Lufkin Well Manager™ 2.0

Rod Pump Controller

User Manual

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Section 1: General Information

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Manual Overview

This manual provides a complete description of the Lufkin Well Manager 2.0 system and the steps required for installing, wiring, and configuring this system.

Notes, Cautions, and Warnings

Notes, cautions, and warnings are used throughout this manual to provide readers with additional information, and to advise the reader to take specific action to protect personnel from potential injury or lethal conditions. They are also used to inform the reader of actions necessary to prevent equipment damage. Please pay close attention to these messages.

Notes

Notes provide useful information and tips that can make the operator’s job easier.

Cautions

The caution symbol indicates that potential damage to equipment or injury to personnel exists. Extreme care should be taken when performing operations or procedures preceded by this caution symbol.

Warnings

The warning symbol indicates a definite risk of equipment damage or danger to personnel. Failure to observe and follow proper procedures could result in serious or fatal injury to personnel, significant property loss, or significant equipment damage.

Illustrations and Photographs

The illustrations and photographs in this manual provide graphical examples of equipment and software screens. These examples are not intended to represent every possible situation and will vary in appearance to the actual equipment and screens.

Safety Guidelines

Caution: Only qualified service technicians should install, operate, or repair this system.

Observe the safety precautions listed below and all safety precautions provided throughout this manual. Following these precautions will protect you and others from injury or death and prevent equipment damage and environmental impact.

- Follow all customer safety guidelines.
- Park vehicles upwind of the wellhead. Stand upwind when installing or dismantling equipment.

Warning: Hydrogen sulfide gas (H2S) may be present in high concentrations. You must have proper H2S detection equipment with you and practice all recommended safety precautions when working around wellheads.

- Live or discharging electrical equipment poses an electrocution hazard. Read the following warnings before attempting any work around the controller enclosure:

Warning: Turn off power at the enclosure and follow proper lockout/tagout procedures before opening the controller enclosure. Failure to heed this warning can result in severe injury or death.

Warning: Capacitors can retain a lethal voltage up to 10 minutes after power has been shut off. While verifying locked-out equipment, you must allow sufficient time for complete discharge of capacitors.

Warning: If it is necessary to work on or around live electrical equipment, you must wear electrical hot gloves, a blast shield, and fire-retardant clothing in addition to regular PPE. Failure to do so could result in severe injury or death.

- Before leaving the location, return all wellhead equipment to normal operating positions.

Technical Support

Assistance is available when needed from Lufkin Automation Technical Support Services at (281) 495-1100, Monday through Friday, between 8:00 A.M. and 5:00 P.M., Central Standard Time.

To help us answer your question as quickly as possible, please have all information that applies to your problem readily available. Write down or print out any onscreen messages you get when the problem occurs, and have your manual with you when you call.

Section 2: System Overview

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Section Overview

This section describes the major components of the Lufkin Well Manager™ 2.0 rod pump controller system and their functions.

System Description

The Lufkin Well Manager™ 2.0 rod pump controller is a pre-programmed device mounted at the wellsite that gathers, processes, stores, and analyzes either analog data obtained from load and position transducers or digital data obtained from motor RPM and crank arm sensors. This controller uses the data from these input devices to monitor and control the operation of a pumping unit and to display graphic data on an LCD display or portable laptop computer in a format easy to understand.

Figure 2-1. Lufkin Well Manager 2.0 Rod Pump Controller

The Lufkin Well Manager (LWM) 2.0 rod pump controller receives information from the input devices to determine whether sufficient fluid is present in the well bore. If the control unit determines that the well is in a pumped off condition, the control unit turns off the motor control output to stop the pumping unit and places the pumping unit into a downtime mode. Downtime mode allows fluid to flow back into the well bore. After downtime elapses, the control unit turns on the motor control output to start the pumping unit again.

The LWM 2.0 controller also uses this information to detect malfunctions and problems with the pumping unit and the load and position input devices. Current information about pumping activity can be obtained on demand. Historical data at the wellsite can also be obtained at any time, and this data can be plotted and produced on reports.

Operation Modes

The LWM 2.0 controller has three rod pump control operation modes:

- **Host**: The controller starts and stops the pumping unit based on a user command. This mode is primarily intended for use with a SCADA system. A Host Mode Off global command can be issued by the SCADA program to shut down specific wells and keep them shut down until the operator decides to re-start them.

  In Host mode, a minimum control capability for peak and minimum load and for end device-checking is available.
- **Timed**: The controller cycles the pumping unit off and on for a user-programmed On Time and Off Time. This mode is used to temporarily continue cycling a well at an historical on/off pattern until repairs can be made to a faulty load or position input device.

