ALiEn 2™
PLUNGER LIFT CONTROLLER

Optimization Techniques

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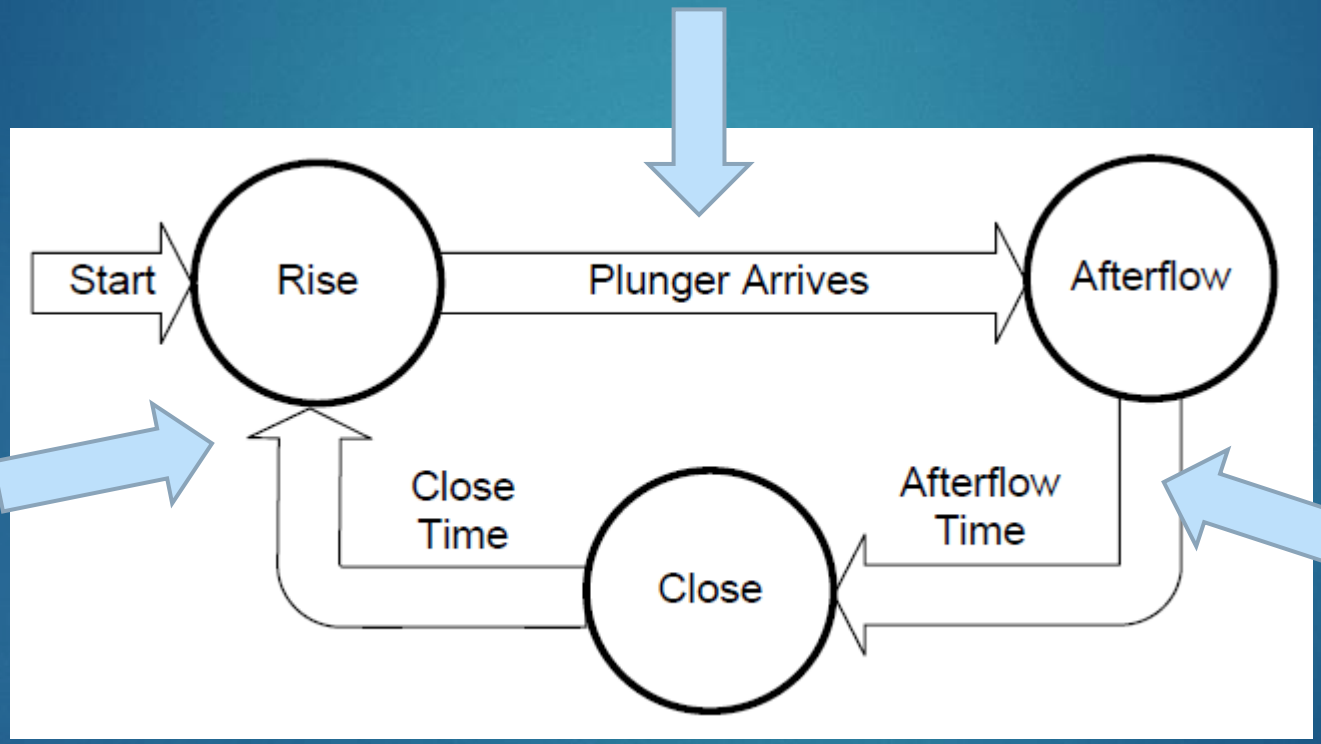
Overview

- Plunger Cycle
- Pressure Optimization
  - Casing Pressure
  - Casing – Line Differential Pressure
  - Tubing Pressure
  - Load Factor
- Time/Velocity Optimization
  - Afterflow
  - Close
  - Close then Afterflow
- Simulator

The Plunger Cycle

Time/Velocity
Optimizations applied



Check Open Pressure Conditions @ end of Close

Check Close Pressure Conditions After Minimum Afterflow

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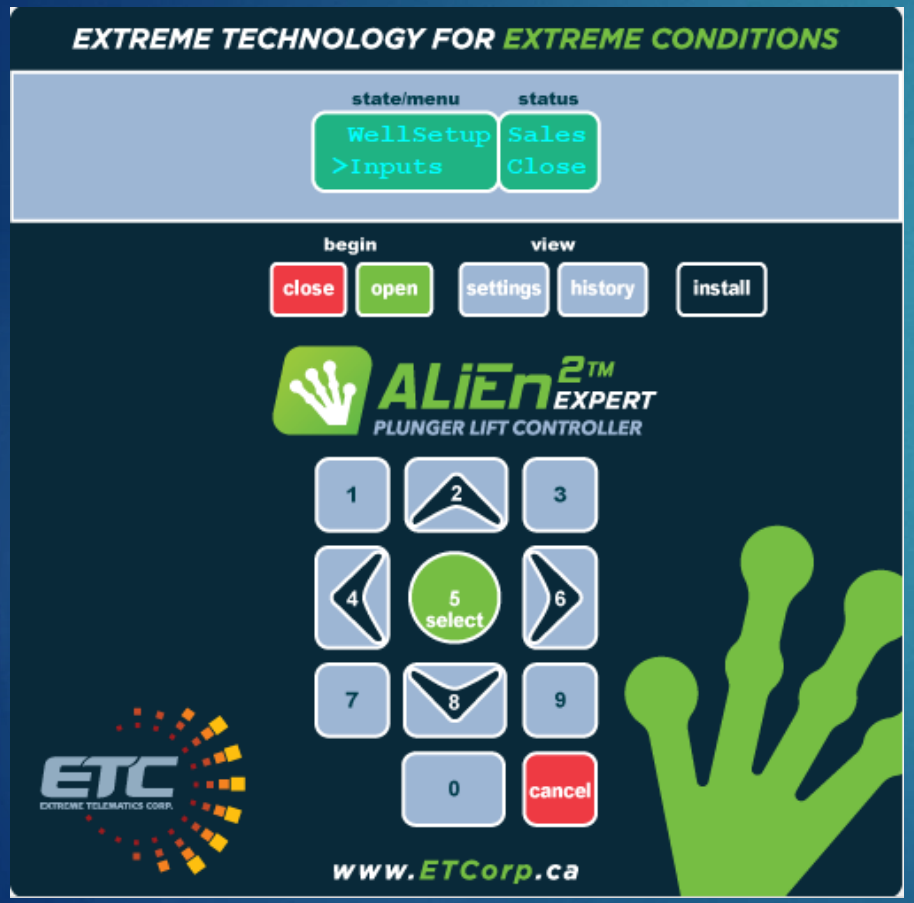
Pressure Optimization

