



Operations Manual

SOFTWARE VERSION 2.41



2901 N US HWY 14/16
Gillette, WY 82716
Website: www.beiwy.com

(307)685-2987
Fax: (307)686-9468

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Main Screen (Start Stop Reset)

The main screen of the POC's HMI includes several buttons and indicators to provide limited feedback and control of the POC. An example of the main screen is shown in the figure below.

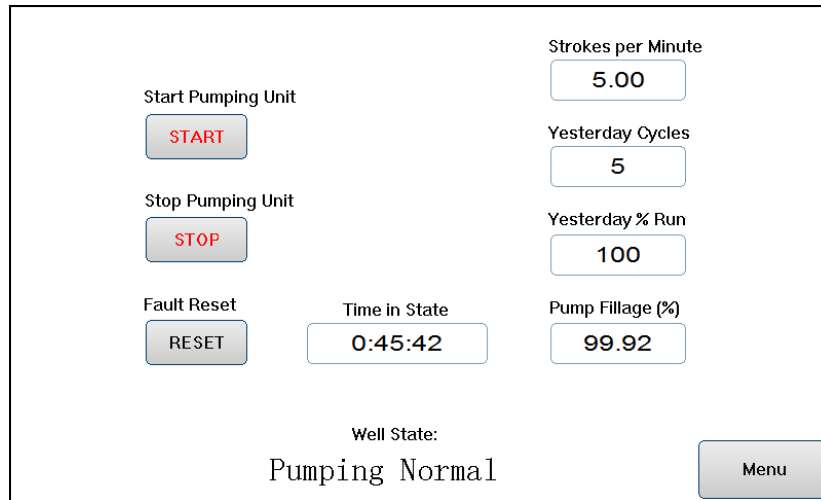


Figure 1 Main Screen

The following list describes the function of each button and indicator:

- **START** – The Start Pumping Unit button, when pressed, will signal the POC to start the pumping unit. If the unit is in a faulted state, the fault must be reset before the unit will be able to start.
- **STOP** – The Stop Pumping Unit button, when pressed, will signal the POC to stop the pumping unit.
- **RESET** – Pressing the Fault Reset button will clear any active fault on the POC.
- **Well State** – This indicator displays the current state of the POC.
- **Time in State** – This indicator shows the amount of time that the POC has been in the current state displayed in the Well State indicator. The format is HH:MM:SS, where H represents the digits for hours, M for minutes, and S for seconds.
- **Strokes per Minute** – Displays the calculated strokes per minute of the pumping unit.
- **Yesterday Cycles** – Shows how many start/stop cycles were completed the previous day.
- **Yesterday % Run** – Shows the percent runtime of the unit for the previous day.
- **Pump Fillage (%)** – Displays how full the pump is as a percentage of its total volume.
- **Menu** – When pressed, this button opens the menu page for the HMI.

Surface and Pump Card

The Surface and Pump Card page provides a graph that plots the surface cards and pump cards as they are captured by the POC. The Surface Card is the white plot, and is directly measured via the unit instrumentation. The Pump Card is the green plot, and is calculated based off of the surface card and the rod taper. Additionally, there are two red lines running horizontally across the screen; the top line is the **Peak Load Limit** and the bottom is the **Min Load Limit**. If the Surface Card extends past either of these limits, the POC will shut down the pumping unit. Both of these limits can be set on the *Min / Max Rod Load Settings* page. The axes grow and shrink with the maximums and minimums of all the cards plotted. A button labeled **Clear** will clear the graph and allow for a new set of cards to be displayed. The indicator labeled **Well State** provides the current state of the unit at the bottom of the page. Depending upon the Control Mode selected on the *Min / Max Rod Load Settings* page, a white or green crosshair will appear where the **Pump Off Load Set Point** and **Pump Off Position Set Point** intersect. For further information on the setup of these points, refer to the *Pump Off Selection and Set-up* page in this document.

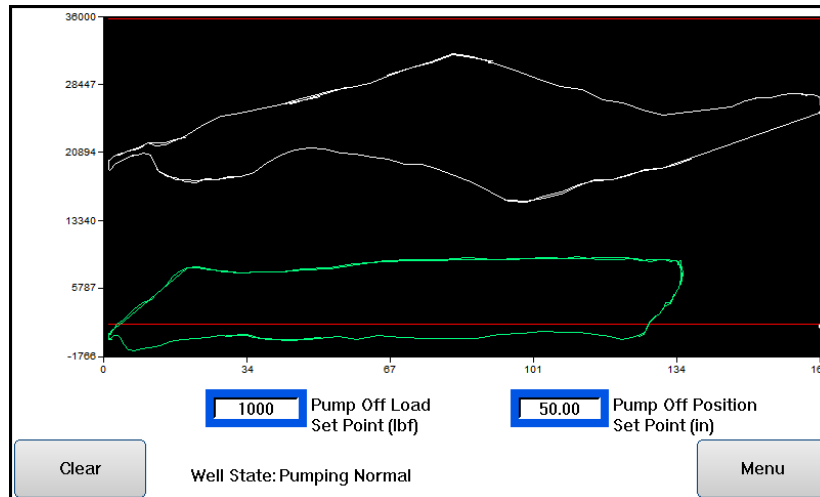


Figure 2 Surface and Pump card page

Surface Card

The Surface Card page provides a graph that plots the surface cards as they are captured by the POC. The axes grow and shrink with the maximums and minimums of all the cards plotted. A button labeled **Clear** will clear the graph and allow for a new set of cards to be displayed. The indicator labeled **Well State** provides the current state of the unit at the bottom of the page.

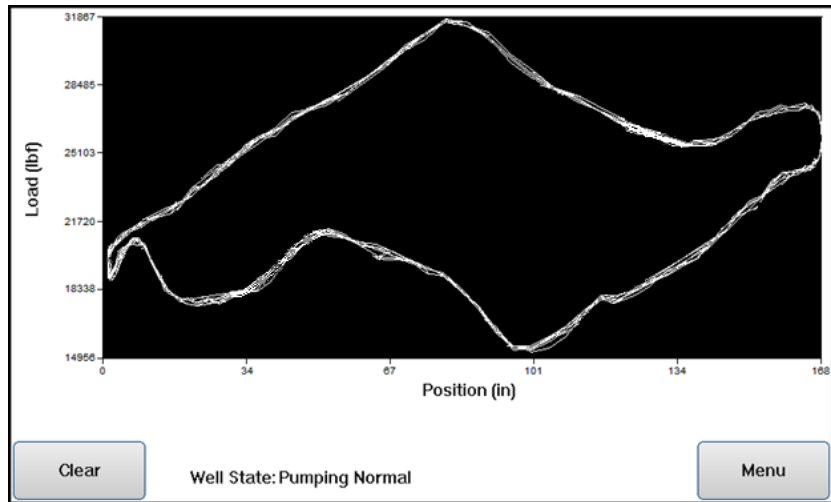


Figure 3 Surface Card page

Pump Card

The Pump Card page provides a graph that plots the pump cards as they are captured by the POC. The axes grow and shrink with the maximums and minimums of all the cards plotted. A button labeled **Clear** will clear the graph and allow for a new set of cards to be displayed. The indicator labeled **Well State** provides the current state of the unit at the bottom of the page. This page also includes indicators for the Pump Fillage, Net Stroke, Gross Stroke, Fluid Load, Peak Load, and Minimum Load.

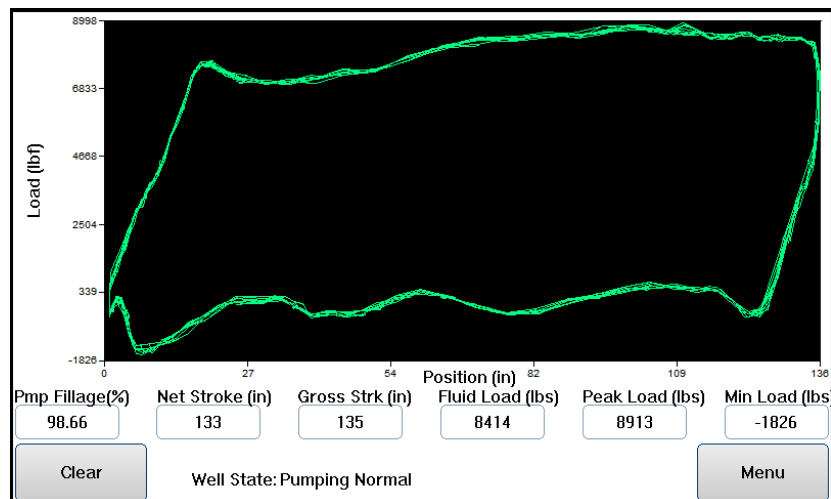


Figure 4 Pump Card page

Pumping Unit Status

The Pumping Unit Status page provides several indicators for viewing the status of various portions of the pumping unit, listed below, and are shown in the following figure.