  Timed mode also provides a minimum control capability for peak and minimum load and for end device-checking.
- **Normal**: This mode is “normally” the operating mode of choice, and can include the following features:
  - Primary control functions
  - Pump off control actions
  - Load and position options
  - Malfunction control functions

These normal operating mode features are described on the following pages.

Primary Control Functions

The basic purpose of the LWM 2.0 controller is to determine when the fluid level in the wellbore is pumped down to the point where pump intake pressure is no longer sufficient to completely fill the pump barrel with fluid during the upstroke. Incompletely filling the pump barrel reduces the efficiency of the pumping operation and the resulting “fluid pound” causes extra wear and tear on pumps, rods, tubing, and surface equipment.

The normal desire of an operator is to pump all of the fluid available, which typically results in the pumping unit system being designed with more lift capacity than required. Overcapacity will in time draw the fluid level down to the point where the pump is no longer completely filled and “fluid pound” occurs. This means the well is pumped off.

The LWM 2.0 controller can use one of two methods to detect a pumped-off condition:

- **Percent pump fillage**: This method is based on a downhole pump card using polished rod load and position inputs, and is the most accurate of the three methods. It is capable of controlling problem wells that surface control might have trouble evaluating. Accurate data for pumping unit dimensions and rod string design does need to be programmed in the controller. The downhole control selection also includes fluid load information.
- **Single setpoint control**: This method is based on a surface dynagraph card using polished rod load and position inputs, and is easier to use for simple well control. However, several factors make the surface dynagraph more difficult to analyze in some wells, and many of the more sophisticated analysis aids provided with the downhole control method are not available.

Pump Off Control Actions

When a pumped off condition is detected, the LWM 2.0 controller is capable of cycling off the well as needed. Downtime can be programmed by the operator based on experience or production tests.

Load and Position Input Options

The LWM 2.0 controller is designed to accept load and position data from a number of input devices. A polished rod load cell provides the load input. Position input is a digital signal from two Hall-Effect transducers, one sensing motor RPM and the other sensing the crank arm.

Any combination of load and position can be used, but there are preferred combinations for best results for the selected pump off control method. Some of the secondary malfunction type controls are not available with some combinations of inputs.

Refer to the section titled “Digital Transducers” on page 2-21 for details on these input devices.

Malfunction Control Functions

The LWM 2.0 controller performs many secondary control functions to detect pumping equipment malfunction and to help protect equipment against further damage in the event of an equipment failure. The LWM 2.0 controller also checks for malfunctioning signal input devices.

The LWM 2.0 controller allows for a programmable number of re-tries when a malfunction event occurs. On the first occurrence, the LWM 2.0 controller shuts off the pumping unit for the programmed downtime, and then re-tries by starting the pumping unit again. If the condition has cleared, the LWM 2.0 controller clears the consecutive count and continues with usual operation. If the condition continues for the programmed number of re-tries, the LWM 2.0 controller shuts down the pumping unit in a malfunction state that requires the operator to solve the problem and return the pumping system to a pumping state. Malfunction control features can be individually enabled or disabled. The malfunction controls include:

- **Malfunction Setpoint**: Shuts down the well if surface load on the upstroke falls below the Malfunction setpoint for the programmed number of consecutive strokes. Pumping equipment failures are detected, such as rod parts or the traveling valve not closing. Load and position inputs are required.
- **Peak Load**: Shuts down the well if the polished rod load exceeds an allowed peak load. Requires load input.
- **Minimum Load**: Shuts down the well if the polished rod load falls below a allowed minimum load. A load input is required.
- **Low Motor RPM**: The LWM 2.0 controller will shut down the pumping unit if the measured motor RPM drops below an allowed low limit. This feature provides protection against stuck pump conditions with quicker response than peak load detection. A Hall-Effect position input is required.
- **No Crank**: Detects the loss of the crank arm Hall-Effect switch input. Without this input, the LWM 2.0 controller has very limited capabilities, so this is treated as a malfunction condition to call operator attention to the need for repairs. This function is only available with the Hall-Effect position input.
- **No RPM**: Detects the loss of the motor RPM Hall-Effect switch input. Without this input, the LWM 2.0 controller has very limited capabilities, so this is treated as a malfunction condition to call operator attention to the need for repairs. It is only available with the Hall-Effect position input.