Pressure Optimization Basics



- Press install
- Enable devices in Inputs
  - Line, Casing, Tubing, Differential, Flow
- Configure device settings
  - Switch, sensor, or virtual
  - Range
- Turn on optimization in Optimize
  - Set Optimization Type to Pressure/Flow
- Setup optimization options in Optimize
  - Open and/or Close conditions
  - Trip, Reset, Stable Time

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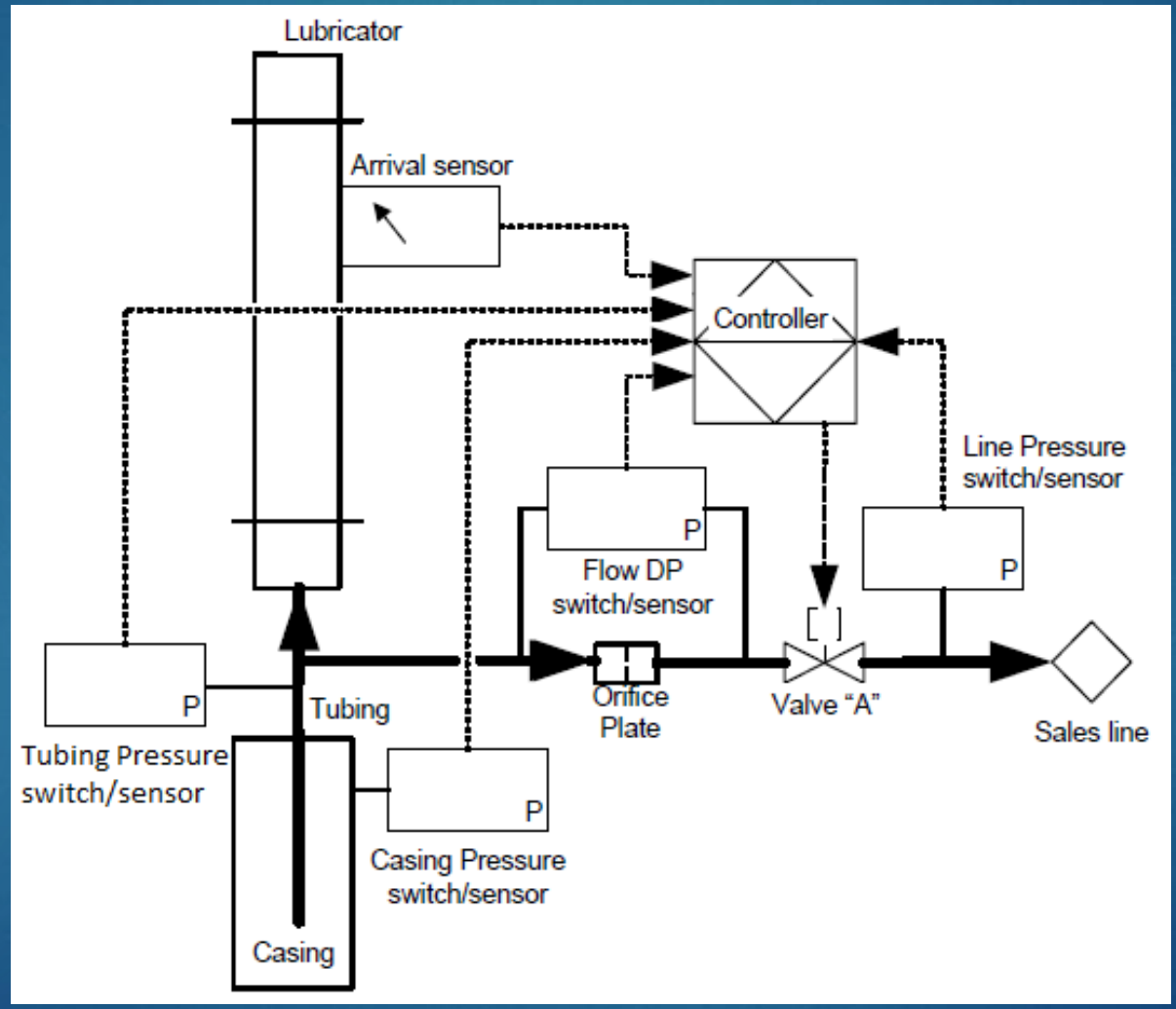
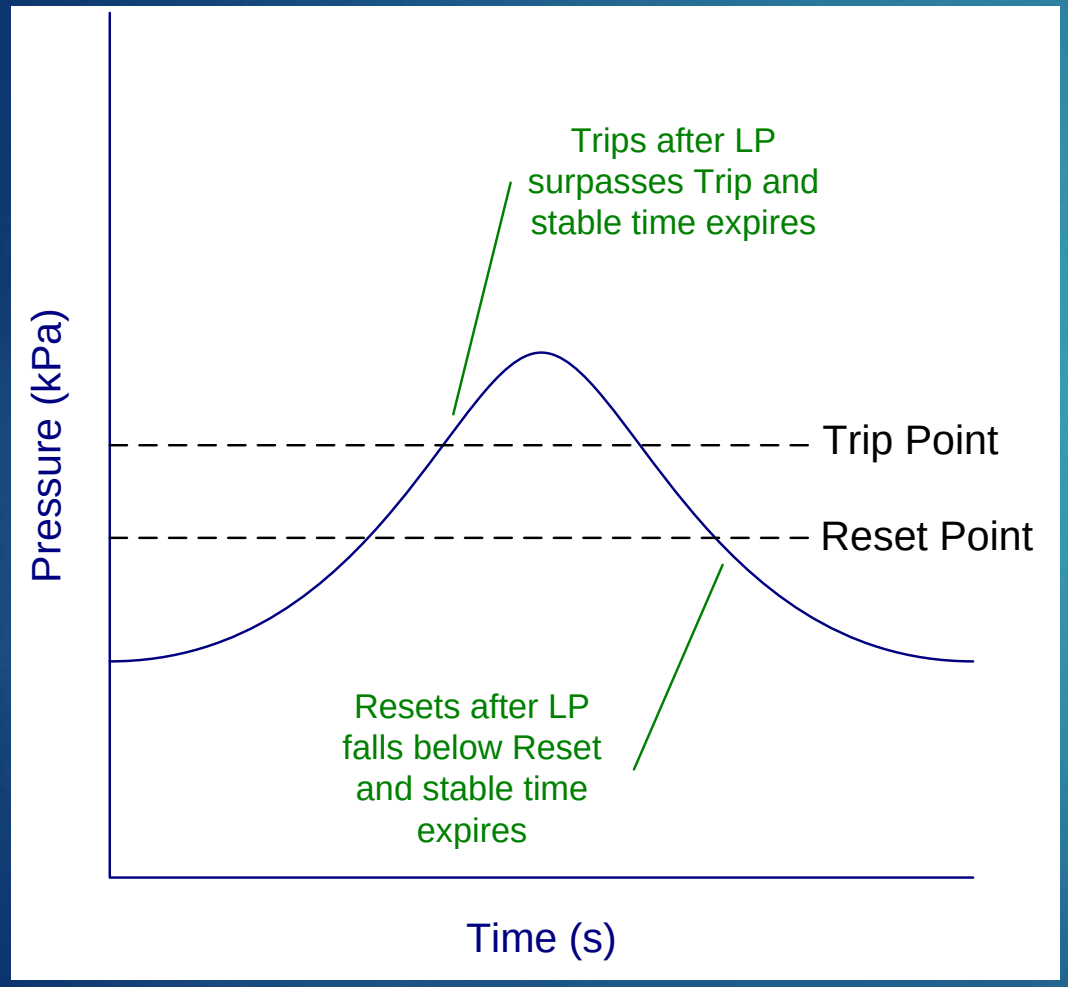
Pressure Sensor Behaviour