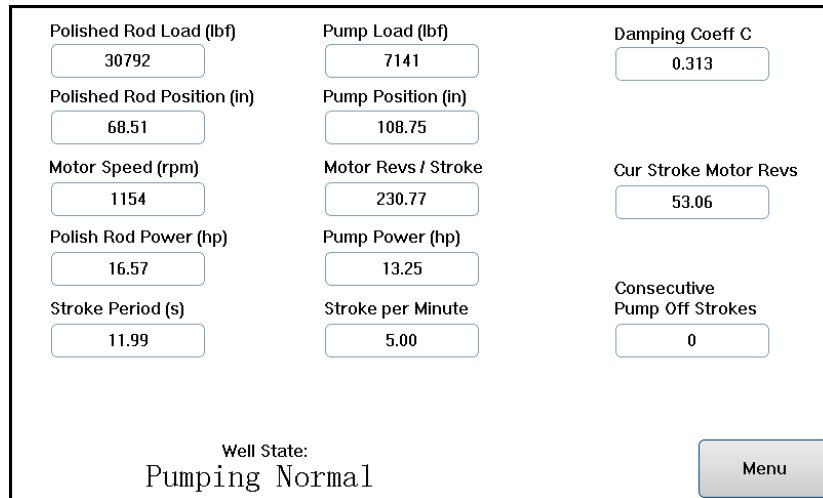


Figure 5 Pumping Unit Status page

- **Polished Rod Load** – Displays the load, in pound force, on the polished rod.
- **Polished Rod Position** – Indicates the position, in inches, of the polished rod relative to the surface of the wellhead.
- **Motor Speed** – Displays the current speed of the motor in RPM.
- **Polish Rod Power** – Indicates the calculated horsepower based off of the surface card and is only updated once per stroke.
- **Stroke Period** – Displays how many seconds it takes the unit to complete one stroke.
- **Pump Load** – Shows the current load on the pump in pounds.
- **Pump Position** – Indicates the calculated position of the pump.
- **Motor Revs / Stroke** – Displays how many revolutions of the motor occur for each stroke of the unit.
- **Pump Power** – Shows how much power, in horse power, the rods are exerting on the pump.
- **Stroke per Minute** – Displays how many strokes occur per minute.
- **Damping Coeff C** – Indicates the calculated friction coefficient.
- **Cur Stroke Motor Revs** – Displays how many revolutions of the motor that have occurred within the current stroke.
- **Consecutive Pump Off Strokes** – Indicates the number of consecutive pump off / pump fillage strokes.

History Cards

The History Cards page provides access to several various cards stored on the POC. There are seven options to choose from – Stored cards, Shutdown 1 Cards, Shutdown 2 Cards, Standard Card, Start-up Card, Pump-Up Card, and Last Stroke. To select an option, press the blue arrows on either side of the card dropdown menu located above the **Update** button, or select the pump cards directly from the card dropdown menu by pressing on it then pressing on the desired item in the list. Once the selection has been made, press the **Update** button and the HMI will produce the desired cards on the graph along with the timestamp for the cards above the **Menu** button. The options for each card are described below:

- **Stored cards** – The last five surface and pump cards.
- **Shutdown 1 Cards** – The shutdown card plus the previous four cards.
- **Shutdown 2 Cards** – This is the previous shutdown card plus its four prior cards.
- **Standard Card** – This function is currently not implemented.
- **Start-up Card** – The card for the transition from starting state to the minimum strokes state.
- **Pump-Up Card** – The card for the transition from the minimum strokes state to the pumping normal state
- **Last Stroke** – This is the card for the previous stroke.

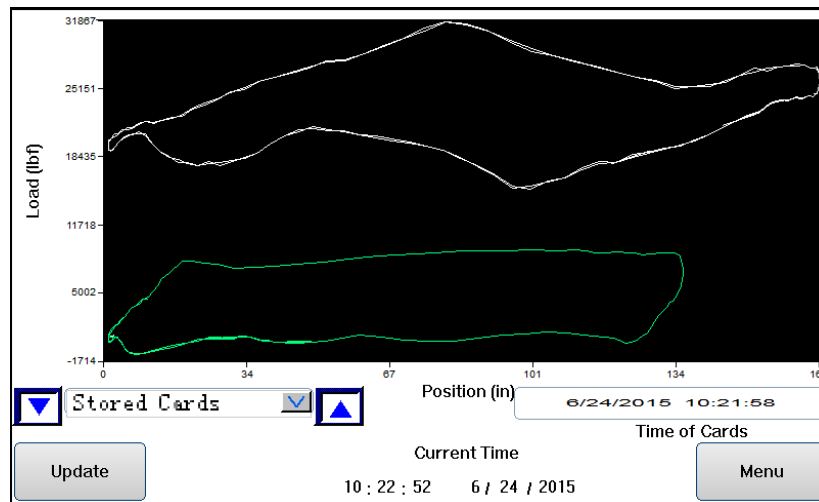


Figure 6 Sample History Cards page

History Graph Menu

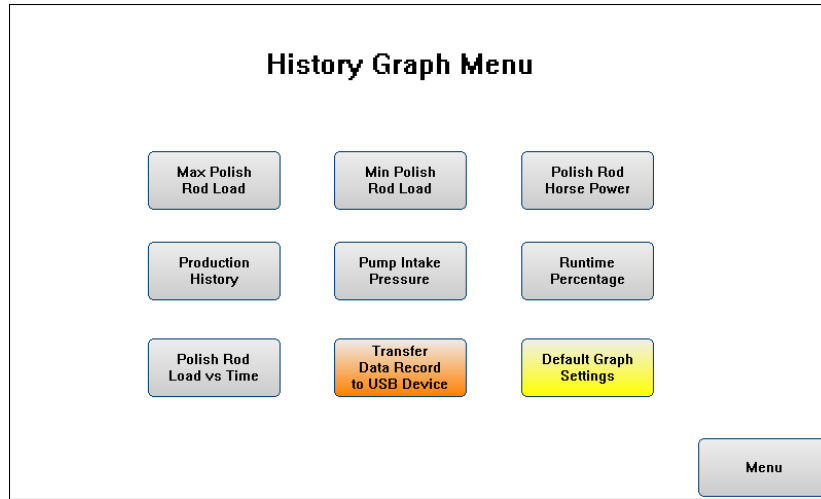


Figure 7 History Graphs Menu page

The POC will log the Max. Polish Rod Load, Min. Polish Rod Load, Polish Rod Horse Power, Production, Pump Intake Pressure, and Runtime Percentage once an hour each day and store that data internally. This data can be viewed in one of two ways:

- 1) By visiting one of the history graph pages from the *History Graph Menu* page or
- 2) By viewing the CSV files that can be stored to a USB flash-drive from a PC.

To copy the CSV files from the POC to the flash-drive, insert the flash-drive into the USB port on the front of the cabinet, wait approximately 10 seconds and then press the **Transfer Data Record to USB Device** button on the *History Graph Menu* page. A small embedded window should appear briefly. Do not touch anything on this window, but instead let it complete its tasks and disappear. Once the window has disappeared, wait another 10 seconds then remove the USB flash drive and insert it into an available USB port on a PC. Once the drive has been recognized, the user can navigate the folder hierarchy and locate the appropriate log files using a file explorer tool, such as Windows Explorer. Open the desired CSV with any spreadsheet program capable of handling CSVs and view the data.

Viewing the data using the history graphs will be covered in the section below titled *Graph Example*, while the *Polish Rod Load vs Time* plot will be discussed in the section with that name following the *Graph Example* section.

Notes:

- 1) The recommended size for a USB flash drive is 4 Gigabytes (GB) or less. The HMI may not correctly write files to the flash drive if the drive has a storage capacity greater than 4 GB.
- 2) When the logger files have been stored on a flash drive, they are stored under the following directory – Flash_Drive/DL/1/Year/ (e.g. (G:)/DL/1/2016/ would contain all of the log files for the year 2016)

Graph Example

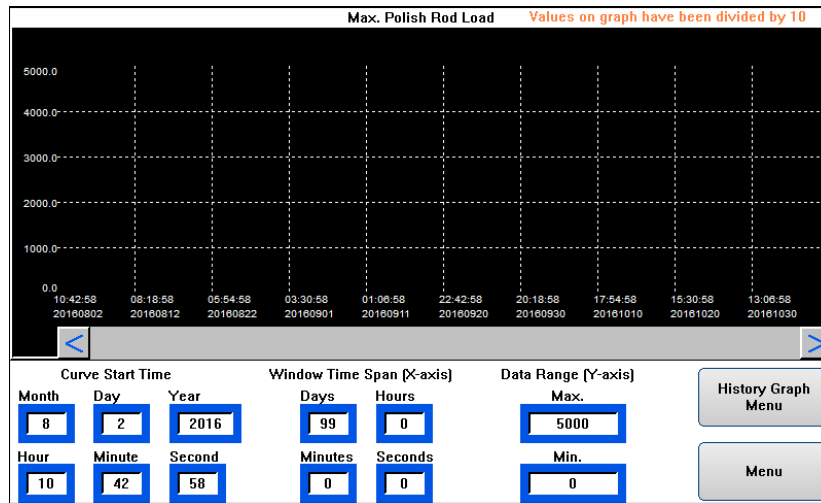


Figure 8 Example Graph page

There are six history graphs that are viewable by the user and all of them are set up using the same procedure. With that said, only one of these pages will be covered, but the information presented is applicable to all of the graph pages.