- **Belt Slippage**: The LWM 2.0 controller counts the number of motor revolutions each pump stroke. If that number rises above a set reference by more than an allowed percentage, an alarm flag is set to alert the operator to possible belt slippage. No control action is taken. A Hall-Effect position input is required.
- **Peak Torque**: Shuts down the well if the calculated maximum torque for a stroke exceeds the allowed limit. The LWM 2.0 controller calculates torque from a speed/torque curve for the pumping unit prime mover and digital inputs for motor shaft RPM and crank arm cycles. A Hall-Effect position input is required. It is available with either surface or downhole control method.
- **Peak PRHP (Polished Rod Horsepower) Limit (lbs)**: When this value exceeds the allowed limit, the controller sets an alert flag to advise the operator that a paraffin treatment may be required. This value is a high limit.

See “Operational Limits Configuration” on page 8-25 for information on configuring these setpoints.

Communication Protocol

The LWM 2.0 RPC uses Modbus-based communications protocol, and also offers the advantages of the Extended Lufkin Automation Modbus (ELAM) protocol for SCADA software packages that goes beyond the limitations of conventional Modbus.

All of the configuration, status, and historical data available at the local keypad interface are also available via data telemetry link to SCADA software.

Operator Interface

Several parameters need to be defined to program the LWM 2.0. Programming is done through the local operator interface, which consists of a full-function LCD graphics display and 32-key keypad. This operator interface is menu-driven.

Figure 2-2. Operator Interface

Keypad

The 32-key keypad shown in Figure 2-2 is mounted on the front of the controller’s enclosure. It allows the operator to program and calibrate the controller and access a large amount of well data.

The following table shows a description of each key’s function on the keypad.

Keypad Functions

Item	Function
Function Buttons	These buttons control the screen functions displayed on the sides and bottom of the screens.
F1 – F5	These buttons control the menu functions displayed on the bottom of every screen.
SOP and ERR lamps	These lamps are not used in this system.
0 – 9	The numerical buttons are used to input parameter values on the programming screens.

Keypad Functions (Continued)

Item	Function
ALT	This button is not used in this release.
MENU	Displays the Main Menu screen.
?	This button displays help messages associated with the active screen. (These will be available in a later release.)
Arrow Keys	Press these buttons to change setpoint position or cursor location in the direction specified by the arrow key. They can also be used to scroll available options in several programming screen fields. The alternate commands (HOME, BACK, AND FWD) are not used in this release.
ENTER	Confirms a correct entry when changing programming data. When this key is pressed, data is updated.
DEL	Voids an incorrect numerical entry if **<ENTER>** is not pressed.
ESC	Displays the previously displayed menu. Cancels any changes made on the current screen if **<ENTER>** is not pressed.

LCD Display

The LWM 2.0 user interface is menu-driven. All menus and screens are shown on the LCD display.

The Main Menu screen (Figure 2-3) is the first screen that appears after the controller is turned on and the initialization process is completed. This screen can be accessed from any screen by pressing the **Main Menu** button.

