Operations Manual

SOFTWARE VERSION 2.62

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Table of Contents

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.

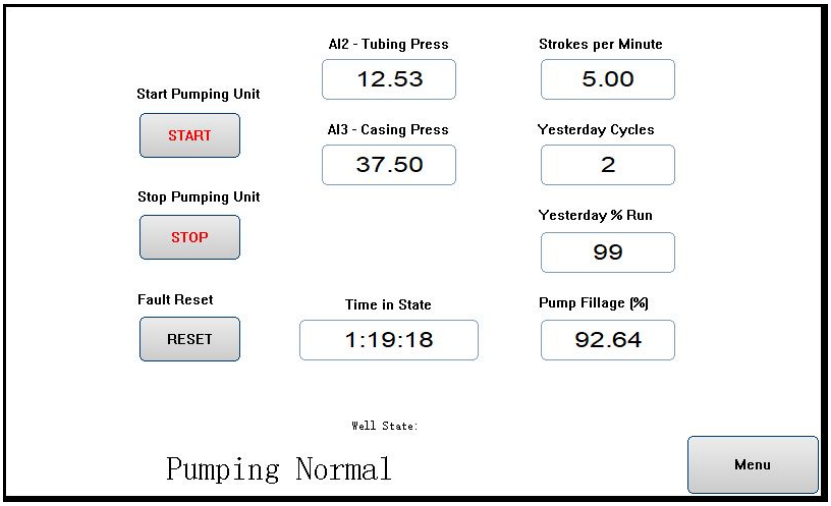

Figure 1 Main Screen

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.
- **AI2 – Tubing Press** – Displays the scaled value of AI2 which should be wired to a tubing pressure transducer.
- **AI3 – Casing Press** – Displays the scaled value of AI3 which should be wired to a casing pressure transducer.
- **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.

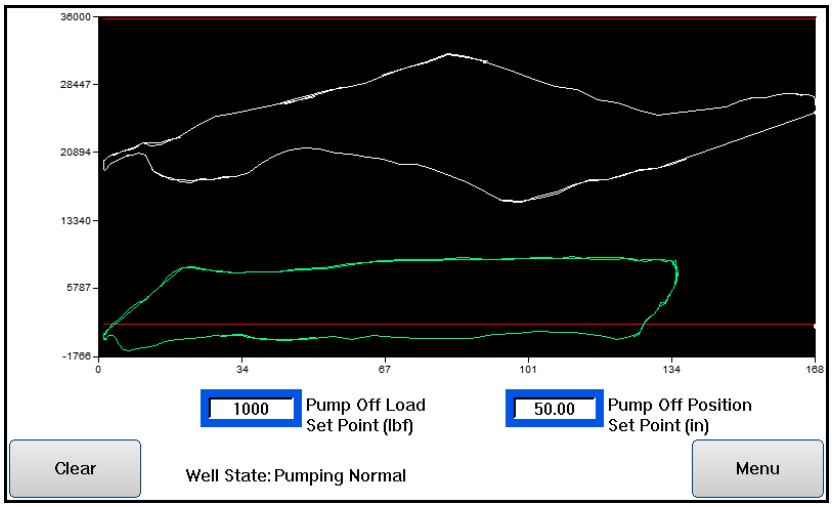

Figure 2 Surface and Pump card page

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.

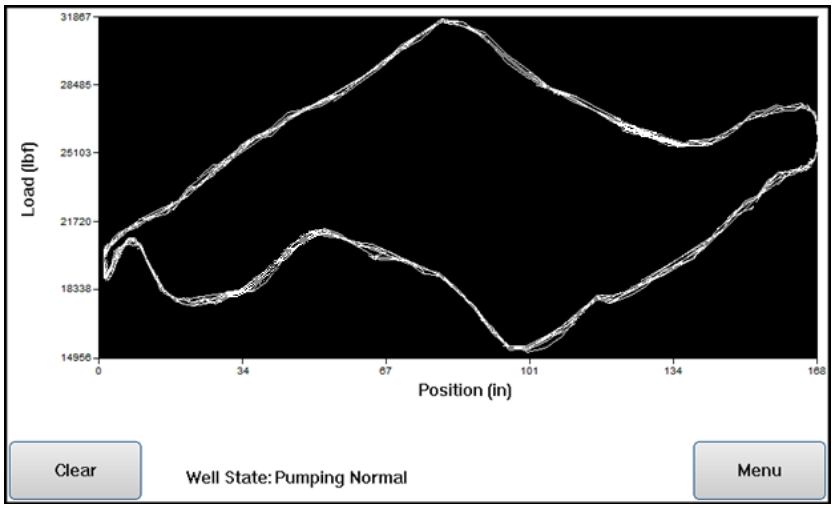

Figure 3 Surface Card page

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.

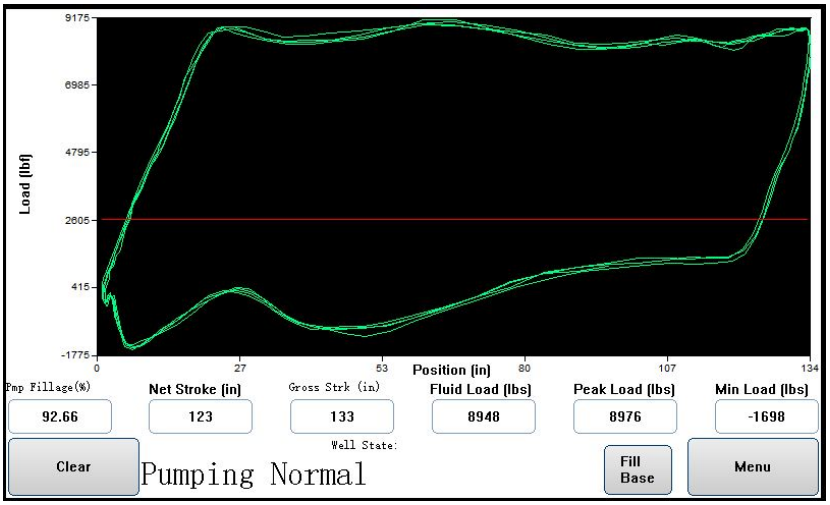

Figure 4 Pump Card page

The “Fill Base” pop-up window is activated by pressing the Fill Base Button on the lower right corner of the “Pump Card” page. It is used to set a user defined fill base in percentage of the Min Load and Peak Load of the Pump Card. It is enabled with the “Custom Fill Base” Enabled/Disabled button. The red line on the pump card is the current calculated fill base load which is also displayed in the pop-up as “Fill Base Calc Load (lbs)”.