To begin, the graphs can be set to their default settings by pressing the **Default Graph Settings** button on the History Graphs Menu page, or by pressing the **Restore Factory Settings** button on the Pumping Unit Selection page (although pressing this button will also reset several other parameters of the POC and is therefore not recommended when the graphs are the only group that needs to be reset to their defaults).

Control of the graph is split up into three different pieces – **Data Range**, **Window Time Span** and **Curve Start Time**. The first and easiest piece to understand is the **Data Range** Min./Max. controls. These controls change the range of data that will be displayed along the Y-axis. For example, placing the minimum equal to 100 and the maximum equal to 5000 will cause only values greater than or equal to 100 and less than or equal to 5000 to be displayed in the graph, with all other values being displayed as either 100, if it is below the minimum, or 5000, if it is above the maximum.

The **Window Time Span** is used to set the amount of data that will be visible along the X-axis of the graph, in a unit of time. As an example, setting this span to 99 Days, 0 Hours, 0 Minutes, and 0 Seconds will cause the graph to display 99 days' worth of data, while setting the span to 0 days, 5 hours, 30 minutes, and 10 seconds will cause the graph to zoom in on the data set.

Working hand-in-hand with the Window Time Span is the **Curve Start Time**. The controls within this group set the X-axis offset for the X-axis window (a.k.a the Window Time Span). Adjusting the time within these controls will move the X-axis window forward in time (by setting the time to a value greater than its current time) or backward in time (by setting the time to a value less than the current time). For example, if the user wanted to view 5 hours' worth of data starting at 2:35 p.m. on Oct. 11th 2016, within the Curve Start Time controls, they would set the Month equal to 10, Day equal to 11, Year equal

to 2016, Hour equal to 14 (because this is based on a 24-hour clock), Minute equal to 35, and Second equal to 0 while setting the Window Time Span controls equal to 0 Days, 5 Hours, 0 Minutes, and 0 Seconds.

Notes:

- 1) The **Curve Start Time** is updated automatically once an hour and is set the current-time minus the total amount of time set in the **Window Time Span** controls.
- 2) The data displayed on the *Min.* and *Max. Polish Rod Load* pages has been divided by 10 for display purposes (e.g. a value of 3000.0 is actually a value of 30000). Please keep this in mind when viewing the data and setting the **Data Range** limits on these two pages.

Polish Rod Load vs Time

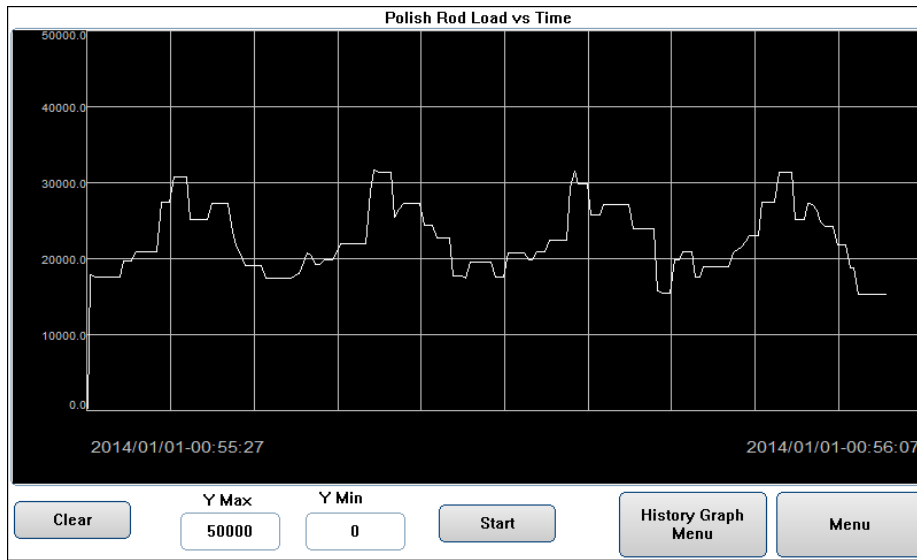


Figure 9 Polish Rod Load vs. Time page

The Polish Rod Load vs Time page is used to aid the user in testing their traveling valve and standing valve, though the procedures for these tests are outside the scope of this manual. This page is only meant to give the user a feel for what is going on downhole and *does not* provide any calculated values that would be useful in the previously mentioned tests.

To make the graph start plotting the polish rod load, press the Start button. This will cause the **Start** button to turn into the **Stop** button, and pressing it again will stop the data collection. Pressing the **Clear** button will clear the graph, while setting the **Y Max** value will set the maximum polish rod load that will be displayed, and setting the **Y Min** value will set the minimum polish rod load to be displayed. The graph will show approximately one minute's worth of data.

Analog I/O Status

The Analog I/O Status page contains two sets of indicators – one for the analog inputs and another for the analog outputs. Both of these sets contain two columns. For the analog inputs, the left-hand column displays the scaled input values, while the right-hand column shows the raw input values for each analog channel. The scale factors for the analog inputs can be modified on the *Analog Input Config* page. For the analog outputs, the left-hand column displays the output value for each channel in milliamps, while the right-hand column displays the raw analog value for each channel. The figure below provides an illustration of this page.

ANALOG INPUTS		ANALOG OUTPUTS	
AI2 Scaled Value	AI2 Raw Value	A01 mA Output	A01 Raw Value
-24.97	1	0.00	0
AI3 Scaled Value	AI3 Raw Value	A02 mA Output	A02 Raw Value
-25.00	0	0.00	0
AI4 Scaled Value	AI4 Raw Value	A03 mA Output	A03 Raw Value
-25.00	0	0.00	0
AI5 Scaled Value	AI5 Raw Value	A04 mA Output	A04 Raw Value
-25.00	0	0.00	0
AI6 Scaled Value	AI6 Raw Value	A05 mA Output	A05 Raw Value
-25.00	0	0.00	0
AI7 Scaled Value	AI7 Raw Value	A06 mA Output	A06 Raw Value
-25.00	0	0.00	0

Figure 10 Analog I/O Status page

Digital I/O Status

The Digital I/O Status page contains two sets of indicators – one for inputs and the other for outputs. Indicators that are dark green show that their associated input or output is **OFF** while light green indicators show that their associated input or output is **ON**. As an example, in the figure below, Digital Input (DI) 1 is off, while DI9 is on.

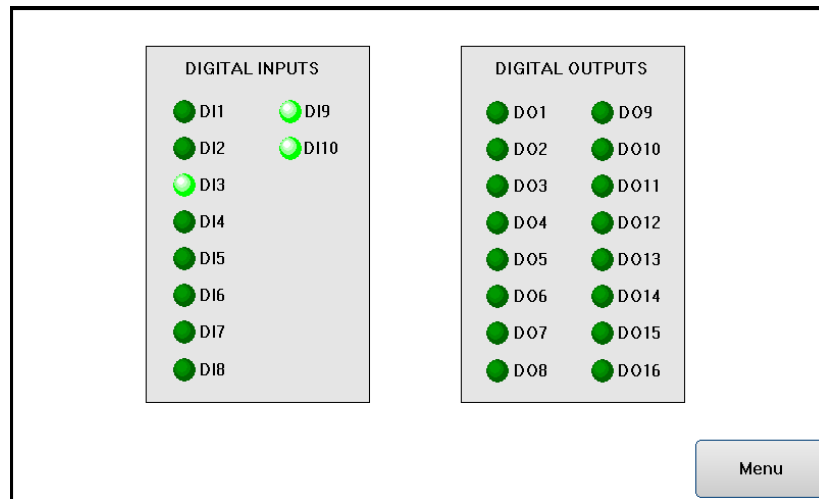


Figure 11 Digital I/O Status page

Alarms

The Alarms page contains several elements for keeping track of the state of the pumping unit. The list below provides a description for each of these elements and Figure 9 displays an example of this page.

- **Well State** – This indicator displays the current state of the POC.
- **Alarm History Display** – This display logs the state of the POC with the time it entered each state on the far left side of the display, followed by the time it exited each state and the name of each state at the end of each row. NOTE: On the current implementation, the time exiting a state will be approximately the same as the time the state had been entered into.
- **RESET** – Pressing this button will clear any active fault on the POC.
- **Time in State** – This indicator shows the amount of time that the POC has been in the current state displayed in the Well State indicator.