- Reset
  - A condition that allows the well to start or continue to flow
- Trip
  - A condition occurs keeps or forces the well to close
- Stable Time
  - The amount of time that must pass when a trip or reset condition occurs before it is acted on

Pressure Sensors



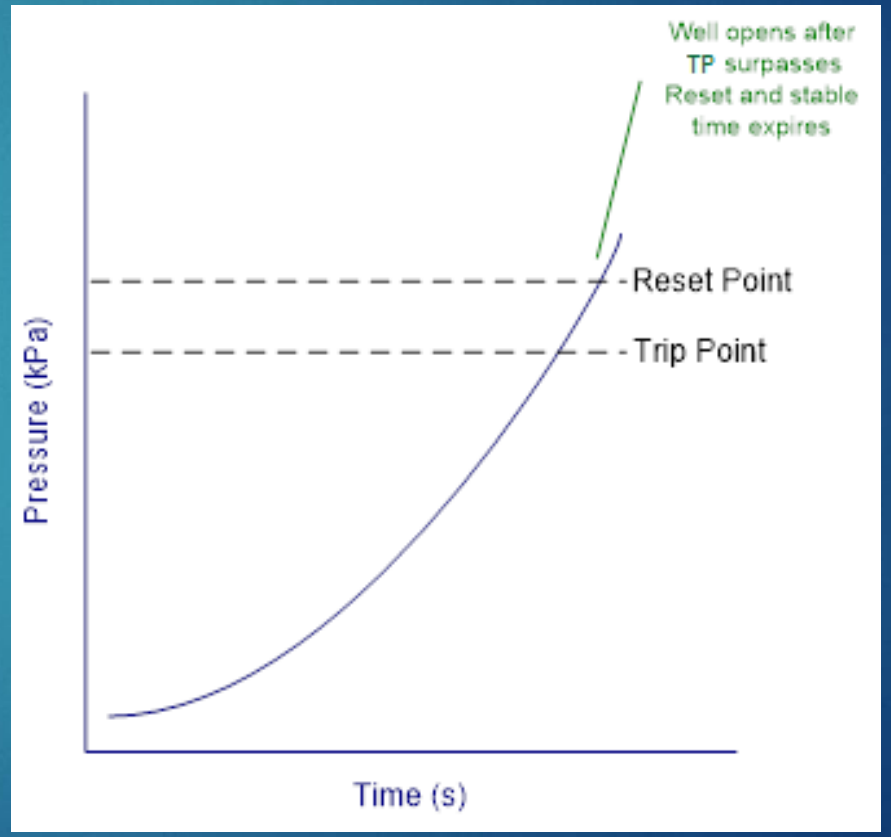
Line Pressure



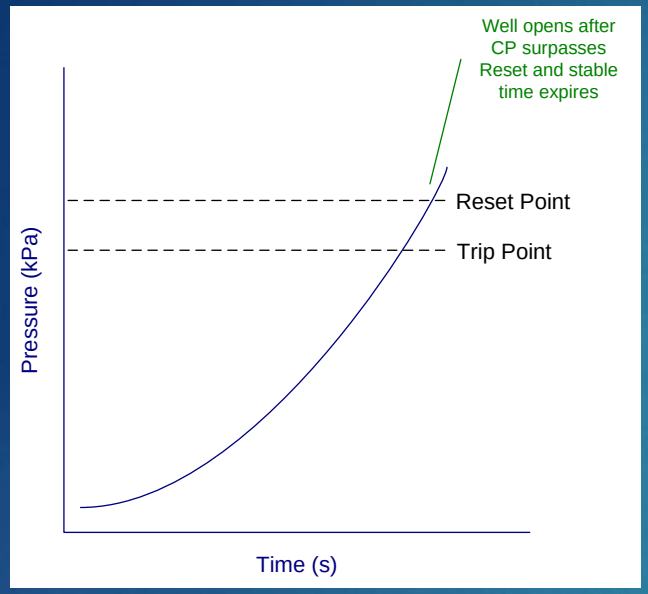
- Protect the well from back flowing
  - Reset enables flow
  - Trip stops flow
- Enable line pressure check per cycle state
- Defaults
  - Close – Enabled
  - Rise – Disabled
  - Afterflow - Enabled

Tubing Pressure

- Indicates that there is enough pressure in the tubing to flow
- Check tubing pressure at end of close
- Reset on high tubing pressure