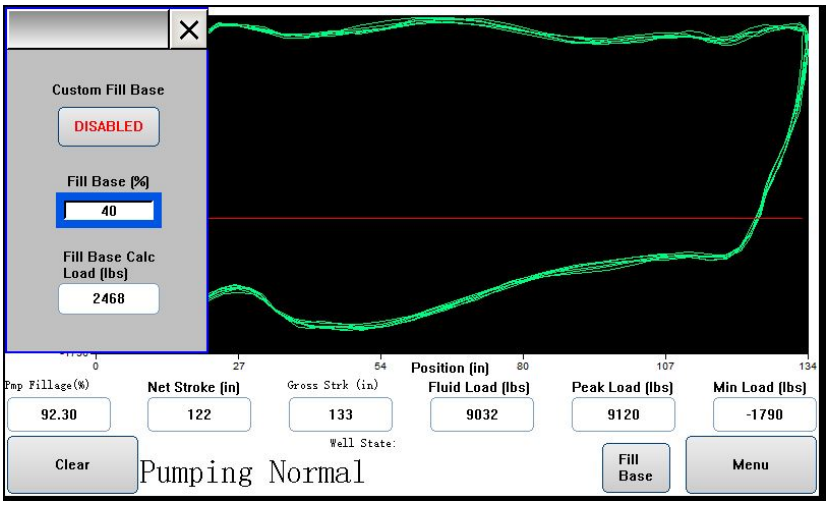

Figure 5 Pump Card with Fill Base pop up page

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.

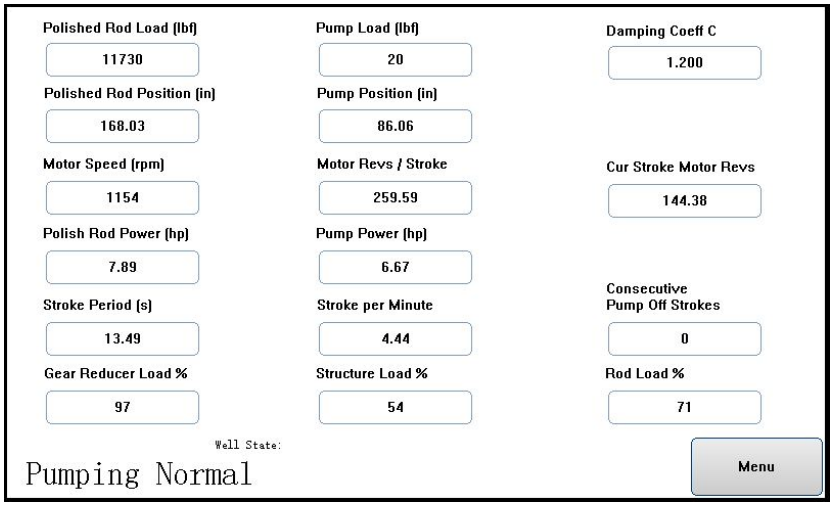

Figure 6 Pumping Unit Status page

- **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.
- **Gear Reducer Load** – Calculated maximum load in % of reducer rating. Assumes perfectly balanced.
- **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 exhorting on the pump.
- **Stroke per Minute** – Displays how many strokes occur per minute.
- **Structure Load** – Maximum load on polish rod as a % of the structure rating.
- **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.
- **Rod Load** – Calculated stress on the most loaded taper as a % of that tapers rating.

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.