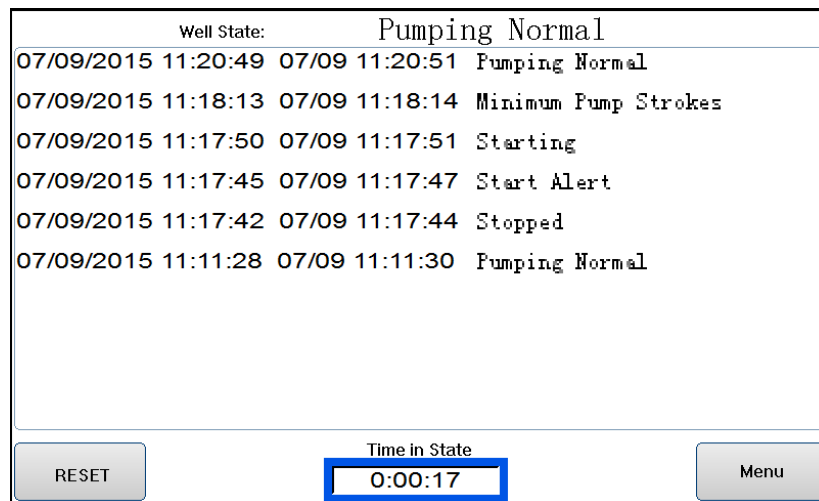


Figure 12 Alarms page

Inferred Production

The Inferred Production page is used for setting up a few parameters for the POC to calculate the production numbers for the current day and the previous day, and once they have been set up, the page is used to view those production numbers. An example of this page is shown in the figure below and the parameter descriptions are listed below it.

Pump Plunger Diam (in) <input type="text" value="1.50"/>	IPA K Factor <input type="text" value="1.00"/>	Pmp Fillage(%) <input type="text" value="100.00"/>	Pump Intake Press (psi) <input type="text" value="0.00"/>
Gauge Off Hour (0-23) <input type="text" value="9"/>	Gauge Off Min (0-59) <input type="text" value="0"/>	Net Stroke (in) <input type="text" value="149"/>	Tubing Grad (psi/ft) <input type="text" value="0.433"/>
Current Fluid (bbls) <input type="text" value="31.6"/>	Yesterday Fluid (bbls) <input type="text" value="0.0"/>	Gross Strk (in) <input type="text" value="149"/>	Tubing Head Press (psi) <input type="text" value="100"/>
Current Oil (bbls) <input type="text" value="31.6"/>	Yest Oil (bbls) <input type="text" value="0.0"/>	Fluid Load (lbs) <input type="text" value="8050"/>	Tubing Head Press Source <input type="text" value="Const."/>
Current Water (bbls) <input type="text" value="0.0"/>	Yest Water (bbls) <input type="text" value="0.0"/>	Pump Card Peak Load (lbs) <input type="text" value="8209"/>	% Water Cut <input type="text" value="0"/>
Current Strokes <input type="text" value="73"/>	Yesterday Strokes <input type="text" value="0"/>	Pump Card Min Load (lbs) <input type="text" value="-1867"/>	<input type="button" value="Menu"/>
Current Cycles <input type="text" value="8"/>	Yesterday Cycles <input type="text" value="0"/>		
Current % Run <input type="text" value="90"/>	Yesterday Run % <input type="text" value="0"/>		

Figure 13 Inferred Production page

- **Pump Plunger Diam** – Used for entering the pump plunger diameter in inches.
- **IPA K Factor** – used to adjust the calculations for pump plunger slippage along with any fluid volume shrinkage that occurs as gas separates from the solution in the production tank.
- **Gauge Off Hour** – This control is used to set the hour at which the values for the current day's production will be rolled over into Yesterday's production and the current day's production numbers will start over from zero. This number is based off of a 24-hour clock, meaning that the only valid values for this control are between 0 and 23
- **Gauge Off Min** – In addition to the Gauge Off Hour, this controls the minute at which the production roles over for the new day. Valid values for this control are between 0 and 59.
- **Tubing Grad** – This control is used to enter the force exhorted by the weight of the fluid on the pump, in psi per foot. This number varies based on entrained gas and water content, and is only used for calculating pump intake pressure.
- **Tubing Head Press** – This controls the constant value for the average tubing head pressure, in psi, and is only used for calculating the pump intake pressure.
- **Tubing Head Press Source** – Controls where the POC monitors the tubing head pressure. When *Const.* is selected, the POC uses the value in the Tubing Head Press control. When *Analog* is selected, the POC uses the scaled value from analog channel 1.
- **% Water Cut** – Controls the percentage of water in the fluid.

Pumping Unit Selection

The screenshot shows a web interface for selecting a pumping unit. It features several input fields and indicators:

- Unit API Size:** A text input field containing "M-912DS-427-192".
- Crank Hole #:** A dropdown menu with "#2" selected.
- Pump Plunger Diam (in):** A text input field containing "1.50".
- Calculated Stroke (in):** A text input field containing "167.99".
- Unit Type:** A dropdown menu with "Mark II" selected.
- Unit Rotation:** A dropdown menu with "Counter Clockwise" selected.
- API Unit Dimensions:** A vertical list of seven indicators, each in a blue-bordered box:
 - R Dimension (in): 62.69
 - K Dimension (in): 312.698
 - C Dimension (in): 306.0
 - P Dimension (in): 228.06
 - A Dimension (in): 384.0
 - I Dimension (in): 228.0
- Buttons:** "Set Custom Unit" (grey), "Restore Factory Settings" (yellow), and "Menu" (grey).
- Text:** "Factory Defaults for all Parameters" is displayed below the rotation dropdown.

Figure 14 Pumping Unit Selection page

The Pumping Unit Selection page is used for setting up the POC to work with the correct pumping unit. This page includes five buttons and seven indicators which are listed below:

- **Unit API Size** – The use of this button is described under the subheading *Unit API Size* below.
- **Set Custom Unit** – Pressing this button will allow the user to set up a custom pumping unit, so long as the user has the **API Unit Dimensions** for the unit. To set a custom unit, press this button, the **Unit API Size** control will display the text “Custom Unit”, and enter the appropriate unit dimensions into the **API Unit Dimension** controls on the right on the screen. Please note that the values for the previous unit will remain in the dimension controls once this button is pressed.
- **Crank Hole #** – Use this button to indicate which of the crank arm hole that the pitman is connected to. Hole one will be the farthest from the gear box shaft, which would produce the longest stroke possible.
- **Pump Plunger Diam** – Used for entering the pump plunger diameter in inches.
- **Calculated Stroke** – This indicator displays the calculated stroke, in inches, of the pumping unit.
- **Unit Type** – This button is used for the selection of the unit type. Options will be auto-selected based on the API size selected, but can be changed. The options are:
 - Conventional
 - Mark II
 - Reverse Mark
 - Torque Master
 - Air Balance
 - Beam Balance
- **Unit Rotation** – Use this dropdown menu button to select the direction of rotation for the crank arm. The two options are Clockwise and Counter Clockwise. The rotation is determined by

observing the unit with the wellhead on your right and watching the rotation of the crank arm as the unit is operating.

- **Factory Defaults for all Parameters** – This button is used for restoring the POC to its factory default settings and can be used to reset the controller in cases where too many settings have been changed and it would be easier to start over from factory defaults than it would be to trace all of the incorrect settings. This is also useful on initial startup of the unit, to bring the settings to a known state.

Unit API Size

When the unit API size button is selected, a pop-up window appears on the display with a fifteen unit segment of the complete list of pumping units stored on the POC, as shown in the figure below. To display a different set of units in the window, press either of the **Up** or **Down** buttons. To select a pumping unit, press on its unit size in the list, ensure that the correct section was made in the Unit API Size indicator, and press on the **X** in the upper right-hand corner of the window or press **EXIT**. Pressing the **X** in the upper right-hand corner or the **EXIT** button without making a unit selection will cancel the selection process and leave the previous unit API size.

The screenshot shows a software interface for selecting a pumping unit. On the left, there are several input fields and buttons for configuring the unit API size. On the right, a pop-up window displays a list of 15 unit models, with navigation buttons for 'Up', 'Down', and 'EXIT'. The 'EXIT' button is highlighted in yellow.

Unit API Size
M-912DS-427-192

Crank Hole # Pump Plunger Diam

Calculated Stroke (in)

Unit Type Unit Rotation

Factory Defaults for all Parameters

Unit Model
M-912D-305-216
M-912DS-365-216
M-1280D-427-192
M-1280D-427-216
M-1824D-427-216
RM-228D-173-74
RM-228D-200-74
RM-228D-213-86
RM-228D-246-86
RM-228D-173-100
RM-228D-213-100
RM-228D-256-100
RM-228D-213-120
RM-320D-246-86
RM-320D-256-100

Figure 15 Pumping Unit Selection Page with Unit API Size window displayed

Rod Taper Set-up

The Rod Taper Set-up page provides the means to set up and modify up to six tapers for the rod string. The page is split up into three columns; the first column is used to set the rod length for each taper in feet, the second column is used for setting the rod diameter for each taper in inches, and the third column is used to select whether a taper is made of steel or fiberglass. To edit a field, press it and enter or select a value. **NOTE:** Any unused tapers should have their rod length and rod diameter set to **zero**. The figure below provides an example taper setup.