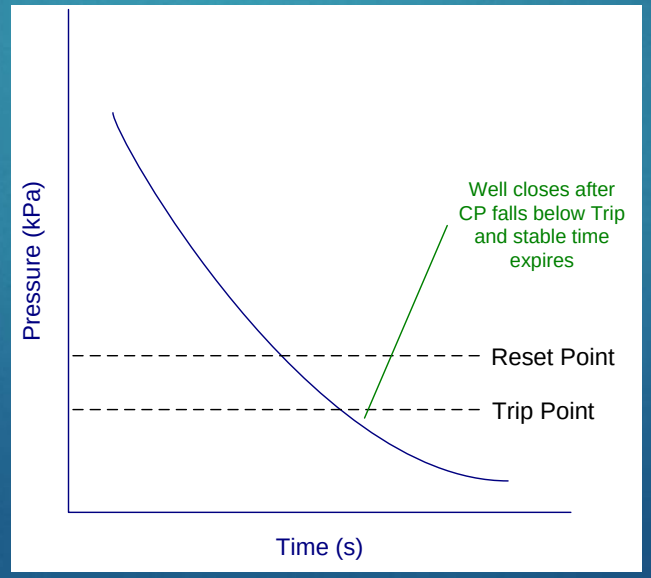


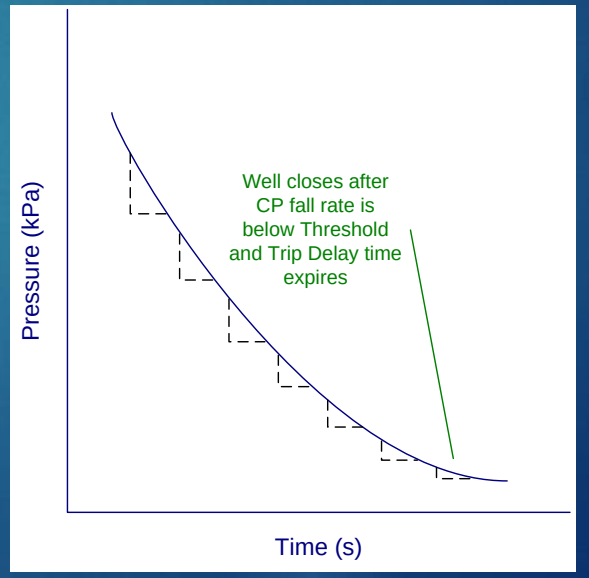
Casing Pressure



- Open
  - Check casing pressure at end of close
  - Go to rise after reset point reached

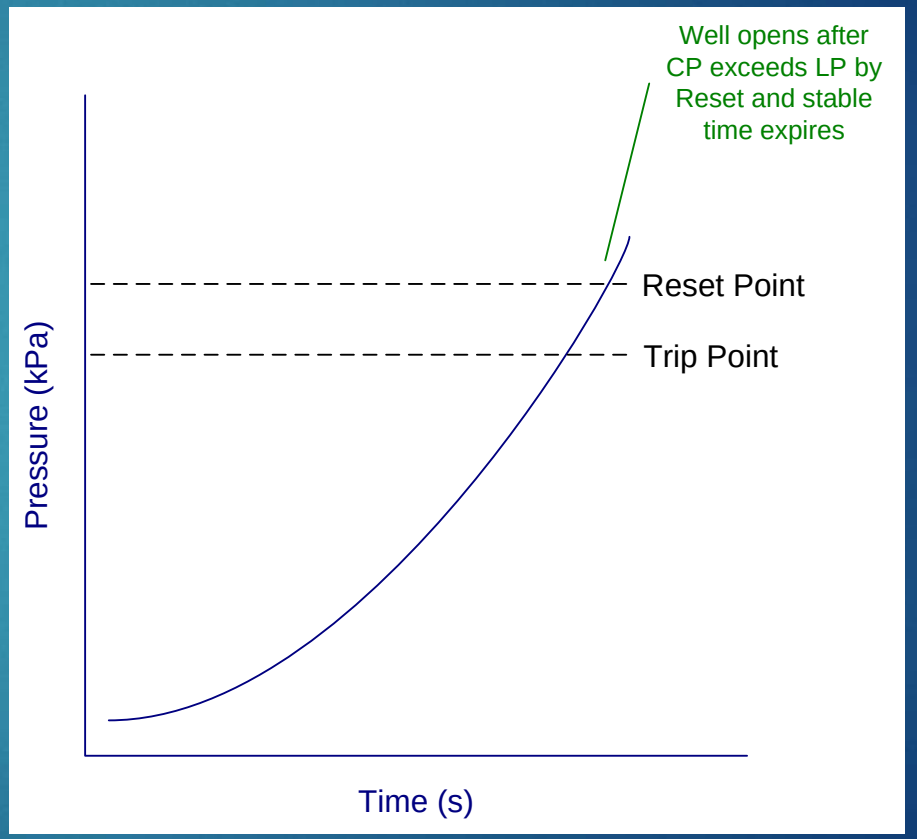
- Close Absolute
  - Go to close after trip point reached
- Close Rate of Change
  - Go to close if fall rate slows
  - Configurable trip delay





Casing - Line Differential

- Helps deal with line pressure fluctuations
- Ensure a minimum difference before opening
- Check CLDP at end of close
- Reset on high CLDP



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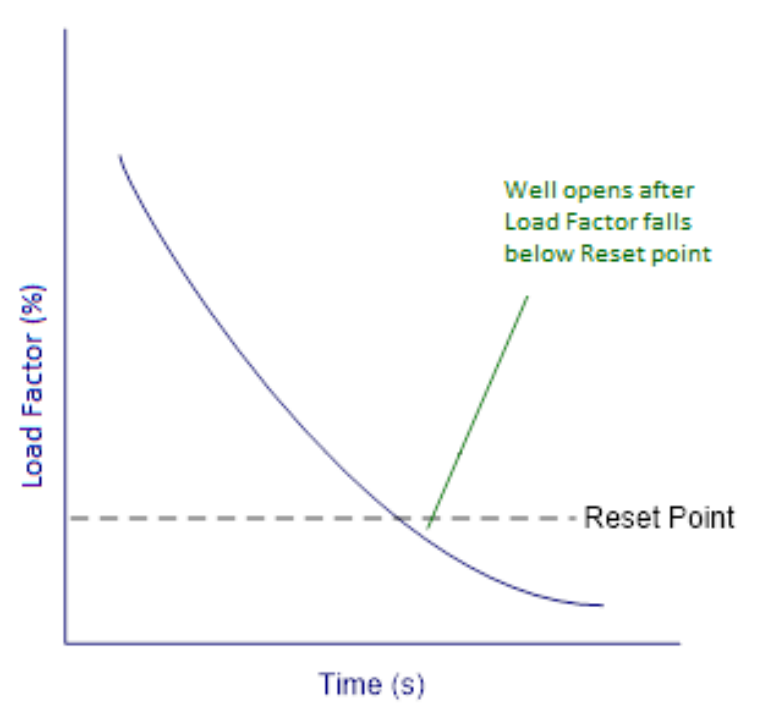
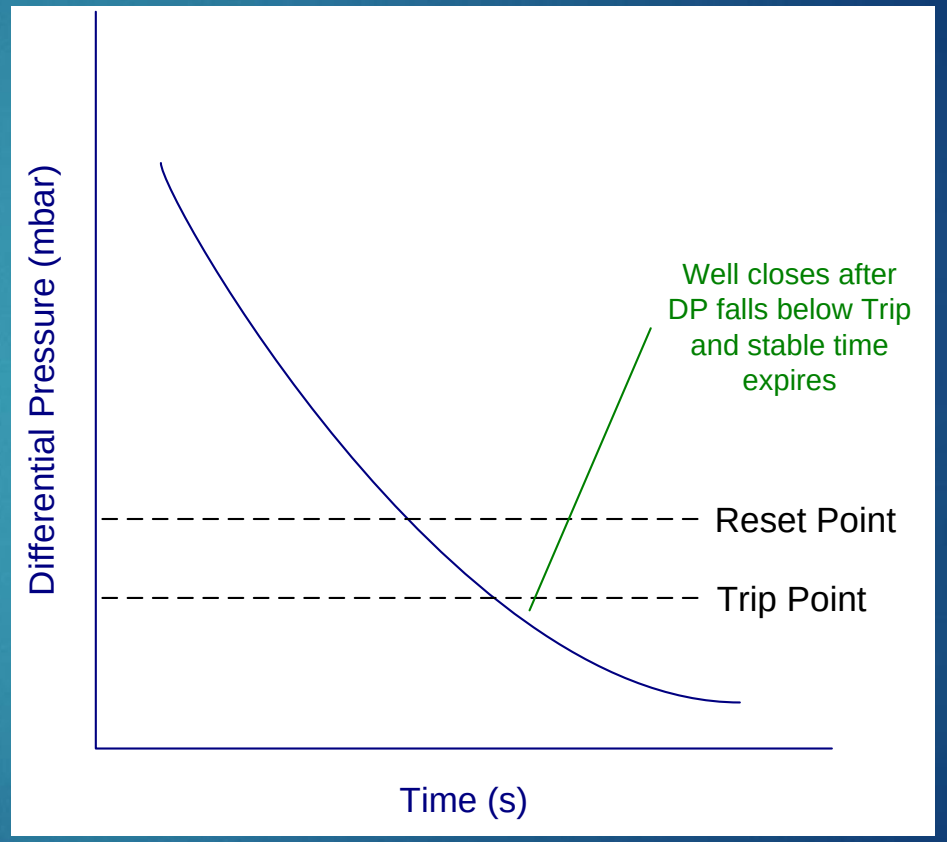
Load Factor