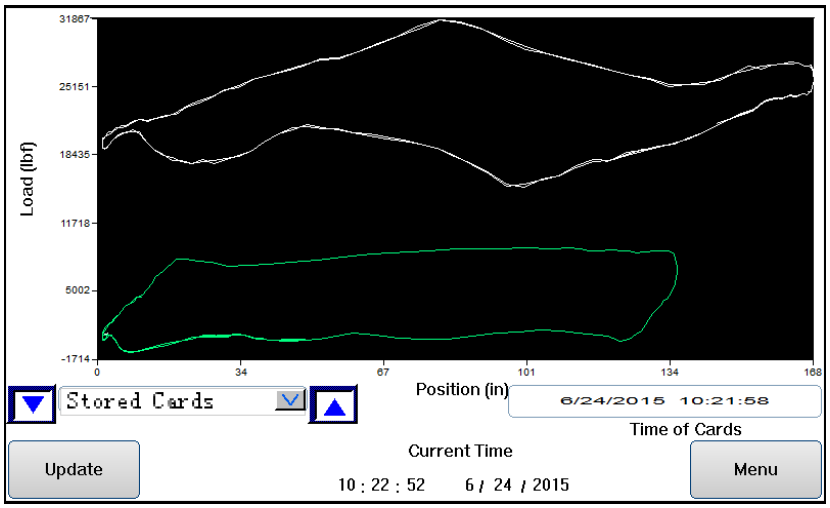

Figure 7 Sample History Cards page

History Graph Menu

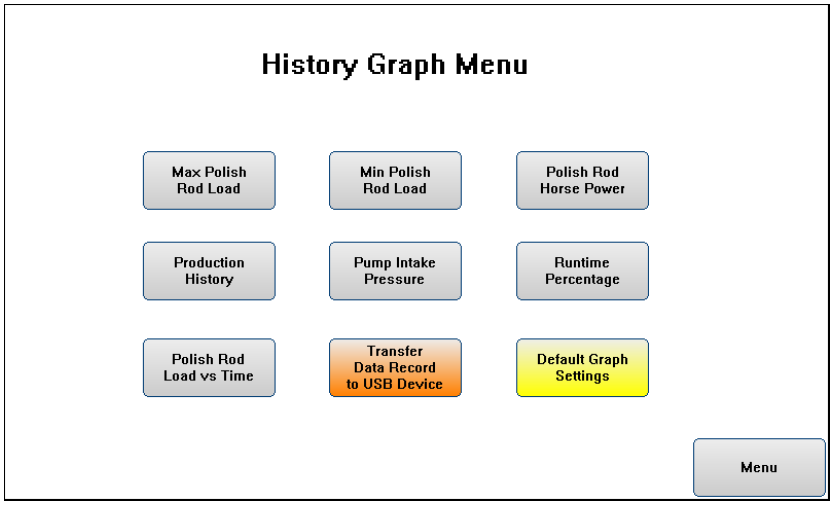

Figure 8 History Graphs Menu page

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

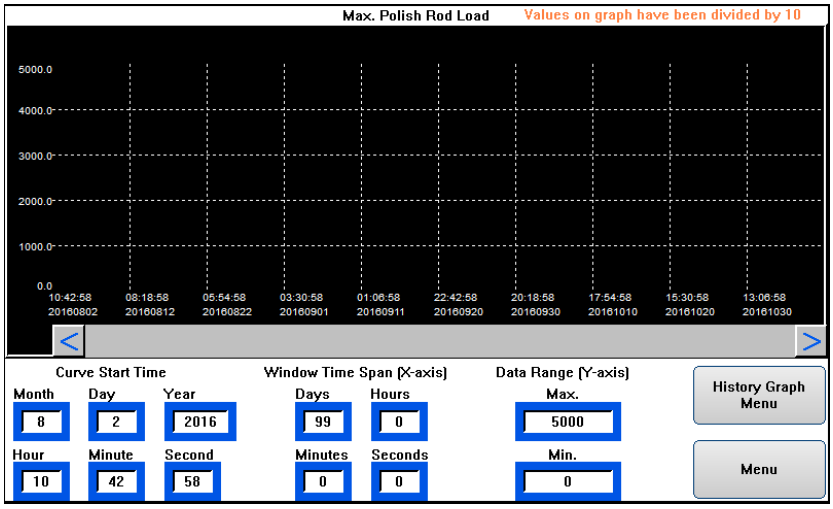

Figure 9 Example Graph page

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

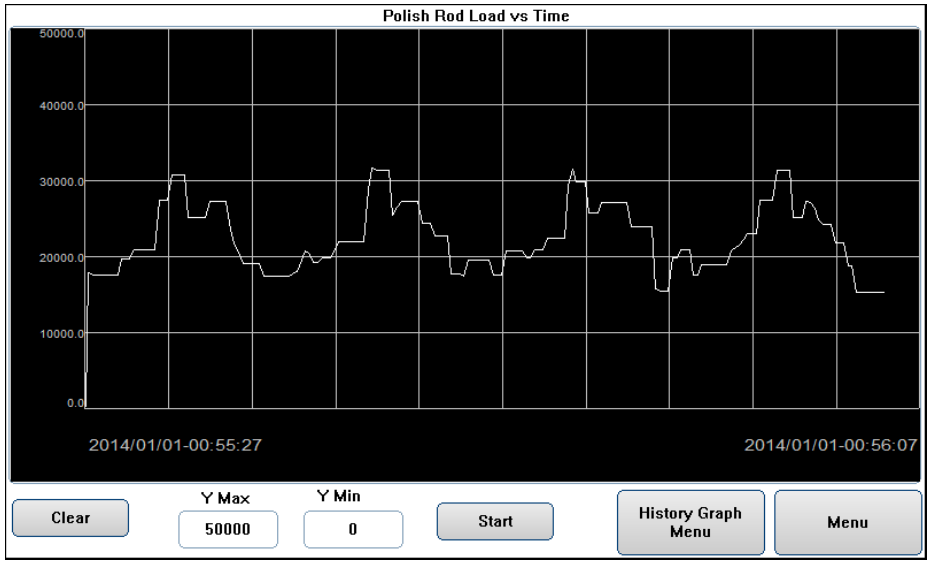

Figure 10 Polish Rod Load vs. Time page

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.

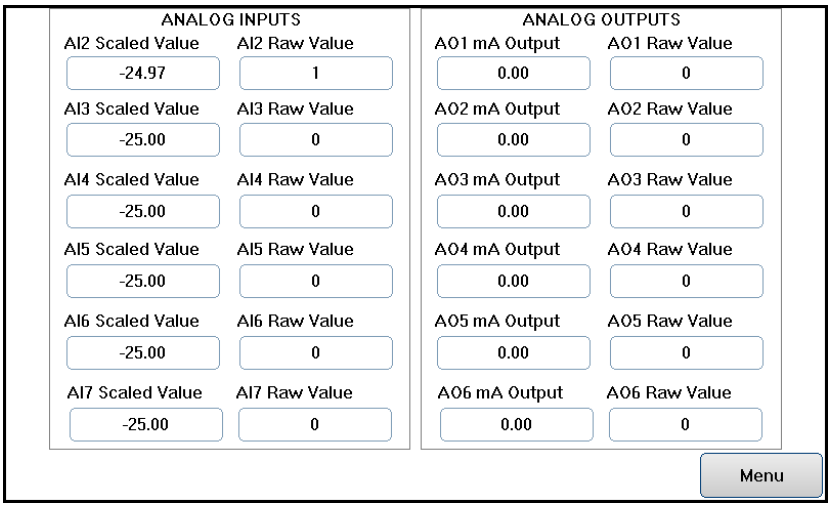

Figure 11 Analog I/O Status page

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.

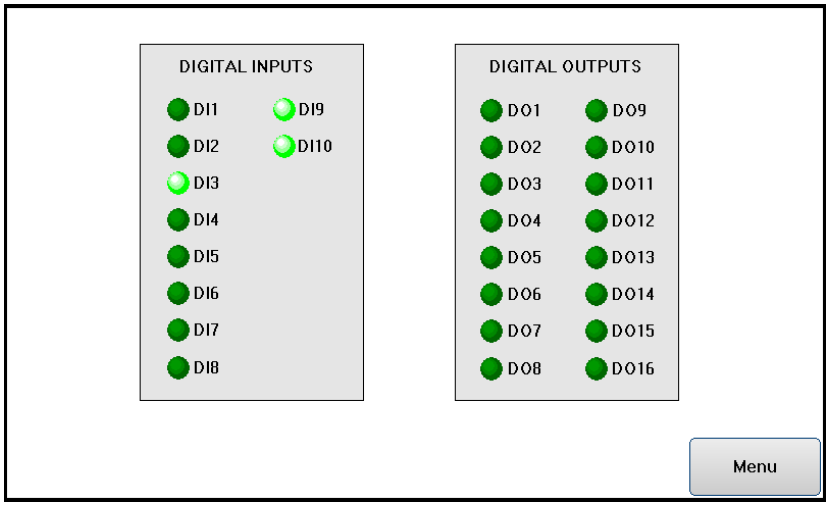

Figure 12 Digital I/O Status page

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 the figure below 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.