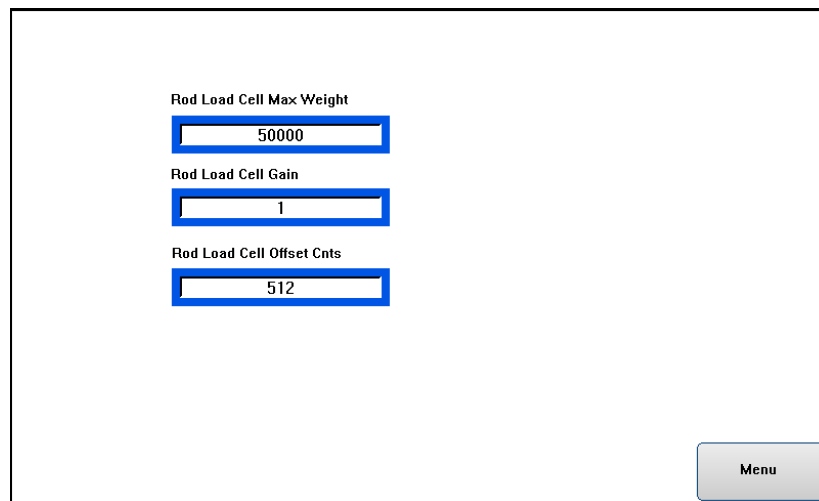
Taper 1 Rod Length (ft) <input type="text" value="3000"/>	Taper 1 Rod Diameter (in) <input type="text" value="1.00000"/>	Taper 1 Rod Type <input type="text" value="Steel"/>
Taper 2 Rod Length (ft) <input type="text" value="3000"/>	Taper 2 Rod Diameter (in) <input type="text" value="0.87500"/>	Taper 2 Rod Type <input type="text" value="Steel"/>
Taper 3 Rod Length (ft) <input type="text" value="3000"/>	Taper 3 Rod Diameter (in) <input type="text" value="0.75000"/>	Taper 3 Rod Type <input type="text" value="Steel"/>
Taper 4 Rod Length (ft) <input type="text" value="250"/>	Taper 4 Rod Diameter (in) <input type="text" value="1.50000"/>	Taper 4 Rod Type <input type="text" value="Steel"/>
Taper 5 Rod Length (ft) <input type="text" value="0"/>	Taper 5 Rod Diameter (in) <input type="text" value="0.00000"/>	Taper 5 Rod Type <input type="text" value="Steel"/>
Taper 6 Rod Length (ft) <input type="text" value="0"/>	Taper 6 Rod Diameter (in) <input type="text" value="0.00000"/>	Taper 6 Rod Type <input type="text" value="Steel"/>

Figure 16 Rod Taper Set-up page

Rod Weight and Analog Scale Factors

The Rod Weight and Analog Scale Factors page provides access to the parameters necessary for setting up the rod load cell. The list below describes each of the inputs for this page and the figure below the list provides an example.

- **Rod Load Cell Max Weight** – Place the maximum rated weight for the load cell into this control.
- **Rod Load Cell Gain** – Normally, this will be set to one, but is used as a multiplication scale factor.
- **Rod Load Cell Offset Counts** – Normally, this will be set to 512, but is used to correct an offset in the load cell.



The screenshot displays a configuration page with three input fields, each highlighted with a blue border. The first field is labeled "Rod Load Cell Max Weight" and contains the value "50000". The second field is labeled "Rod Load Cell Gain" and contains the value "1". The third field is labeled "Rod Load Cell Offset Cnts" and contains the value "512". In the bottom right corner of the page, there is a button labeled "Menu".

Figure 17 Rod Weight and Analog Scale Factors page

Pump Off Selection and Set-up

The Pump Off Selection and Set-up page is used for setting the startup, pump off, and operation parameters on the POC. An example of this screen is shown in the figure below.

The screenshot displays a configuration interface for a Pump Off Control (POC) system. It is organized into several sections:

- Top Row:** Three input fields for "Power On Delay (Seconds)" (10), "Start Alert (Seconds)" (5), and "Minimum Pump Strokes" (15).
- Second Row:** Two dropdown menus for "Control Mode" (set to "Pump Card") and "Operation Mode" (set to "Normal Mode").
- Third Row:** Three input fields for "Pump Off Load Set Point (lbf)" (1000), "Pump Off Position Set Point (in)" (50.00), and "Consecutive Pump Off Strokes Allowed" (3).
- Fourth Row:** Three input fields for "Pump Off Down Time (hrs)" (0), "Pump Off Down Time (mins)" (30), and "Pump Fillage Set Point %" (90.0000).
- Fifth Row:** Four input fields for "Timed Mode On (hours)" (0), "Timed Mode On (mins)" (30), "Timed Mode Off (hours)" (0), and "Timed Mode Off (mins)" (30).
- Shut Down Enables:** Two radio buttons: "Pump Off Set Point" (selected) and "Pump Fillage Set Point".
- Bottom Right:** A "Menu" button.

Figure 18 Pump Off Selection and Set-up page

The list below describes the controls and indicators in this page:

- The **Power On Delay** is used for delaying startup of the unit after a power outage. This can be used to stagger the startup of multiple units.
- The **Start Alert** is how long the POC will sound the horn every time the unit starts.
- The **Minimum Pump Strokes** is used to set the minimum number of strokes that must occur before the pump/surface cards can be used for determining shutdown.
- **Control Mode** – The following options are provided for this control:
 - **Surface Card** – When this option is selected, the POC examines the Pump Off Set Point on the unit's down stroke to see if it is below the surface card. If the set point is below the down stroke of the surface card, then the POC counts that stroke as a consecutive pump off stroke, incrementing the Consecutive Pump Off Stroke counter. Once this counter reaches the limit set in the Consecutive Pump Off Strokes Allowed control, the POC will shut the unit down. When the set point is in the area above the down stroke for the surface card, the consecutive pump off stroke counter is reset and the unit is allowed to continue operation. **NOTE:** When this mode is selected, the POC will not allow the Pump Fillage Set Point to be selected. Additionally, Pump Off Set Point must be selected in order for pump off to occur.
 - **Pump Card**
 - **Pump Fillage Set Point** – When the Pump Card control mode and Pump Fillage Set Point are selected, the POC examines the Pump Off Set Point on the unit's down stroke to see if it is below the pump card. If the set point is below the down stroke of the pump card, then the POC counts that stroke as a consecutive pump off stroke, incrementing the Consecutive Pump Off Stroke counter. Once

this counter reaches the limit set in the Consecutive Pump Off Strokes Allowed control, the POC will shut the unit down. When the set point is in the area above the down stroke for the pump card, the Consecutive Pump Off Stroke counter is reset and the unit is allowed to continue operation.

- **Pump Fillage Set Point** – When the Pump Card control mode and Pump Fillage Set Point are selected, the pump fillage will need to be above the Pump Fillage Set Point % or the POC will begin counting Consecutive Pump Off Strokes and shut the unit down once it has reached the consecutive number of pump off strokes allowed.
- **NOTE:** When Pump Card is selected, the Shut Down Enables will automatically switch to Pump Fillage Set Point, but can be changed to Pump Off Set Point. To do this, deselect Pump Fillage Set Point by pressing it, then select the Pump Off Set Point.
 - **Not Used** – If this option is selected, then the POC will not be in a control mode for pump off.
 - **VFD Surface** – please refer to the VFD Configuration page below.
 - **VFD Downhole** – please refer to the VFD Configuration page below.
- **Operation Mode** – The options for this control are listed below:
 - **Normal Mode** – This mode allows the unit to be run based on the mode selected in the Control Mode controller.
 - **Timed Mode** – When selected, the POC will start and stop the unit based on the timers set up in the Timed Mode section of this page.
 - **Host Mode** – When this option is selected, the POC will start and stop the unit based solely on the commands received from SCADA.
- **Pump Off Load Set Point** – This control sets the maximum load, in pound force, that the POC will allow before pump off, in turn controlling the vertical movement of the pump off set point on the Surface and Pump Card page.
- **Pump Off Position Set Point** – Use this control to set the pump/surface card position, in inches, during the down stroke that the Pump Off Load Set Point will be used in determining pump off conditions. Modifying the value in this control allows for the horizontal movement of the Pump Off Set Point on the Surface and Pump Card page.
- **Consecutive Pump Off Strokes Allowed** – This controls the number of consecutive pump off strokes that will be allowed by the POC before pump off.
- **Pump Off Down Time (hrs)** – Controls the amount of hours that the POC will remain in the off state after a pump off shutdown.
- **Pump Off Down Time (mins)** – Controls the amount of minutes that the POC will remain in the off state after a pump off shutdown. The total down time will be the sum of both the Pump Off Down Time (hrs) and Pump Off Down Time (mins).
- **Pump Fillage Set Point %** - This controls the minimum percent fillage of the pump that the POC will allow before it starts counting consecutive pump off strokes in Pump Card and VFD Downhole modes while Pump Fillage Set Point is selected.

