:51.670 [INFO] Plunger 0, exit 'wait for flow' state. Reason 'minimum off time', time in state 3 (minutes). Limit 3, actual value 3 [1958]
(32) 2019-Nov-20 08:41:21.670 [INFO] Plunger/Gas Lift 0, pre-arrival injection stop, total time in state 150(seconds), delay 0(seconds), max time 600seconds [2176]
(33) 2019-Nov-20 08:41:21.670 [INFO] Plunger 0, plunger arrival, total 246, normal 239, early 5, late 2, no arrival 0, consecutive very early 0, consecutive no arrival 0, arrival time 2 (min
(34) 2019-Nov-20 08:41:26.680 [INFO] Plunger 0, exit 'after flow delay' state. Time in state 0, limit 0 (minutes) [1946]
(35) 2019-Nov-20 08:46:36.690 [INFO] Plunger 0, exit 'wait for shut in' state. Reason 'maximum on time', time in state 5 (minutes). Limit 5, actual value 5 [1947]
(36) 2019-Nov-20 08:46:36.700 [INFO] Plunger 0, valve controlled. Old state -1, new state 0, reason 3 [1948]
(37) 2019-Nov-20 08:46:51.670 [INFO] Plunger 0, exit 'after shut in delay' state. Time in state 0, limit 0 (minutes) [1944]
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Figure 3 - Diagnostic Log Example

4.2 Data Logging

Schneider Electric SCADAPack RTUs have built-in data logging functionality. Status information from the SCADASuite Plunger Lift and Gas Lift application can easily be logged using this feature.

High resolution logged data can be used to fine tune your application configuration and enhance production.

Logs can be retrieved by most popular SCADA systems, including Weatherford Cygnet, Schneider GeoSCADA (ClearSCADA), Trihedral VTScada and many 3rd party OPC drivers, like Autosol ACM. There is also a standalone SCADALog program that can retrieve logged data from SCADAPack.

4.3 Data Export

The SCADASuite family of applications for SCADAPack also includes a data export application that uses the MQTT protocol to push data from the RTU to some other computer system, bypassing the traditional SCADA and operational systems. This makes it easy to get the data that you need for additional analysis.

5 Conclusion

The SCADASuite Plunger and Gas Lift application makes it easy to safely increase production from your wells. The SCADASuite platform also comes with significant advantages to get the most out of your automation investment, and includes advanced features like compare (diff), version migration, Modbus register contention reports and others.

Most importantly, if you don't see features that you need, let us know, and we'll see what we can do to help. Using our [framework based approach](#), we can deliver fully tested and documented updates in days or weeks, instead of months.