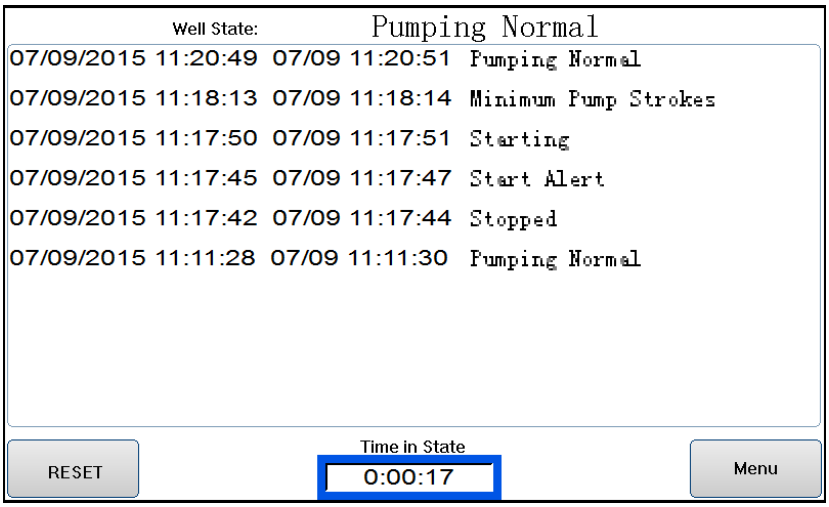

Figure 13 Alarms page

Energy Management

The Energy Management page is used for setting two separate time periods for the controller to either shut down pumping operations or slow to VFD minimum speed settings. This feature also allows the operator to choose which days the feature will be active. The figure below provides an illustration of this page.

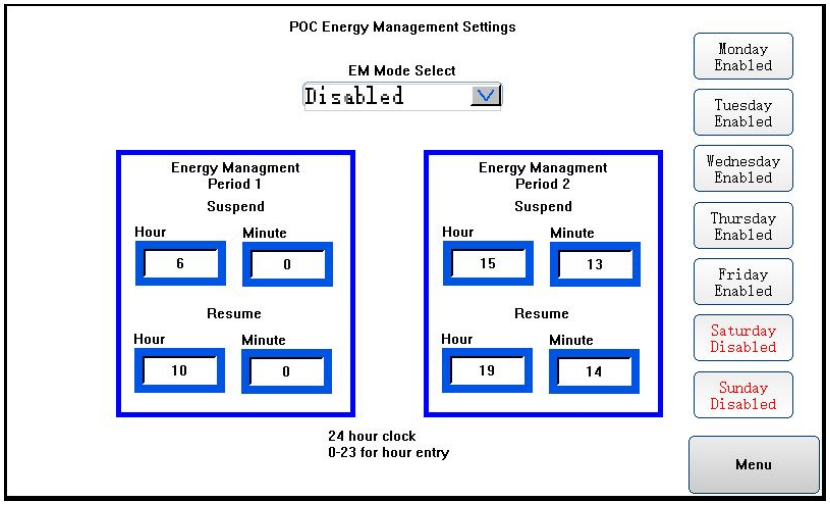

Figure 14 Energy Management page

- **EM Mode Select** – Selects the operating modes of the Energy Management function. The options are as follows:
    - Disabled - no action on any of the time periods.
    - Stop – Stops the pumping unit during the active time periods.
    - VFD Min Speed – Runs the pumping unit VFD at its "VFD Min Op Spd" setting found on the "VFD Configuration" page during the active time periods. This mode overrides all other VFD speed control functions.
- **Monday – Sunday Enabled/Disabled buttons –** Selects which days the Energy Management function is active if the "EM Mode Select" is in "Stop" or "VFD Min Speed" mode.
- **Energy Management Period 1 –** Suspend Hour and Minute sets the desired time to begin either Stop or VFD minimum speed operation. Resume Hour and Minute sets the desired time to resume normal pumping operations. **Note:** this is a 24-clock setting i.e., 0-23 on the hour and 0-59 on the minute setting.
- **Energy Management Period 2 –** Suspend Hour and Minute sets the desired time to begin either Stop or VFD minimum speed operation. Resume Hour and Minute sets the desired time to resume normal pumping operations. **Note:** this is a 24-clock setting i.e., 0-23 on the hour and 0-59 on the minute setting.

Note: Either Time Period can be disabled by setting the Suspend Hour and Minute equal to the Resume Hour and Minute.

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.

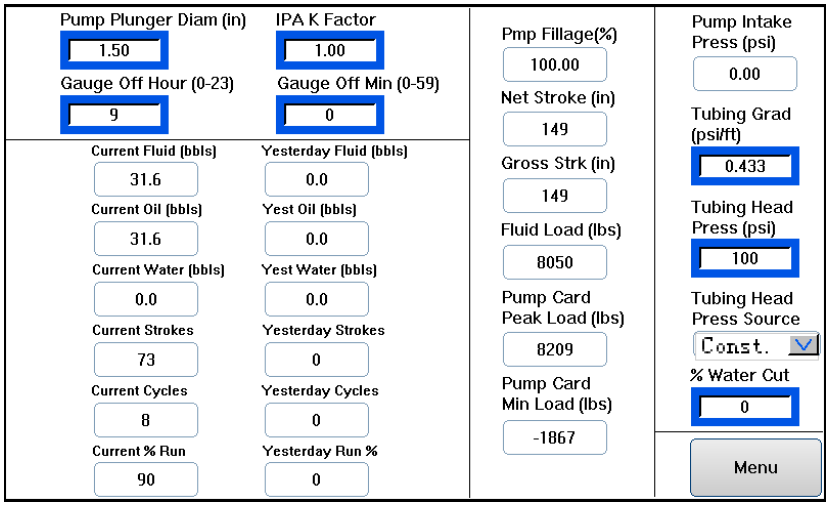

Figure 14 Inferred Production page

- **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.
- **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.
- **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

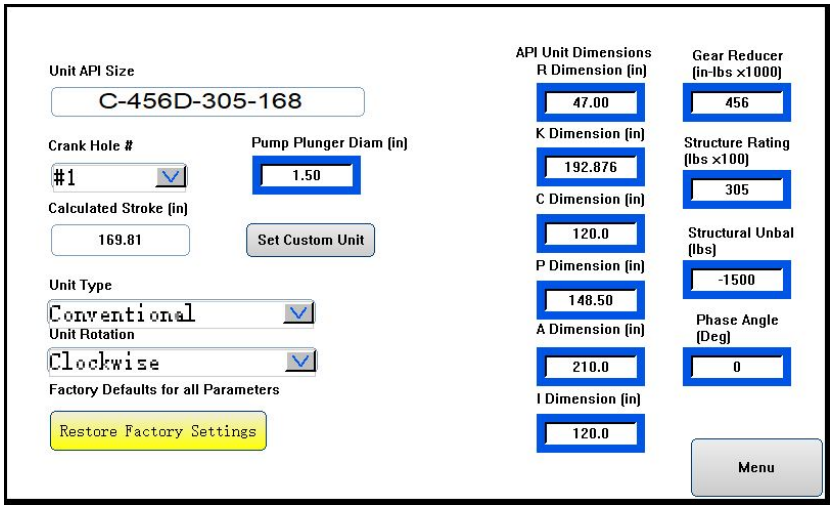

Figure 15 Pumping Unit Selection page

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 then 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.