- **Timed Mode On (hrs)** – Controls the amount of time, in hours, that the POC will run the unit when in the Timed Mode of operation.
- **Timed Mode On (mins)** – Controls the amount of time, in minutes, that the POC will run the unit when in the Timed Mode of operation.
- **Timed Mode Off (hrs)** – Controls the amount of time, in hours, that the POC will keep the unit stopped after the Timed Mode On timer has expired in the Timed Mode of operation.
- **Timed Mode Off (mins)** – Controls the amount of time, in minutes, that the POC will keep the unit stopped after the Timed Mode On timer has expired in the Timed Mode of operation.

Min / Max Rod Load Settings

The Min/Max Rod Load Settings page, as seen in the figure below, is used to set the parameters necessary to shut down the pumping unit when it is carrying too light of loads or too great of loads. The list below describes the function for each of the buttons and indicators:

- **Last Stroke Min Load** – This indicator displays the minimum load, in pounds, seen by the pumping unit on the last stroke.
- **Min Load Limit** – This control sets the minimum limit, in pounds, for loads being lifted by the pumping unit.
- **Consecutive Min Load Allowed** – This control sets the maximum number of allowed minimum loads that the POC will tolerate before shutting down the pumping unit. The load is checked every two milliseconds by the POC, therefore the time to trip will be the count multiplied by two milliseconds.
- **Last Stroke Peak Load** – This indicator displays the maximum load, in pounds, seen by the pumping unit during the last stroke.
- **Peak Load Limit** – This control sets the maximum limit, in pounds, for loads being lifted by the pumping unit.
- **Consecutive Peak Load Allowed** – This control sets the maximum allowed peak loads that the POC will tolerate before shutting down the pumping unit. The load is checked every two milliseconds by the POC, therefore the time to trip will be the count multiplied by two milliseconds.

The screenshot displays the Min / Max Rod Load Settings page with the following values:

Last Stroke Min Load (lbs)	14663	Min Load Limit (lbs)	12000	Consecutive Min Load Allowed 2ms/Count	50
Last Stroke Peak Load (lbs)	31085	Peak Load Limit (lbs)	35000	Consecutive Peak Load Allowed 2ms/Count	50

A Menu button is located in the bottom right corner of the settings area.

Figure 19 Min / Max Rod Load Settings page

VFD Configuration

The VFD Configuration page is used for setting up the POC to speed up and slow down the drive when the Control Mode dropdown menu on the *Pump Off Selection and Set-Up* page is placed in either the VFD Surface or VFD Downhole modes. It is also used to set the VFD speed reference scaling for analog output 1 no matter what Control Mode is selected. The **VFD Min Spd Scale**, **VFD Max Spd Scale**, and **VFD Speed Ref Output Mode** are used to match the VFD analog input to the BEPOC analog output. The values in the BEPOC should match the values in the VFD. The **VFD Min Op Spd** and **VFD Max Op Spd** are used to set the operating speed range that the BEPOC is allowed to send to the VFD. The Settings must meet the following criteria:

$$\text{VFD Min Spd Scale} \leq \text{VFD Min Op Spd} < \text{VFD Max Op Spd} \leq \text{VFD Max Spd Scale}$$

The screenshot shows the VFD Configuration page with the following settings:

- Pump Fillage SP: 90
- Dead Band of Pump Fillage: 5.00
- VFD Speed Inc %: 5
- VFD Speed Dec %: 1
- VFD Min Spd Scale: 15.0
- VFD Max Spd Scale: 60.0
- VFD Min Op Spd: 20.0
- VFD Max Op Spd: 40.0
- VFD Speed Ref Output Mode: 4-20mA
- VFD Spd Ref Out: 22.7

Text on the right side of the page:

If Control Mode is set to VFD Surface:
The Pump Off Position and Pump Off Load are used on the Surface Card with the Dead Band in inches to increase or decrease VFD speed by the percentage of full speed set by VFD Speed Inc % and VFD Speed Dec %

If Control Mode is set to VFD Downhole:
The Pump Fillage SP is used on the Downhole Card with the Dead Band in % fillage to increase or decrease VFD speed by the percentage of full speed set by VFD Speed Inc % and VFD Speed Dec %

Menu

Figure 21 VFD Configuration page

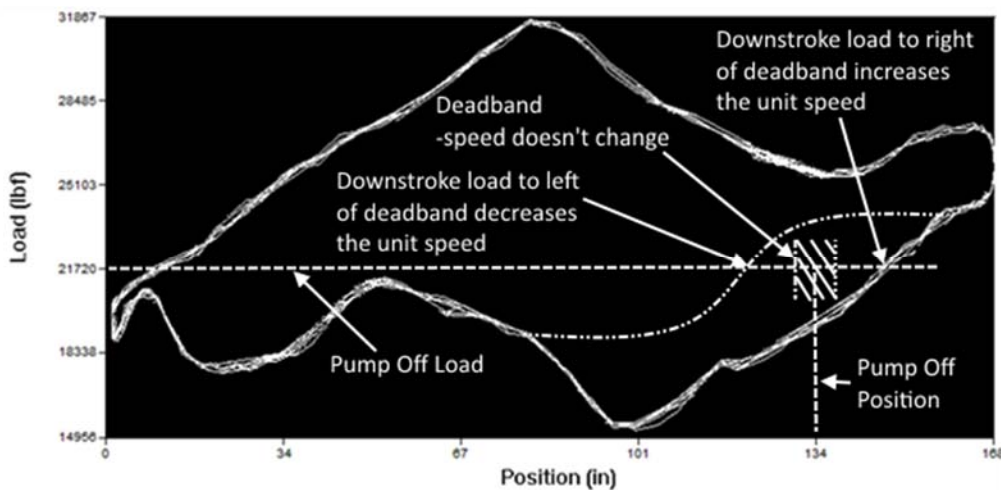


Figure 20 Deadband description for VFD Surface mode

If the **Control Mode** is set to *VFD Surface*, a dead band will be calculated for the down stroke of the unit, based off of the **Pump Off Position** and **Pump Off Load** and the value for the **Dead Band of Pump Fillage** control. The dead band is centered on the Pump Off Position along the Pump Off Load and extends to \pm the Dead Band of Pump Fillage value. For example, using Figures 20 and 21, the Pump Off Load is 21720 lbs, the Pump Off Position is 134 inches, and the Dead Band of Pump Fillage is 5.00 inches, so the dead band starts at 129 inches and advances to 139 inches. When the down stroke of the pump card is outside the upper bound of the dead band (139 inches in the above example), the POC will begin stepping up the speed of the unit by the value in **VFD Speed Inc %** (5 % in this example, which corresponds to 5% of the Op Speed Span) to bring the load's position within the dead band. Once the down stroke load enters into the dead band, the POC will stop increasing the unit's speed and instead hold it constant. When the load position extends below the bottom portion of the dead band (129 inches in this example), the POC will begin counting pump off strokes and slow down the unit in increments set by the **VFD Speed Dec %** (1 % in this example, which corresponds to 1% of the Op Speed Span). The speed will continue to decrease until the unit either reaches the maximum number of pump off strokes and shuts down, or the down stroke load position returns to the permissible range within the dead band, at which point the POC will keep the unit at a constant speed.

When the **Control Mode** is set to *VFD Downhole* with the **Shut Down Enables** set to *Pump Off Set Point*, the POC operates in the same manner as when Control Mode is set to VFD Surface, described in the previous paragraph, with the exception that it uses the downhole pump card instead of the surface card.

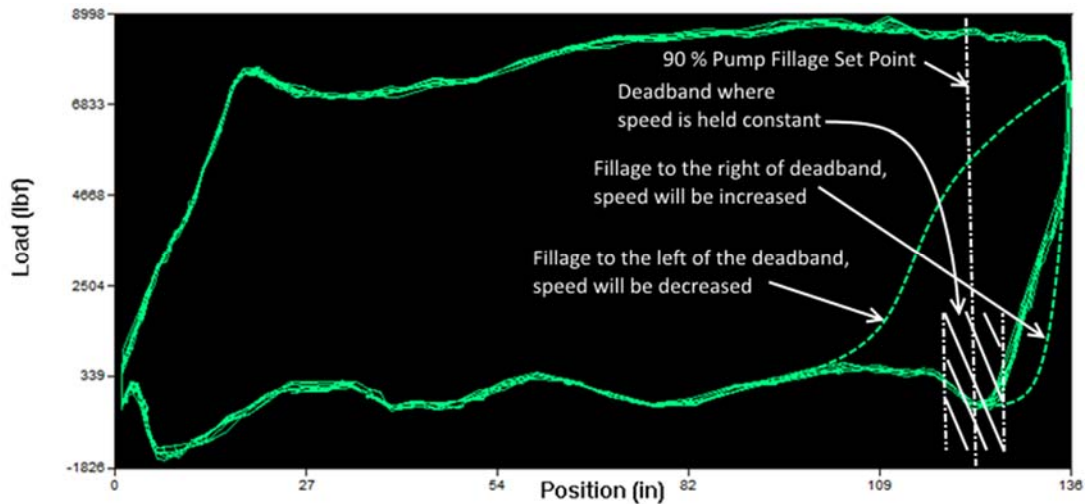


Figure 22 Deadband description for VFD Surface mode

If the **Control Mode** is set to *VFD Downhole* and the **Shut Down Enables** set to *Pump Fillage Set Point* (SP), a dead band will be calculated for the down stroke of the pump, based off of the **Pump Fillage SP** and the value for the **Dead Band of Pump Fillage** control. The dead band is centered on the Pump Fillage SP and extends to \pm the Dead Band of Pump Fillage value. For example, using Figures 20 and 22, the Pump Fillage SP is 90 with the Dead Band of Pump Fillage at 5.00, so the dead band starts at 85 % and advances to 95% of the pump fillage. When the down stroke of the pump card is outside the upper