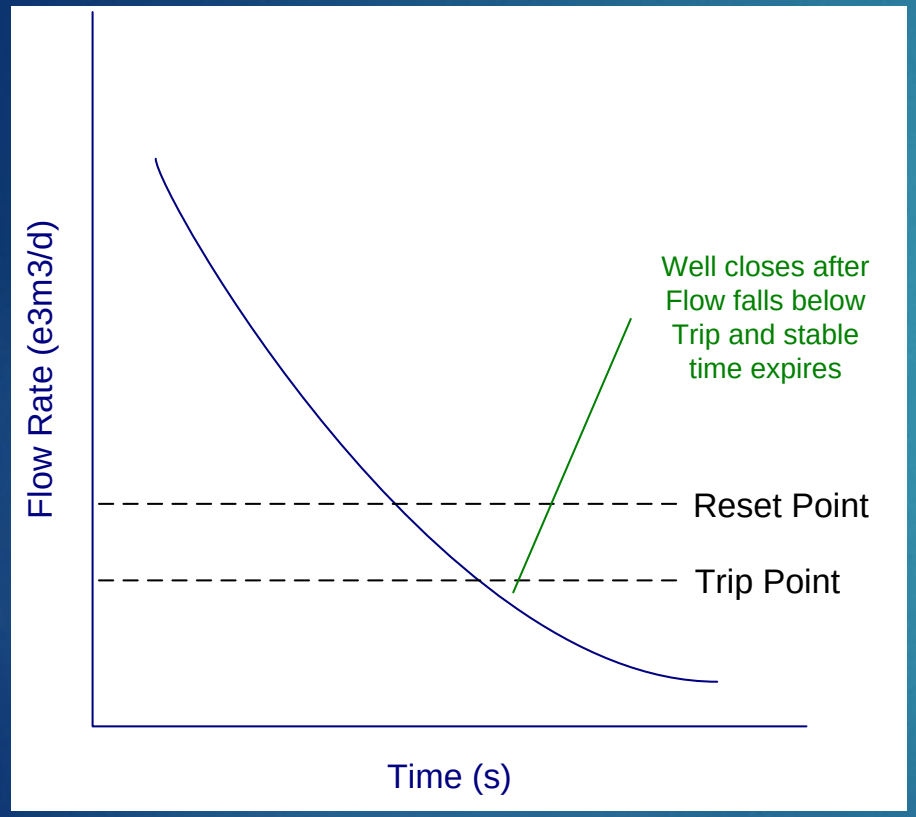
- Requires Tubing, Line, and Casing
  - Pressure splitter required
- Load Factor = Fluid Pressure/Lift Pressure
  - Fluid Pressure = Casing – Tubing
  - Lift Pressure = Casing – Line
- Check load factor at end of close
- Reset on falling load factor

Flow Differential Pressure

- Measure differential across orifice plate
- Proportional to flow
- Check DP during afterflow
- Trip on low DP



Flow Rate



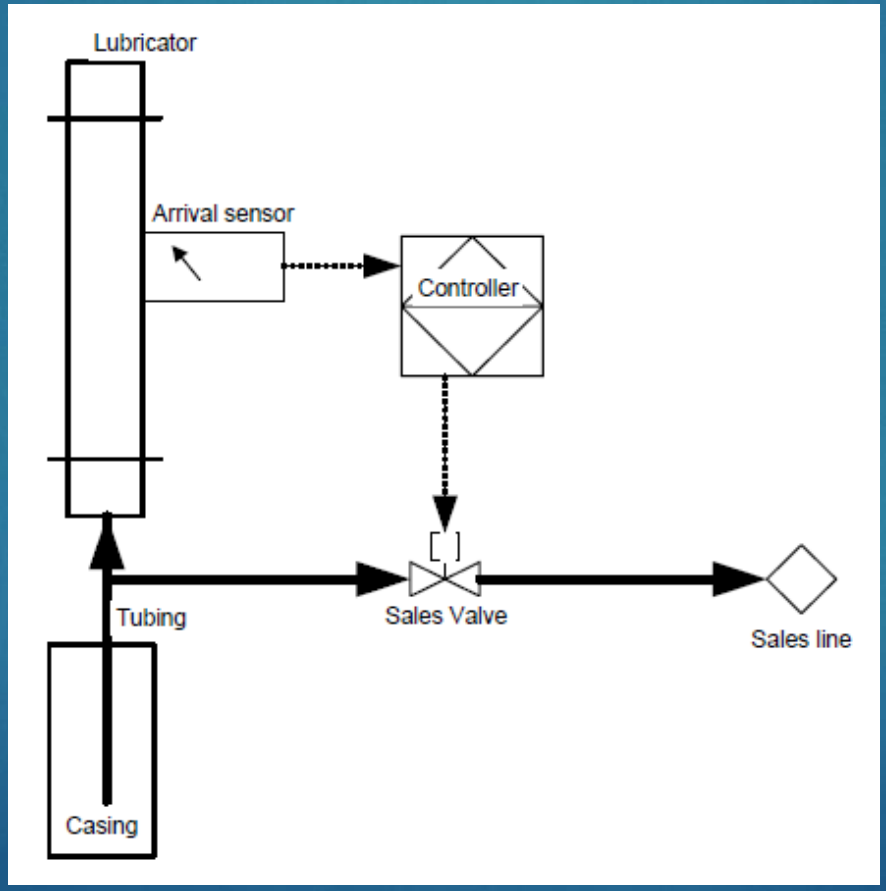
- Use differential pressure and line pressure to calculate flow
- Other settings required
  - Temp
  - Density
  - Meter run size
  - Orifice plate size
- AGA 3 table lookup (Not custody transfer compliant)
- Check flow during afterflow
- Trip on low flow rate