The following can only be set in custom unit selection:

- **R Dimension** – The radius of crank arm in inches determined by crank hole number.
- **K Dimension** – The fixed distance between the crank arm center and the walking beam fixed pivot point.
- **C Dimension** – The distance between the walking beam fixed pivot point and the pitman arm connection to walking beam.
- **P Dimension** – The length of the pitman arm.
- **A Dimension** – Distance from front of horses head to the walking beam fixed pivot point.
- **I Dimension** – Horizontal Distance from the crank arm center to the walking beam fixed pivot point.
- **Gear Reducer** – The API Reducer # or rating of reducer in (in-lbs)/1000 ex: 456,000 is a 456.
- **Structure Rating** – The API Structure # or rating of structure in (lbs/100) ex: 30,500 is a 305.
- **Structural Unbal –** The structural unbalance in lbs of the unit for gear reducer load calculations.
- **Phase Angle –** The phase angle of the unit in degrees for gear reducer load calculations.

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.

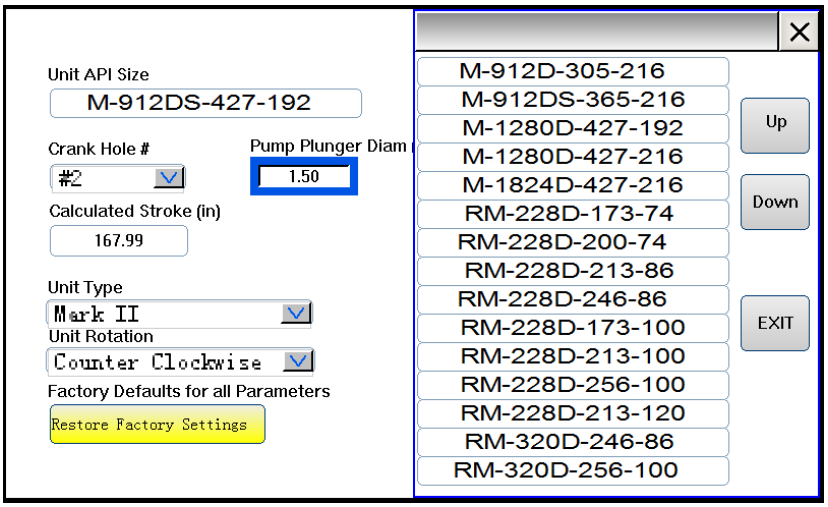

Figure 156 Pumping Unit Selection Page with Unit API Size window displayed

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. No 0 length taper is allowed between tapers. The **Buoyed Rod Weight** is the buoyant weight of the entire string in lbs.

Figure 17 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.
- **Unit Position Transducer Type** – The default setting is "Hall-Effect Xducers" for the typical motor rpm and crank arm sensors to calculate unit position. Selecting "Analog Position Inclinometer" allows for the use of an inclinometer on AI7 to calculate unit position. It is best if the inclinometer has a voltage output of at least 1 to 8 VDC or a max of 0 to 10VDC output.

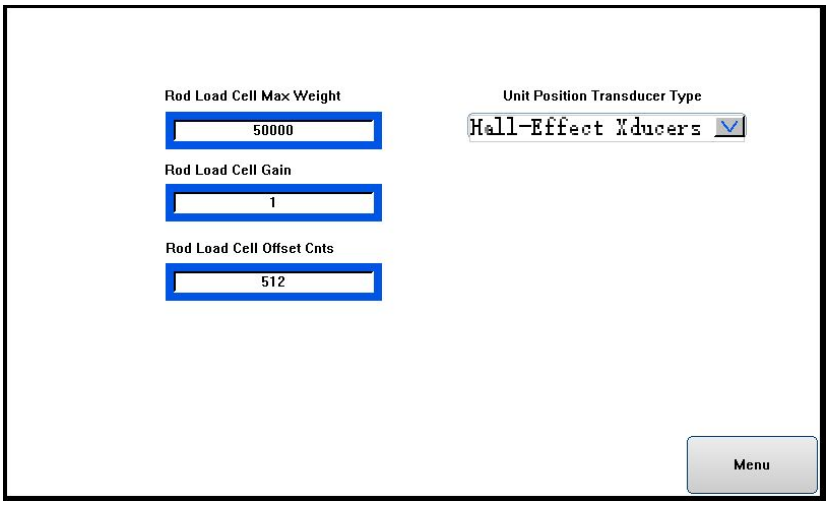

Figure 18 Rod Weight and Analog Scale Factors page

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.

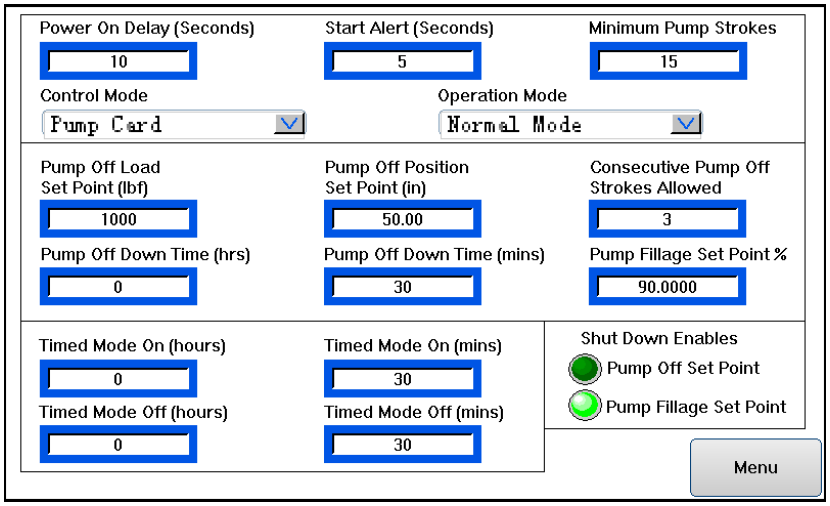

Figure 19 Pump Off Selection and Set-up page

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 stager 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:

Figure 20 Min / Max Rod Load Settings page

- **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.
- **Consec Strk Malf SP (cnt)** – This is the consecutive violations of the load malfunction set point.
- **Load Malf SP (lbs)** – This is load malfunction set point in lbs. If the peak load for the entire stroke is less than this setting the “Consec Strk Malf SP (cnt)” is incremented else it is reset.
- **Consec Malf SP Strokes Allowed** – This is the allowed number of consecutive strokes for “Load Malf SP violations before a “Malfunction Malfunction Setpoint” state is set. Setting this to 0 will disable the “Load Malfunction Set Point” function.