bound of the dead band (95 % in the above example), the POC will begin stepping up the speed of the unit by the value in **VFD Speed Inc %** (5 % in this example, which corresponds to 5% of the Op Speed Span) to bring the pump fillage within the dead band. Once the down stroke fillage enters into the dead band, the POC will stop increasing the unit's speed and instead hold it constant. When the fillage extends below the bottom portion of the dead band (85 % in this example), the POC will begin counting pump off stokes and slow down the unit in increments set by the **VFD Speed Dec %** (1 % in this example, which corresponds to 1% of the Op Speed Span). The speed will continue to decrease until the unit either reaches the maximum number of pump off strokes and shuts down, or the down stroke fillage returns to the permissible range within the dead band, at which point the POC will keep the unit at a constant speed.

Speed vs. Position

The Speed vs. Position page is used in conjunction with a variable frequency drive to tune the speed of the pumping unit for various positions within a pumping stroke. Two modes are available for speed control, *Constant Speed* (Const Spd) and *Speed vs. Position* (Spd vs Pos), which are selected using the Speed Mode dropdown menu. When in constant speed mode, the drive will run the motor at the percentage of full speed set in the *Const Speed %* control. In speed vs. position mode, the speed of the pumping unit is allowed to vary based on the position of the unit within its stroke, with the Const Speed % used as an overall multiplier to achieve the desired strokes per minute (SPM). This page also includes an indicator for the percent displacement of the polished rod relative to the top of the stuffing box, an indicator for the current position of the pumping unit within its stroke (in percent), controls for the positions and speeds for the speed vs position mode, and indicators for the strokes per minute and the motor speed. An example screenshot of this page is shown in the figure below.

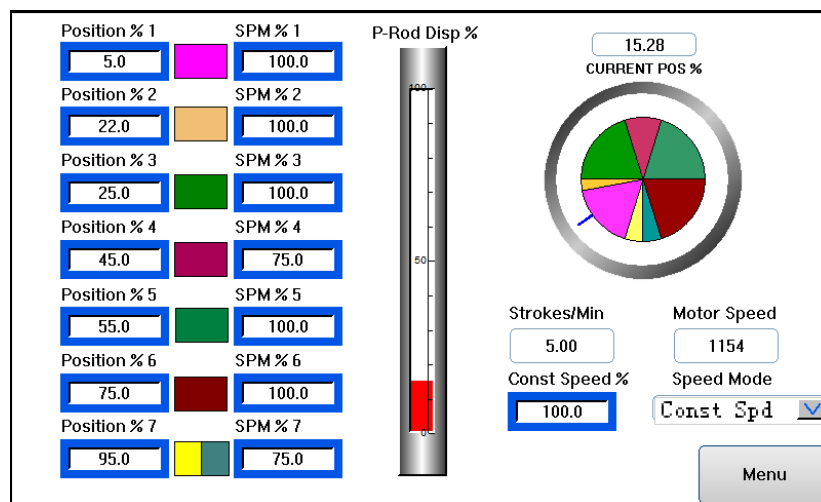


Figure 23 Speed Vs Position page

For speed vs. position mode, each stroke is split up into seven different positions for the drive to speed up and slow down the pumping unit. The start of each position is placed in the Position % 1 through 7 controls. A visual representation for each of these positions can be seen on the pie chart overlapping the

CURRENT POS % clock-like indicator, with the colors for each slice displayed next to the corresponding Position % control. When entering a value for the start of a position, the value cannot be less than the value for the position ahead of it or greater than the value for the position that comes after it, otherwise the POC will autocorrect the value(s) to within the permissible range. Referring to the figure below as an example, if 4.0 is entered for Position % 2, the POC will move Position % 1 from 5.0 down to 3.9, but if 26.0 is entered for Position % 2, the POC will limit it to 24.9 to keep it from exceeding the value in Position % 3. The values in SPM % 1 through 7 control the percent of full speed that the motor will run for the associated position within the stroke, with valid values being between 0 and 100%.

The following list details the indicators on this page:

- **Current Fluid** – Shows the amount of fluid pumped, in barrels, for the current day.
- **Current Oil** – Shows the amount of oil pumped, in barrels, for the current day.
- **Current Water** – Displays the amount of water pumped, in barrels, for the current day.
- **Current Strokes** – Displays the number of strokes that have occurred within the current day.
- **Current Cycles** – Indicates how many Start-Stop cycles the unit has gone through within the current day.
- **Current % Run** – Shows how long the pumping unit has been running, as a percentage, within the current day.
- **Yesterday Fluid** – Shows the amount of fluid pumped, in barrels, for the previous day.
- **Yesterday Oil** – Shows the amount of oil pumped, in barrels, for the previous day.
- **Yesterday Water** – Displays the amount of water pumped, in barrels, for the previous day.
- **Yesterday Strokes** – Displays the number of strokes that occurred the previous day.
- **Yesterday Cycles** – Indicates how many Start-Stop cycles the unit went through the previous day.
- **Yesterday % Run** – Shows how long the pumping unit ran, as a percentage, during the previous day.
- **Pump Fillage (%)** – Displays how full the pump is with each stroke. It is shown as a percentage.
- **Net Stroke** – Displays the portion of the stroke that moved fluid, in inches.
- **Gross Stroke** – Shows the total displacement of the pump, in inches, for the current stroke.
- **Fluid Load** – Indicates the fluid load on the pump by first calculating the friction load then removing it from the pump card.
- **Pump Card Peak Load** – Displays the peak load, in pounds, that was on the pump during the last stroke.
- **Pump Card Min Load** – Shows the minimum load, in pounds, that was on the pump during the last stroke.
- **Pump Intake Press** – Displays the intake pressure, in psi, at the pump during the current stroke.

Communication Port Settings

The Communications Port Settings page is used to set up the necessary POC parameters to allow for communications between the POC and an external device using the MODBUS Protocol in RTU mode, with the POC acting as the slave and the external device acting as the master. Each column on the page represents settings for a specific communications port, with the name of each port designated at the top of the column. The fields, which are common for each of the ports, are described below with an example shown in figure following the parameter descriptions. **NOTE:** If a Wi-Fi module is installed, it uses communications port 0 with the following settings – RTU Address set to 1, Baud Rate set to 115200, Data Bits set to 8, Stop Bits set to 1, and Parity set to None.

- **RTU Address** – This is the slave ID number for the POC, which can be set by pressing the field and entering a number between 1 and 247. If an address from 248 to 2295 is entered the system automatically switches from standard Modbus protocol to ELAM (Extended Lufkin Automation Modbus) protocol.
- **Baud Rate (bps)** – The options for this dropdown menu are 300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200 bits per second.
- **Data Bits** - The options for this dropdown menu are 5, 6, 7, or 8 bits.
- **Stop Bits** - The options for this dropdown menu are 1, 2, or 1.5 bits.
- **Parity** - The options for this dropdown menu are None, Even, or Odd.

Com Port 0 Settings	Com Port 1 Settings	Com Port 2 Settings
RTU Address <input type="text" value="1"/>	RTU Address <input type="text" value="1"/>	RTU Address <input type="text" value="1"/>
Baud Rate (bps) 115200	Baud Rate (bps) 115200	Baud Rate (bps) 9600
Data Bits 8	Data Bits 8	Data Bits 8
Stop Bits 1	Stop Bits 1	Stop Bits 1
Parity None	Parity None	Parity None
WiFi uses Com 0 Settings 1, 115200, 8, 1, None		Menu

Figure 24 Communication Port Settings page

Analog Input Configuration

The Analog Input Configuration page is used for setting the scaling of the analog values. The first column contains fields where the minimum scale value is entered; the second column contains fields for the maximum scale value contained; the third column is used for selecting the range of the input, via a dropdown menu; and the fourth column is meant for the selection of the units of measurement, also using a dropdown menu. Pressing the **Analog Fault Config** button will change the screen to the *Analog Input Fault Configuration* page. The **AI Filter Time Constant (ms)** is used to set the analog input lowpass filter time constant in milliseconds. The filter is applied to all 6 AI channels. If the filter time constant is set to 0ms or greater than 10000ms it is reset to the default 2000ms.

