Application Note:
Pressure and Flow Optimization

June 19, 2013

Background

All models of ETC plunger lift controller have the ability to utilize pressure. The base model comes with a line pressure input, allowing the controller to protect the well from high sales line pressure situations that could damage the well.

The upper models of controller also provide an input for Casing Pressure or Differential Pressure. These pressure inputs are used to enhance production. They allow the well to open at the right time to ensure proper flowing conditions, but also allow the well to stay running longer to ensure maximum efficiency of the plunger lift system. Two pressure devices can be used together to provide enhanced functionality.

All ETC controllers are shipped with the pressure devices turned off. This saves power and minimizes the number of settings that appear in the menus. As devices are configured, the settings associated with these devices such as the range, scan rate, and trip/reset points become available. As more devices are enabled, the features and set points for them will automatically change to give you the best available optimization algorithms.

Input Device Types

Discrete Switch

All pressure inputs can be used with a two wire, discrete switch. The most common switch that can be found at a number of well sites is a Murphy switch. This is an easy to understand device that simply closes a contact when the pressure reaches a certain value. The two wires are connected across the SIG and COM connections and the PWR connection is ignored.

This basic device is used for high line pressure or casing pressure optimization, but is very limited because the set point is configured on the Murphy switch. As well, since the controller only knows if the pressure is good (reset) or bad (tripped), more advanced algorithms that use a pressure value will not be available.

Analog Pressure Transducer

By using a pressure transducer, the controller will produce a numeric pressure value. The range of device can easily be changed and the value can be reported to the user and used for internal optimization algorithms. This also allows the operator to modify the set points either locally or remotely.

The pressure transducers that we recommend are the American Sensor Technologies AST4400 series with the ratiometric output. This particular model of pressure transducers are rated for Class I Div 1 and are intrinsically safe (IS). This means that they can be connected directly to ETC controllers without an IS barrier. As well, they are single seal approved, meaning that a costly secondary seal is not required for a safe installation.

ETC controllers are preprogrammed to support the low power, ratiometric AST interface. This means that many other types of sensors cannot be utilized. The following is a summary of the supported interface:

Excitation Voltage: 5 V Regulated
Voltage Output Expected: 0.5 V – 4.5 V
Range: 100 psi – 5000 psi

Differential Pressure Transducer

A differential pressure transducer is used to measure the pressure differential across an orifice plate. This is a key parameter used in any flow calculation. It can be used on its own or in combination with a number of other settings to give a flow reading. Although there are a number of different manufacturers that provide differential pressure transducers, few can operate off a low voltage, narrowing the acceptable models. In general, ETC controllers use this interface:

Excitation Voltage: 5 V Regulated
Voltage Output Expected: 0.8 V – 3.2 V
Range: 30 "WC – 3000 "WC

This interface is supported by the 1151L and 3051CD models of differential pressure transducer from Rosemount as long as it is ordered with Output Code M.

Some ETC controllers have a selectable setting for the expected voltage and can support 0.5 V – 4.5 V or 1 V – 5 V interfaces. AST is in the process of developing a differential pressure transducer that supports the 0.5 V – 4.5 V ratiometric interface.

Functionality

Line Pressure

Line pressure allows the operator to protect their well from flowing in the wrong direction. When line pressure is enabled, it is used at two different times. When the close time has expired the controller checks the line pressure before moving to the rise portion of the cycle. If the line pressure is too high, the well will remain closed until it drops to an acceptable level and stays there consistently for a minimum amount of time (stable time).

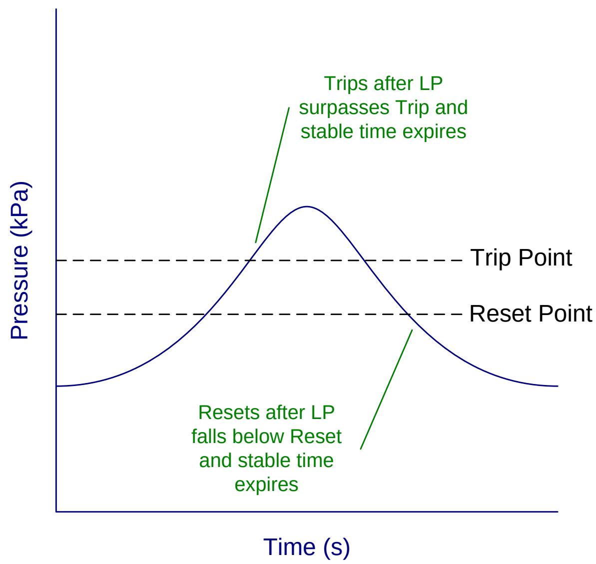

Figure 1 - Line Pressure

The line pressure will also be monitored during the afterflow portion of the cycle. If at any time the line pressure rises above an acceptable level and stays there for a given period of time (stable time), the controller will close the well and start the close time.

If the line pressure climbs during the rise portion of the cycle, the controller will not react, giving the plunger an opportunity to come to the surface before taking any action.