- **VFD Speed Load Limit Set Point** – Default is 60,000 lbs (disabled). Set this below the "**Peak Load Limit"** to have the VFD slow down if the present load is greater than the **"VFD Speed Load Limit Set Point"**.
- **VFD Speed Load Limit Gain** – Default is 0 %/FS-lbs (disabled). This how aggressive the speed reduction is in % speed reduced per pound over the **"VFD Speed Load Limit Set Point"**.

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:

VFD Min Spd Scale ≤ VFD Min Op Spd < VFD Max Op Spd ≤ VFD Max Spd Scale.

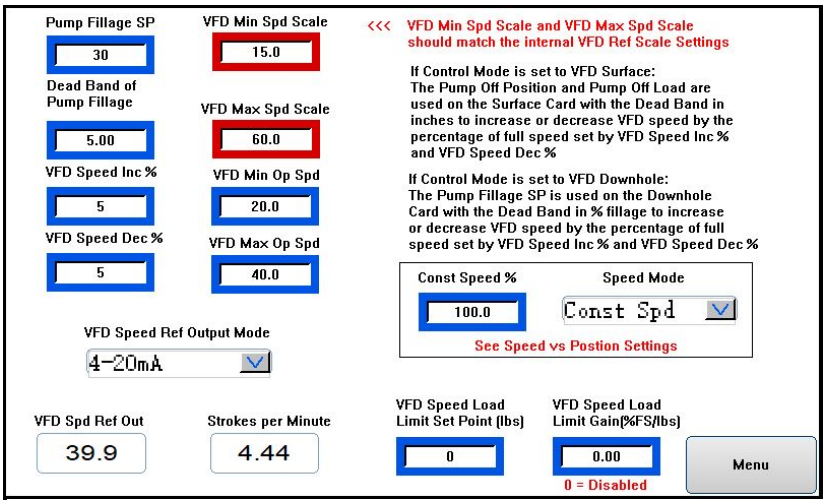

Figure 21 VFD Configuration page

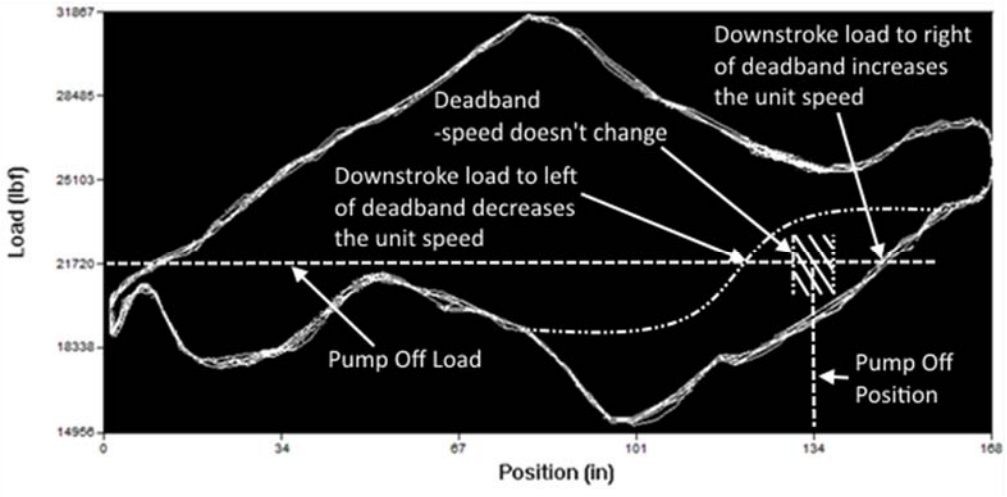

Figure 22 Deadband description for VFD Surface mode

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 ± 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 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 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.

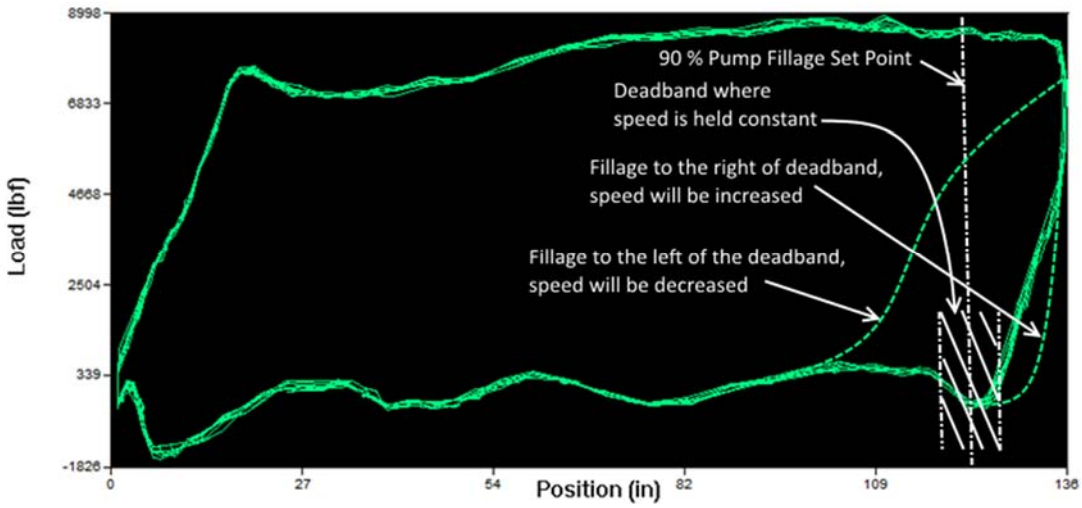

Figure 23 Deadband description for VFD Surface mode

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 ± 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**.**

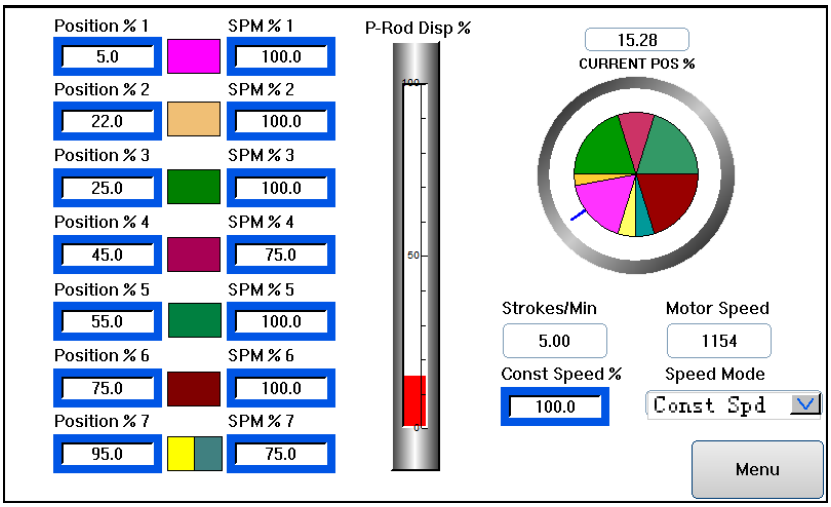

Figure 24 Speed Vs Position page

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%.