Time/Velocity Optimization

Time/Velocity Optimization

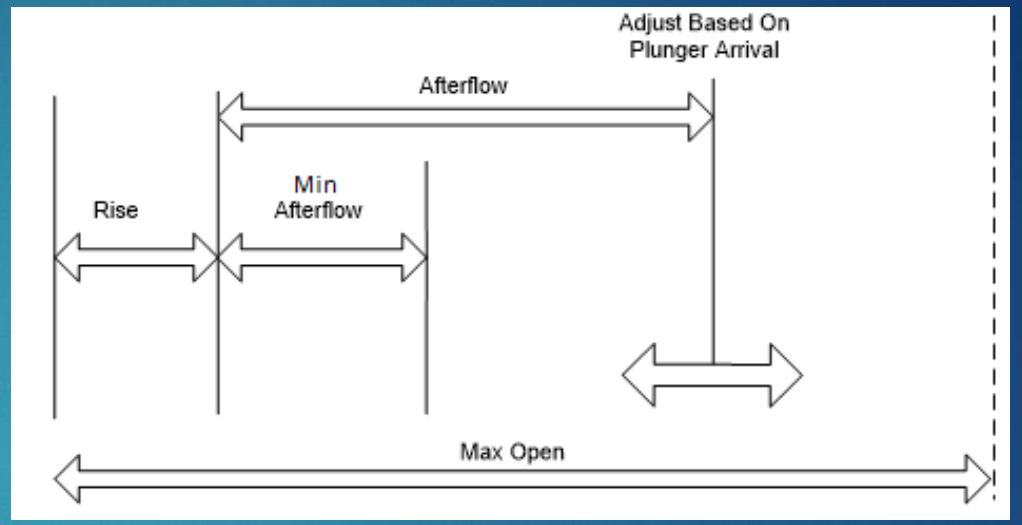
- Goal
  - Modify system parameters to influence the plunger to arrive at a given velocity.
  - Velocity must be slow enough to be safe, but fast enough to lift fluid.
- Overview
  - Each fast or slow plunger arrival causes a **proportional** adjustment to either the afterflow or close time.
- Assumption
  - Velocity of plunger is dependent on the amount of fluid being brought to surface

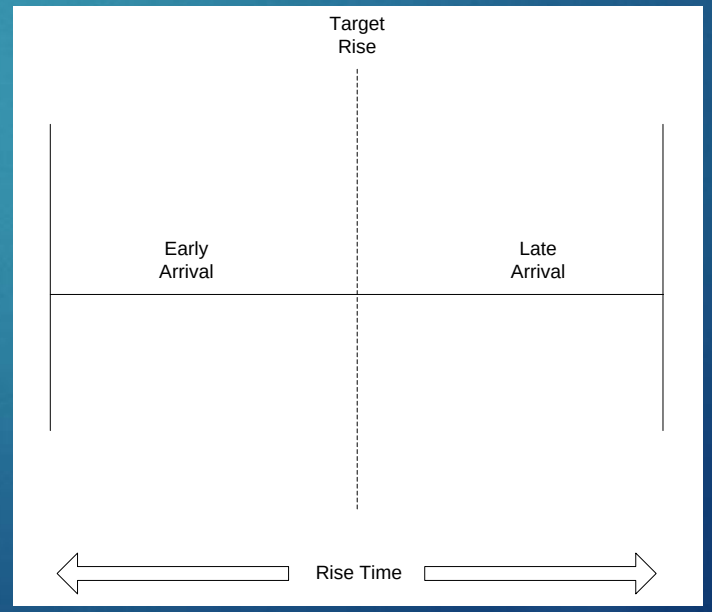
Plunger Arrival Sensor



Time/Velocity Optimization Basics

- Modify afterflow or close based on plunger arrival time/velocity
  - Min sets the lower bounds
  - Max sets the upper bound
- Rise time is the arrival window
- Target rise is the desired arrival time
- Actual rise time compared and the miss represented as percentage
  - i.e. 10 min target and 1 min early is a 10% miss.





Arrival Time Optimization - Afterflow

Algorithm:

$$\Delta Afterflow = \frac{Rise_{Target} - Rise_{Actual}}{Rise_{Target}} \cdot S \cdot Afterflow$$

Afterflow = Afterflow Time

Rise = Rise Time

S = Scale Factor

- Fast plunger adds to Afterflow Time
- Slow plunger subtracts from Afterflow Time
- Changes proportional to:
  - magnitude of the miss
  - Amount of current Afterflow time
- Scale Factor used to dampen the response

Arrival Time Optimization - Close

Algorithm:

$$\Delta Close = \frac{Rise_{Actual} - Rise_{Target}}{Rise_{Target}} \cdot S \cdot Close$$

Close = Close Time

Rise = Rise Time

S = Scale Factor

- Fast plunger subtracts from Close Time
- Slow plunger adds to Close Time
- Changes proportional to:
  - magnitude of the miss
  - Amount of current Close time
- Scale Factor used to dampen the response