Casing Pressure

Casing pressure is used in two different instances. The first is at the end of the close time. The casing pressure is checked to ensure that it is sufficiently high enough to flow the well. If the casing pressure is at an acceptable level, the well will be allowed to open. If it has not reached the set point, the well will remain closed indefinitely.

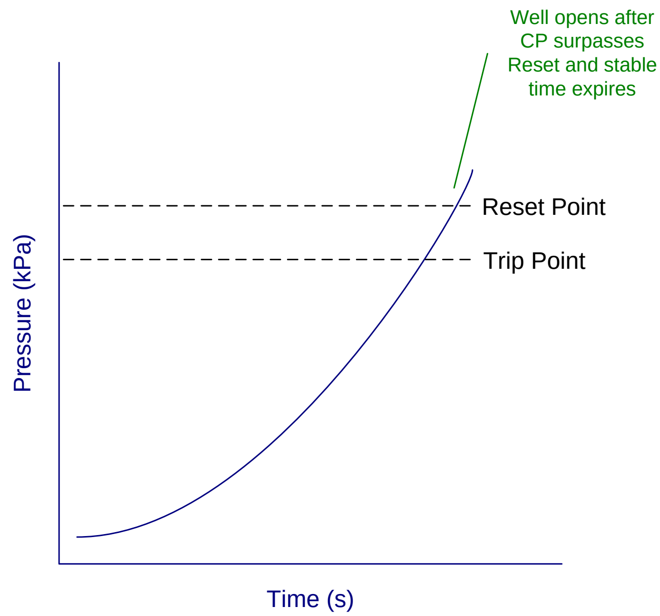

Figure 2 - Open Casing Pressure

When the controller is in afterflow and the minimum afterflow time has passed, the casing pressure will be monitored. The controller will decide when to close the well based on the algorithm that is selected. Absolute casing pressure will close the well once the casing pressure has dropped below a set point.

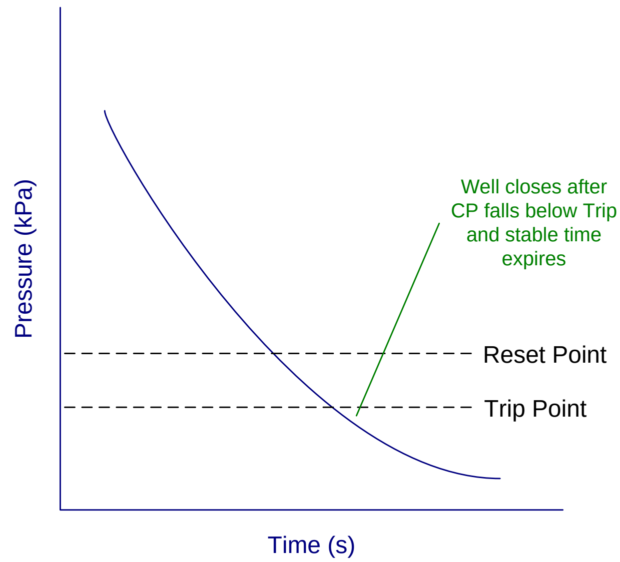

Figure 3 - Close Casing Pressure - Absolute

Rate of change will monitor how fast the casing pressure is falling and determine when it has slowed enough to take action. At that point in time, a trip delay timer will be started. At the expiry of this timer, the well will be closed.

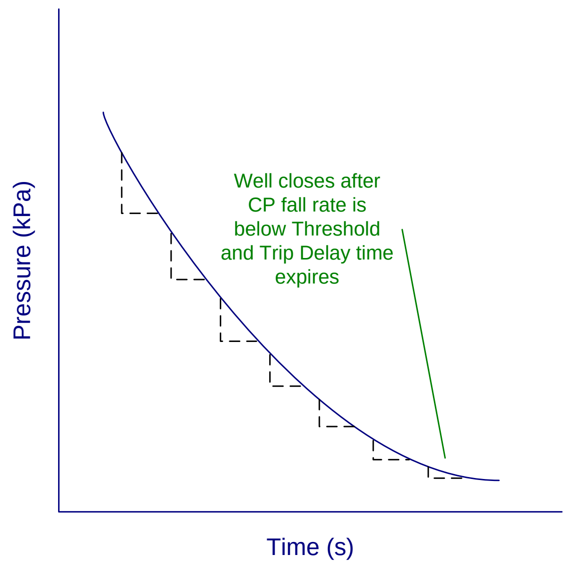

Figure 4 - Closing Casing Pressure - Rate of Change

Casing Line Differential Pressure

If you are using a line pressure and casing pressure transducer, you will have the ability to use casing line differential. Simply put, the controller will subtract the line pressure from the casing pressure and decide if there is a big enough spread to properly flow the well. The operator will configure a set point that is lets the controller know what difference to open on. Once again, the decision to open the well or keep it shut in is made once the close timer expires.