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.

- **Enabled / Disabled –** This will enable or disable the respective communication port. When disabled all received bytes on the communication port are stop by the transceiver.
- **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.
- **Received Bytes** – This is the number of received bytes since last reset or clear.

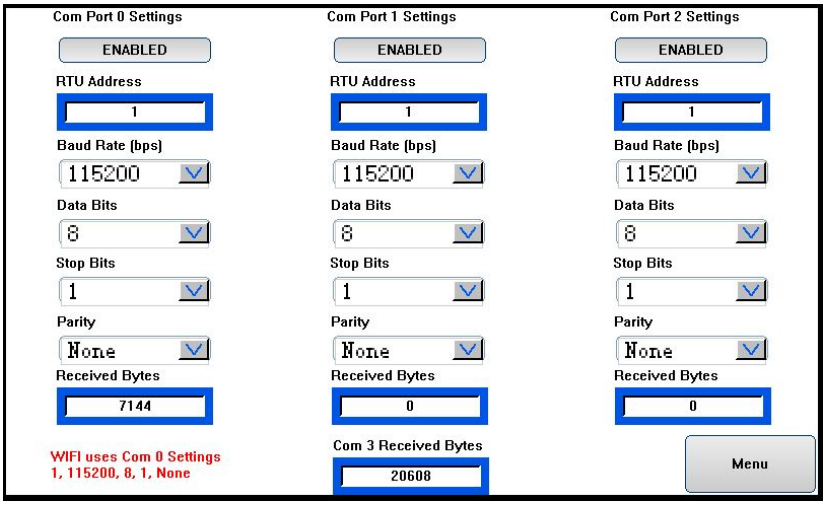

Figure 25 Communication Port Settings page

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 forth 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.

Figure 26 Analog Input Configuration page

Analog Input Fault Configuration

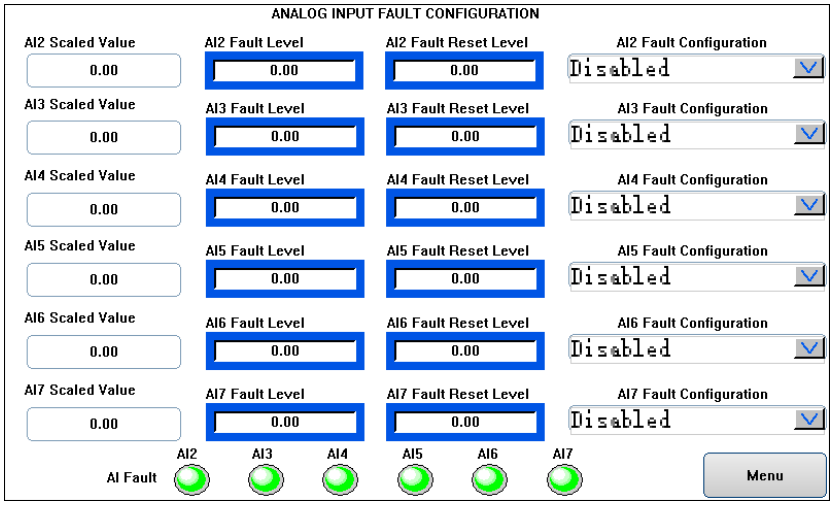

Figure 27 Analog Input Fault Configuration page

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 Fault Configuration

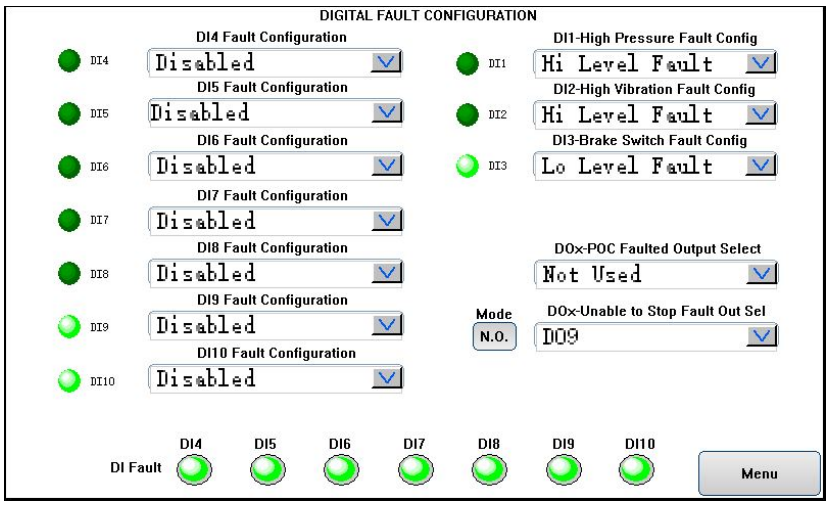

Figure 28 Digital Input Fault Configuration page

The Digital Fault Configuration page is used to set up the built-in faults (DI1-DI3) and user-defined faults (DI4-DI10) 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.

DOx-POC Faulted Output Select is used to turn on a digital output when the POC is down other than when in Downtime Pumpoff, Downtime Host, or Down Time Timed Mode. This allows the user to select DO5 – DO16.

DOx-Unable to Stop Fault Output Select is used to turn on (or off depending on the "Unable to Stop Mode Select") a digital output when the POC is faulted on the "Unable to Stop Fault". This allows the user to select DO5 – DO16.

Unable to Stop Fault Mode Select is used to make the associated Digital Output either NO-Normally Open or NC- Normally closed.

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.