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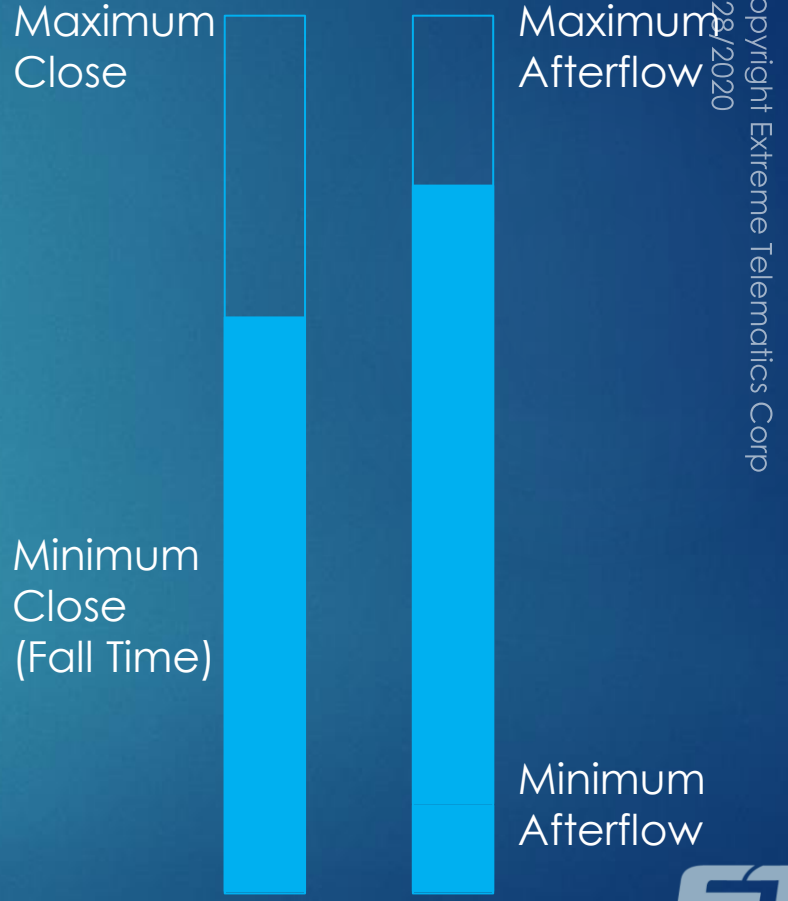
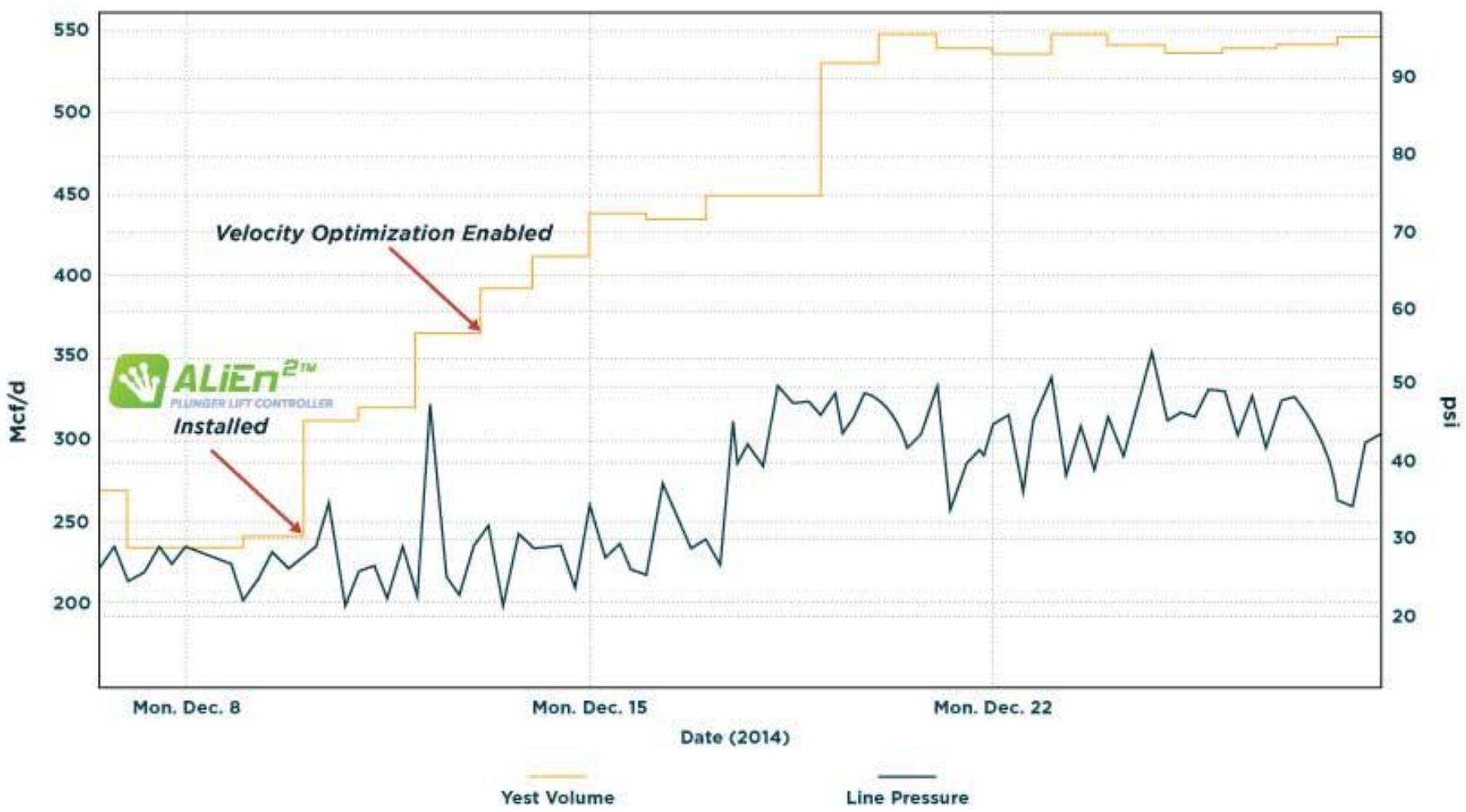
Close Then Afterflow

- Close Time is minimized as well is unloaded and plunger arrives faster than the target
- Then Afterflow Time is maximized to increase production while plunger is still arriving faster than target
- Slow plunger reduces Afterflow Time. If Afterflow Time at minimum, Close Time is increased
- Fast plunger reduces close once again. If close is at the minimum, Afterflow Time is increased
- This is a dynamic system that responds to changing conditions and does not require operator intervention



Optimization Algorithm Results



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Velocity Optimization

Algorithm:

$$\Delta AF_{Time} = \frac{V_{Actual} - V_{Target}}{V_{Target}} \cdot S \cdot AF_{Time}$$