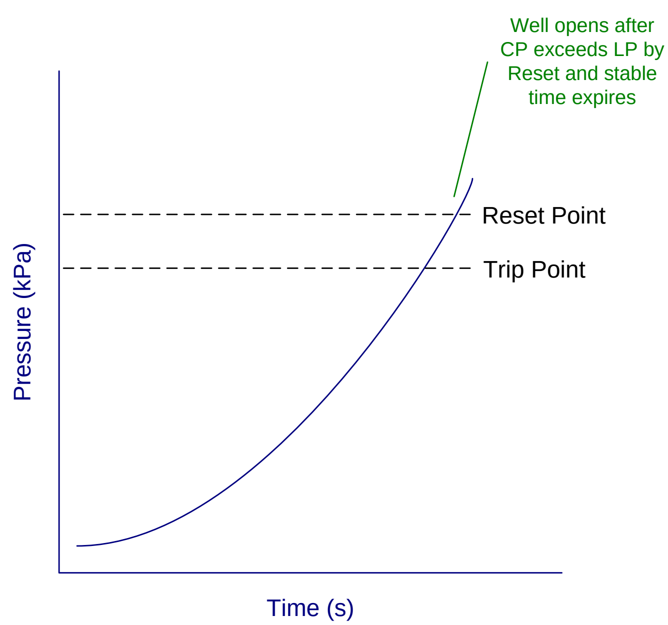

Figure 5 - Open Casing-Line Differential Pressure

Differential Pressure

Differential pressure is only monitored during afterflow since it is related to flow. Once the minimum afterflow has passed, the controller will decide whether to keep the well flowing or shut it in and return to close. As the difference in pressure drops below the trip point, the well will be closed. Differential pressure can be combined with line pressure and a number of other parameters to calculate flow. This is discussed in the next section.

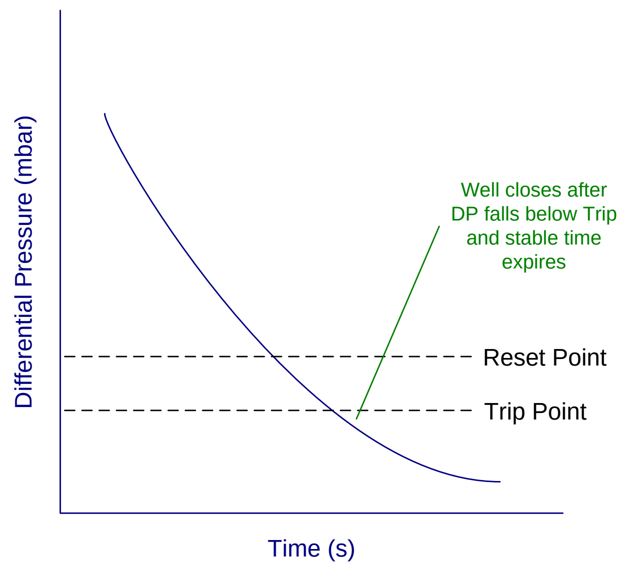

Figure 6 - Close Differential Pressure

Flow

Flow can be calculated from a differential pressure, line pressure, and several other static parameters. When the differential pressure sensor and line pressure sensor are both enabled, the orifice plate, temperature, and density parameters become visible. Every second that the well is flowing, an AGA 3 table based calculation is run, which produces an instantaneous flow rate. This flow rate is good enough to optimize a well and sum up total production for the day, but is not accurate enough for government reporting.

Flow can also be set as virtual. This means that the flow number is written into a Modbus register by the master on a regular basis so that the controller can use it for optimization.

As with differential pressure, the flow is only monitored during the afterflow portion of the cycle. Once the minimum afterflow time passes, the flow value is used to decide whether to keep the well open or to shut it in and go back to close.

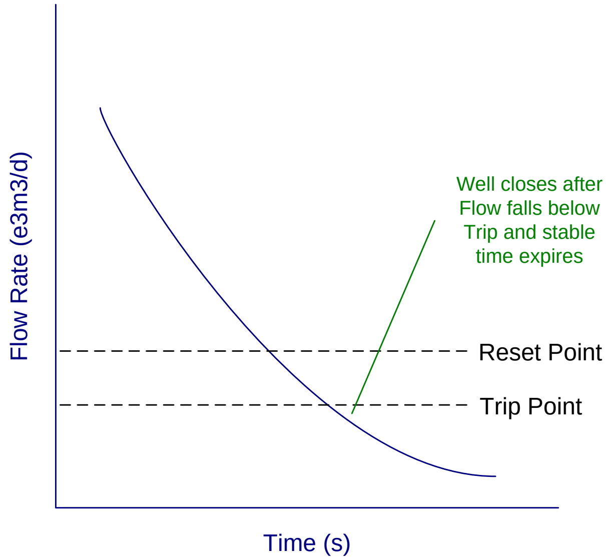

Figure 7 - Close Flow Rate

Whenever flow is used, the total production for the day is summarized and made available through the daily history logs. The history logs are cut off each day at the specified day start time. These logs allow the operator to see the comparative production each day.