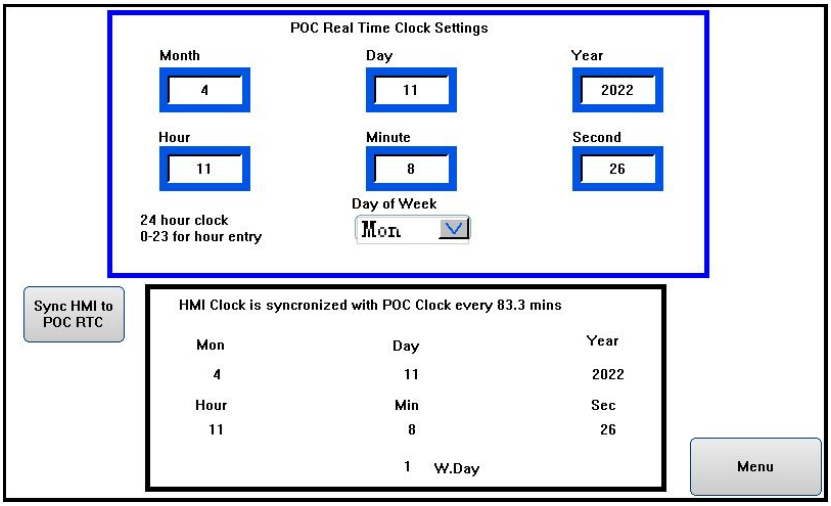

Figure 29 Time and Date page

Advanced Settings

The Advanced Settings are used to rotate a pump card that is tilted up or down. First the **Pump Card Rotation Correction Enable** must be enabled. The amount of rotation required to level the card is the slope of the card either positive or negative. The slope can be calculated from the pump card page. The amount of load difference from the 0 position to the full stroke position divided by full stroke is the rotation (slope) correction required to give a level card. The formula would be (load difference) / (pump stroke length). The Pump Card offset can be used to push the pump card up or down by the load amount entered into **Pump Card Rotation Correction Offset** in lbs. This can be a positive or negative number.

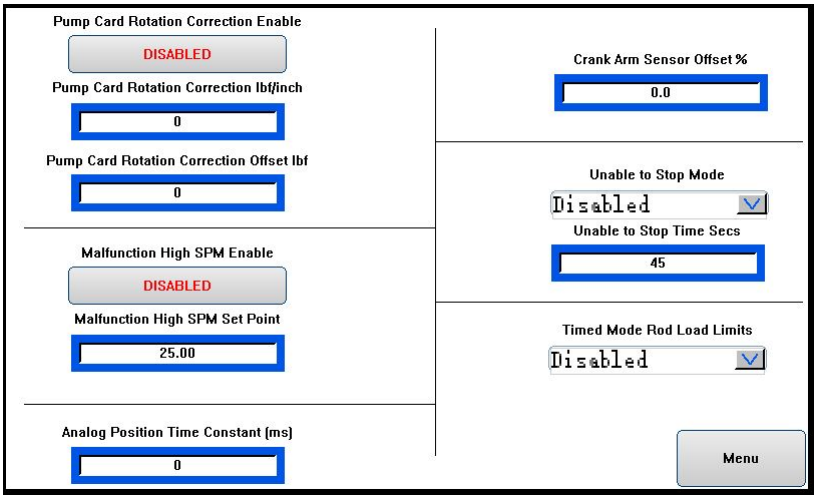

Figure 30 Advanced Settings

Crank Arm Sensor Offset % - is used to offset the crank arm hall effect sensor when it can not be placed exactly at the bottom of pumping unit stroke. The user can set the offset from -50.0% to 50.0%. The offset is positive if the sensor is offset before reaching bottom of stroke and negative if the sensor is after reaching bottom of stroke. This is direction dependent. This should only be used when safety reasons don't allow placing the Hall Effect sensor exactly at bottom of stroke.

Unable to Stop Mode – Selects the operation mode for the unable to stop function. The options are as follows:

- **Disabled –** Disables the unable to stop function.
- **Motor and Crank –** Enables the unable to stop function with the motor and crank arm sensors in conjunction to determine if the unit is stopped.
- **Motor Only –** Enables the Unable to stop function with the motor sensor only to determine if the unit is stopped.
- **Crank Only –** Enables the Unable to stop function with the crank arm sensor only to determine if the unit is stopped.

Unable to Stop Time Secs - Is used during the stopping state of the unit to give it time to come to a complete stop. The controller monitors the motor speed and/or crank arm DIs during the stopping state and if do DI is trigger for at least the last 10 secs of the "Unable to Stop Time" the controller will transition to the stopped state else it transitions to the Unable to Stop State. The minimum setting is 15 seconds and the maximum setting is 300 seconds.

Timed Mode Rod Load Limits – Is used to enable or disable the rod load limits in the "Timed Mode" Operation Mode. The default setting is disabled.

Malfunction High SPM Enable – Enables or Disables the "Malfunction High SPM" Shut-Down feature.

Malfunction High SPM Set Point – If the function is enabled and the SPM is greater than the "Malfunction High SPM Set Point" the system will set the "Malfunction High SPM" controller state and shut down immediately.

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.

If direction control (up stroke direction and down stroke direction) is required enable the **Direction Control** set the **Sprocket Radius** to 0, set the **Distance Between Sprockets** to the pumping unit stroke length in inches. The POC will calculate position from a top of stroke proximity sensor, bottom of stroke proximity sensor, and time. An example would be a hydraulic pumping unit.

Direction Control is intended to use a position sensor for the top and bottom of stroke indication. This is useful for a hydraulic or rack and pinion style pumping units. The direction control utilizes 2 digital outputs one for upstroke and one for down stroke control. The **Jog Up** and **Jog Down** buttons are used to move the unit up or down when **Direction Control** is enabled and the unit is in the **Stopped State**.

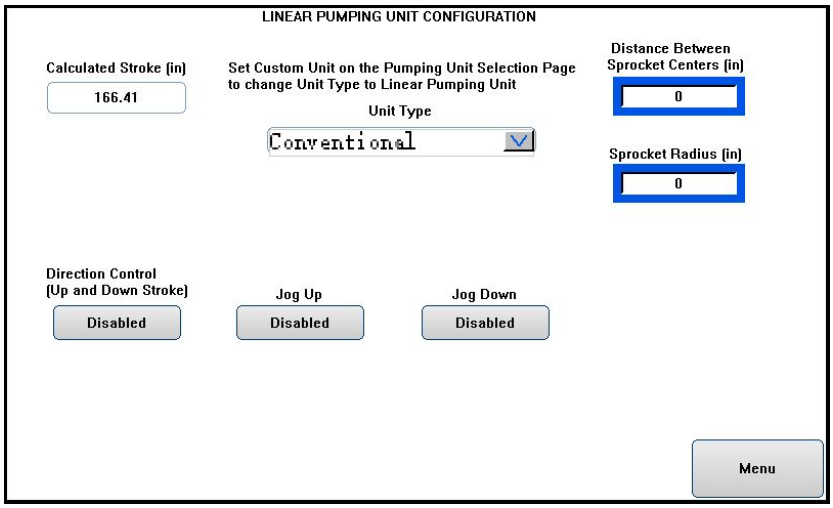

Figure 31 Linear Pumping Unit Configuration