AI2 Min Scale	AI2 Max Scale	AI2 Range	AI2 Units
<input type="text" value="0.00"/>	<input type="text" value="100.00"/>	4 to 20 mA	psi
AI3 Min Scale	AI3 Max Scale	AI3 Range	AI3 Units
<input type="text" value="0.00"/>	<input type="text" value="100.00"/>	4 to 20 mA	psi
AI4 Min Scale	AI4 Max Scale	AI4 Range	AI4 Units
<input type="text" value="0.00"/>	<input type="text" value="100.00"/>	4 to 20 mA	psi
AI5 Min Scale	AI5 Max Scale	AI5 Range	AI5 Units
<input type="text" value="0.00"/>	<input type="text" value="100.00"/>	4 to 20 mA	psi
AI6 Min Scale	AI6 Max Scale	AI6 Range	AI6 Units
<input type="text" value="0.00"/>	<input type="text" value="100.00"/>	4 to 20 mA	psi
AI7 Min Scale	AI7 Max Scale	AI7 Range	AI7 Units
<input type="text" value="0.00"/>	<input type="text" value="100.00"/>	4 to 20 mA	psi
<input type="button" value="Analog Fault Config"/>		AI Filter Time Constant (ms)	<input type="button" value="Menu"/>
		<input type="text" value="2000"/>	

Figure 25 Analog Input Configuration page

Analog Input Fault Configuration

Channel	Scaled Value	Fault Level	Fault Reset Level	Fault Configuration
AI2	0.00	0.00	0.00	Disabled
AI3	0.00	0.00	0.00	Disabled
AI4	0.00	0.00	0.00	Disabled
AI5	0.00	0.00	0.00	Disabled
AI6	0.00	0.00	0.00	Disabled
AI7	0.00	0.00	0.00	Disabled

AI Fault AI2 AI3 AI4 AI5 AI6 AI7 Menu

Figure 26 Analog Input Fault Configuration page

The Analog Input Fault Configuration page is used to set up the user-defined faults for each of the analog input channels AI2 – AI7 (one fault per channel). Using the AI Fault Configuration drop-down lists, the type of fault can be selected. The options for these controls are listed below:

- 1) **Disabled** – This disables the fault. When this is selected for a fault, the associated fault indicator at the bottom of the page will appear to be on, but the fault itself will not be active.
- 2) **Hi Level Fault** – Once the scaled value rises above the value specified in the AIX Fault Level control, the POC will shut the unit down and the fault will only be reset when the user presses the **Reset** button on either the *Start Stop Reset* page or the *Alarms* page.
- 3) **Lo Level Fault** – Once the scaled value drops below the value specified in the AIX Fault Level control, the POC will shut the unit down and the fault will only be reset when the user presses the **Reset** button on either the *Start Stop Reset* page or the *Alarms* page.
- 4) **Hi Level w/ Reset** – Once the scaled value rises above the value specified in the AIX Fault Level control, the POC will shut the unit down. The fault can be reset by pressing the **Reset** button on either the *Start Stop Reset* page or the *Alarms* page, or the fault will get reset automatically by the POC when the scaled value drops below the value set in the AIX Fault Reset Level control.
- 5) **Lo Level w/ Reset** – Once the scaled value drops below the value specified in the AIX Fault Level control, the POC will shut the unit down. The fault can be reset by pressing the **Reset** button on either the *Start Stop Reset* page or the *Alarms* page, or the fault will get reset automatically by the POC when the scaled value rises above the value set in the AIX Fault Reset Level control.

Fault indicators for each of the faults is given at the bottom of the page. A fault is active when the indicator has turned red and is inactive when the indicator is green.

Digital Input Fault Configuration

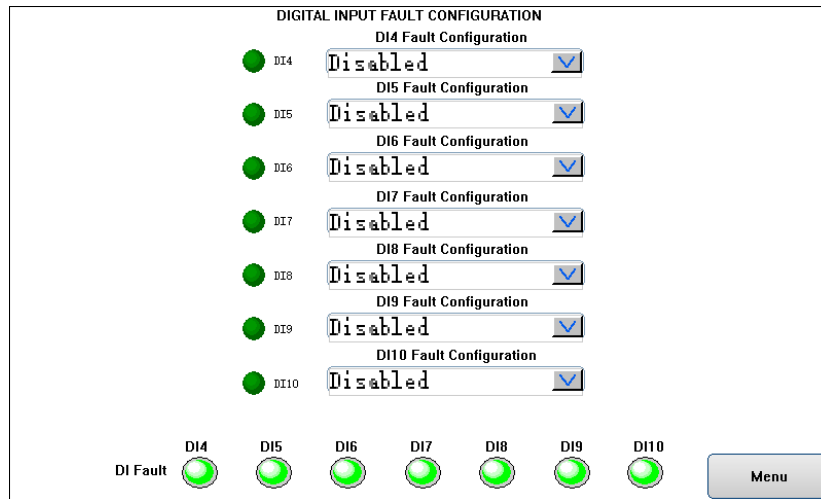


Figure 27 Digital Input Fault Configuration page

The Digital Input Fault Configuration page is used to set up the user-defined faults for each of the digital input channels DI4 – DI10 (one fault per channel). Using the DI Fault Configuration drop-down lists, the type of fault can be selected. The options for these controls are listed below:

- 1) **Disabled** – This disables the fault. When this is selected for a fault, the associated fault indicator at the bottom of the page will appear to be on, but the fault itself will not be active.
- 2) **Hi Level Fault** – This forces the fault to be a Normally Open type of fault. Once the input goes high, the POC will shut the unit down and the fault will only be reset when the user presses the **Reset** button on either the *Start Stop Reset* page or the *Alarms* page.
- 3) **Lo Level Fault** – This forces the fault to be a Normally Closed type of fault. Once the input drops out, the POC will shut the unit down and the fault will only be reset when the user presses the **Reset** button on either the *Start Stop Reset* page or the *Alarms* page.
- 4) **Hi Level w/ Reset** – This forces the fault to be a Normally Open type of fault. Once the input goes high, the POC will shut the unit down. The fault will be reset automatically by the POC when input is no longer sensed on the DI.
- 5) **Lo Level w/ Reset** – This forces the fault to be a Normally Closed type of fault. Once the input drops out, the POC will shut the unit down. The fault will be reset automatically by the POC when input is once again sensed on the DI.

Status indicators for each DI are shown on the left of each *DIx Fault Configuration* control, while Fault indicators for each of the faults is given at the bottom of the page. A DI is active when its status indicator has turned to bright green and is inactive when the indicator is a dark green. A fault is active when its fault indicator has turned red and is inactive when the indicator is green.

Linear Pumping Unit Configuration

The Linear Pumping Unit Configuration starts with setting the **Unit API Size** to “Custom Unit” by pressing the **Set Custom Unit** button on the **Pumping Unit Selection** page then select “Linear Pumping Unit” from the **Unit Type** drop down on either the **Pumping Unit Selection** page or the **Linear Pumping Unit Configuration** page. Next set the **Distance Between Sprocket Centers** in inches. Then set the **Sprocket Radius** in inches. The system will calculate the stroke length from the two entered measurements.

The screenshot shows a web-based configuration interface titled "LINEAR PUMPING UNIT CONFIGURATION". It contains several input fields and a dropdown menu. The "Calculated Stroke (in)" field is a text box containing "0.00". The "Chain Sprocket Output Ratio" field is a text box containing "0.00". The "Distance Between Sprocket Centers (in)" field is a text box containing "0". The "Sprocket Radius (in)" field is a text box containing "0". The "Unit Type" dropdown menu is currently set to "Conventional". A "Menu" button is located in the bottom right corner of the interface.

Field Name	Value
Calculated Stroke (in)	0.00
Chain Sprocket Output Ratio	0.00
Distance Between Sprocket Centers (in)	0
Sprocket Radius (in)	0
Unit Type	Conventional

Figure 28 Linear Pumping Unit Configuration

Time and Date

The Time and Date page is used for setting the 24-hour real time clock (RTC) on the POC and for synchronizing the HMI's RTC. To adjust the POC's month, day, year, etc., press on the desired field and enter in the desired value. To synchronize the HMI's RTC with the POC's RTC, press the **Sync HMI to POC RTC** button. **Note:** Pressing the *Sync HMI to POC RTC* button is only necessary on initial startup, as the HMI will synchronize its RTC with the POC's RTC every 83.3 minutes. The synchronization of the HMI to the POC is necessary to keep the timing of the alarms on the Alarms page in time with the alarm state on the POC.

POC Real Time Clock Settings

Month	Day	Year
6	19	2015
Hour	Minute	Second
11	32	2

24 hour clock
0-23 for hour entry

Sync HMI to POC RTC

HMI Clock is synchronized with POC Clock every 83.3 mins

Day	Mon	Year
6	19	2015
Hour	Min	Sec
11	32	41
	5 W.Day	

Menu

Figure 29 Time and Date page