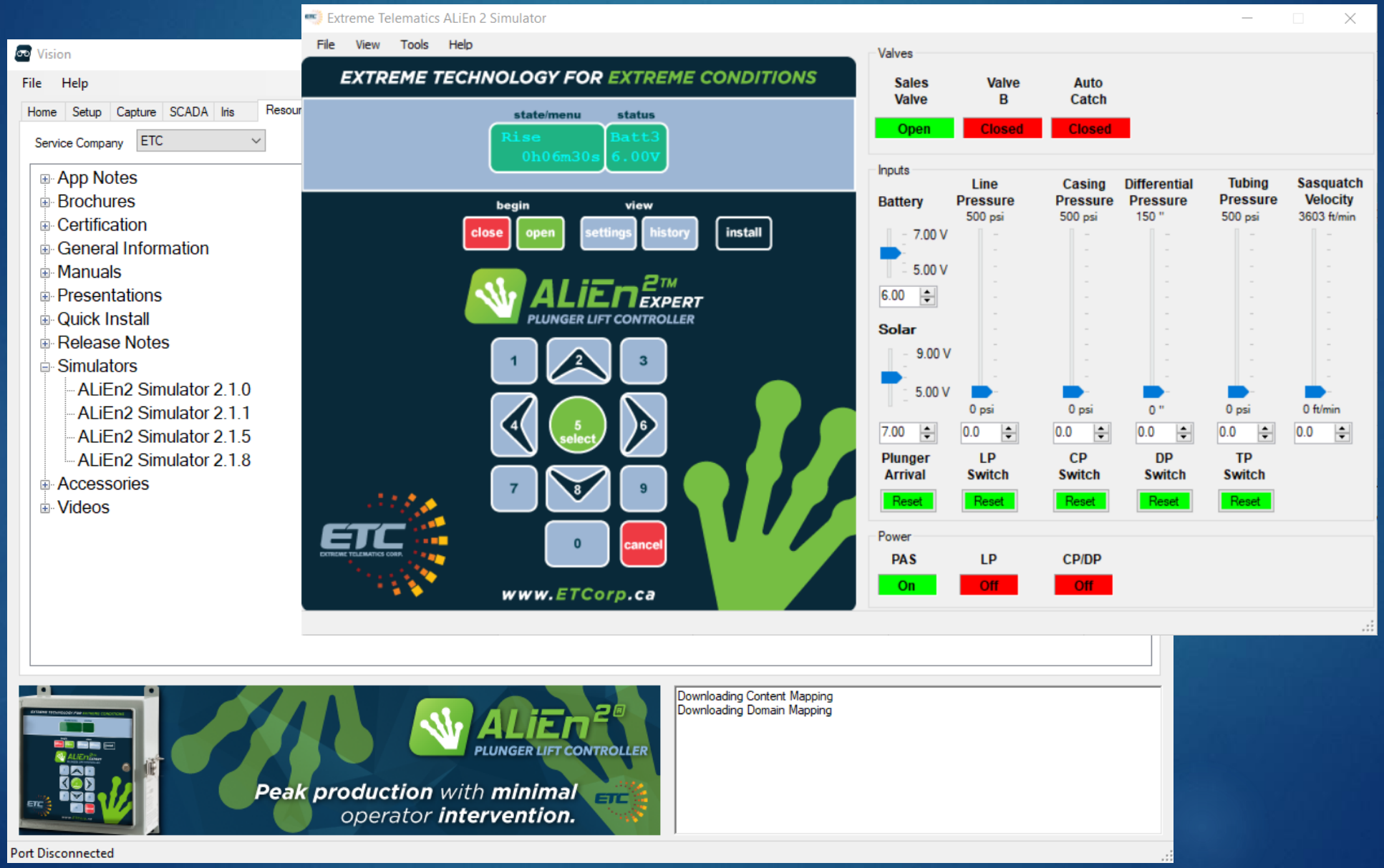
AF = Afterflow

V = Velocity

S = Scale Factor

- Based on arrival time optimization
- Safety factor can be reduced to increase production
- Proportionally adjust afterflow and close times based on instantaneous surface velocity
- Makes small corrections on each run instead of trying to stop a dangerously fast plunger

Simulator



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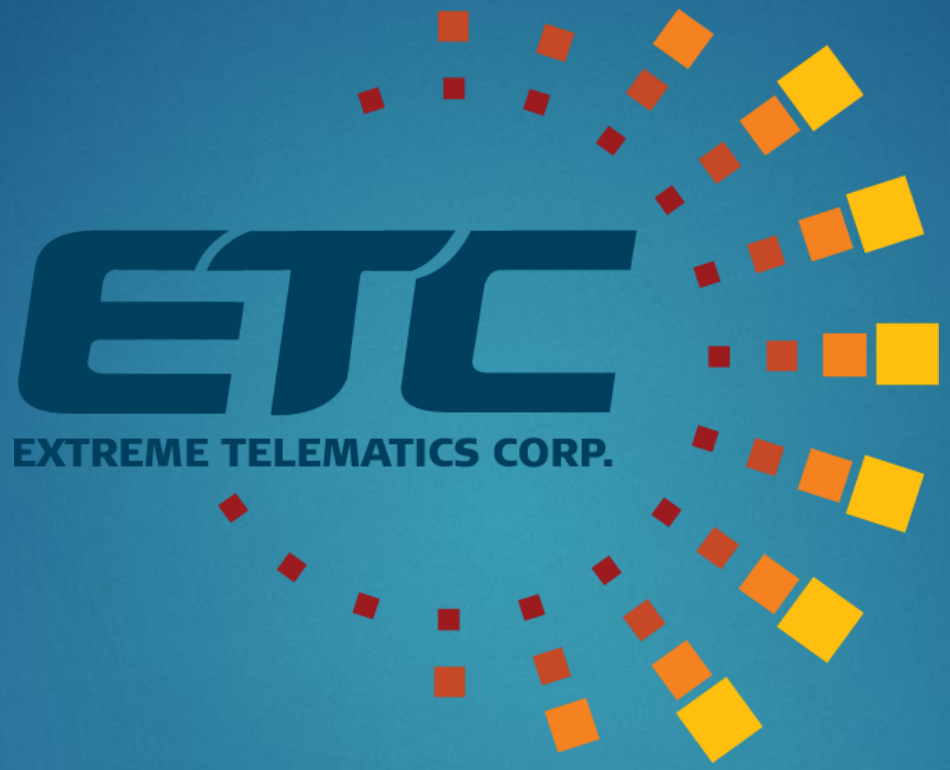

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