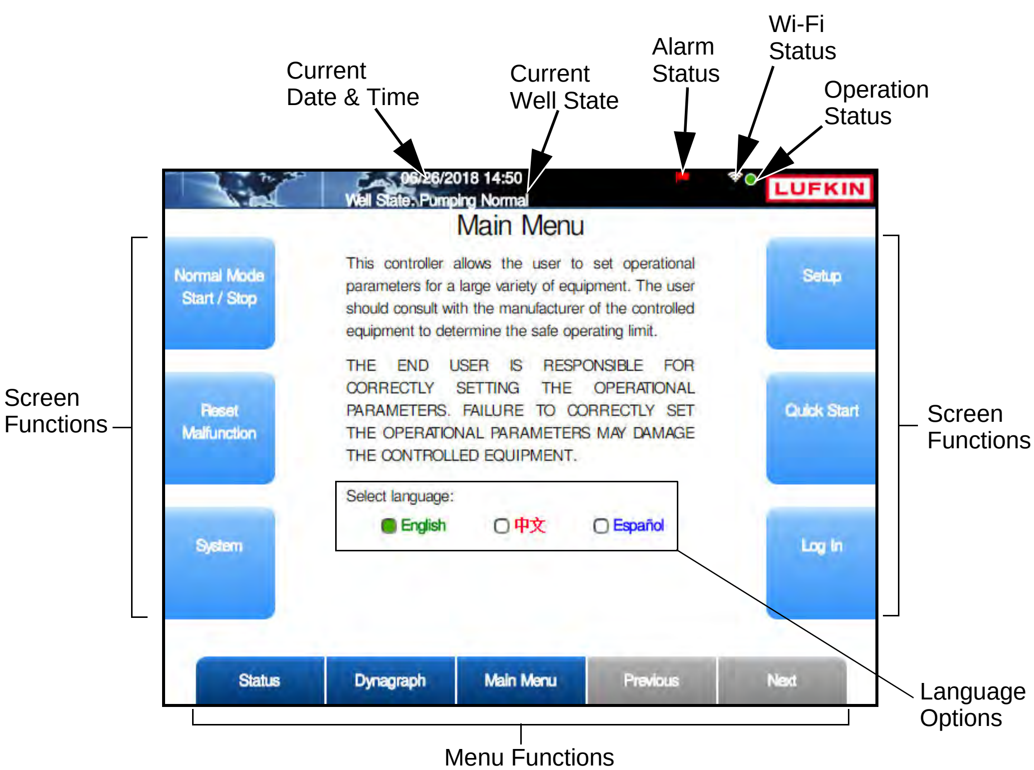


Figure 2-3. Main Menu Screen

Status Information

The following system status information is displayed at the top of every screen:

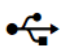
- Current date and time
- Current well state of the controller

Note: Refer to “Well State Descriptions” on page 12-4 for more information about each well state.

- Alarm Status: This icon indicates an active alarm condition.
- Wi-Fi Enabled: This icon indicates that the Wi-Fi network is active.
- Operation Status: This icon indicates the current operation status of the pumping unit:
  - Green (Blinking): Indicates normal pumping operation.
  - Amber: Indicates a downtime well state.
  - Red: Indicates a system malfunction.

Additional icons may be visible during certain situations. These are listed in the table below.

Additional Status Icons

Icon	Description
	This icon indicates a USB logging session is in progress. (Displayed in white.)
	Indicates an alert condition is present. (Displayed in yellow.)
ALT	Indicates that the alternate keypad characters are enabled.
BYP	Indicates that the VSD inverter has been bypassed.

Buttons

The buttons at the bottom of the screen provide access to the top level menu screens. These buttons are available on every screen.

The buttons on the sides of the screen provide access to specific screen functions and additional screens.

Language Selection

The LWM 2.0 screens can be displayed in three different languages:

- English
- Chinese
- Spanish

To change the screen language, use the left or right arrow keys to select the desired language and then press <**ENTER**>.

Control Parameter Programming

Control parameters are edited (programmed) on a data field basis. To program a parameter, press the arrow keys to highlight the desired parameter field, press <**ENTER**>, and then choose one of the following methods:

- To select an option from a drop-down list, use the arrow keys to highlight the desired option and then press <**ENTER**> again.
- When the parameter is a numerical entry, use the number keys to enter the desired value and then press <**ENTER**> again.

When parameter values are changed, the green **Discard** and **Save** buttons will appear at the bottom of the screen as shown in Figure 2-4.

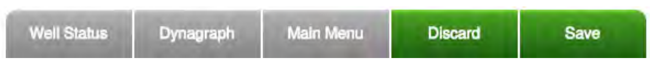


Figure 2-4. Menu Bar with Discard and Save Buttons

Press the **Save** button to save the programming change or the **Discard** button to discard the change. The **Discard** and **Save** buttons will then be replaced with the **Previous** and **Next** buttons.

After all parameters are correctly programmed on the screen, you can do either of the following to exit from the screen:

- Press the **Main Menu** button to return to the Main Menu screen.
- Press <**Esc**> to move up one level in the menu tree.

Mobile Display Options

The LWM 2.0 controller provides options for viewing controller data on other devices such as laptop computers, smartphones, or tablets. Instructions for connecting these devices are discussed below.

Laptop Computers

Laptop computers can connect to the LWM 2.0 controller using an Ethernet cable or Wi-Fi. Once connected, the user can view and make changes to the controller screens with a compatible Internet browser.

Note: The LWM 2.0 controller screens are best viewed using the Google Chrome browser.

Connecting a Single Laptop through Ethernet

To connect a single laptop computer using an Ethernet cable, perform the following steps:

1. Plug the Ethernet cable into the Ethernet port on the front of the controller.
2. Plug the other end of the cable into the Ethernet port on the computer.
3. Open an Internet browser window and type **172.16.0.2/index.php** into the location field. (This is the default Ethernet IP address of the controller.)

   The controller's Main Menu screen should appear as shown in Figure 2-5.

Figure 2-5. Main Menu Screen

Connecting Two Laptops through Ethernet

The LWM 2.0 controller has additional Ethernet ports available on the communication gateway module inside the enclosure. These ports can be used for connecting two laptop computers to the controller.

If more than one laptop computer is connected to the controller, each computer must have a different IP address. Perform the following steps to change one computer's IP address:

1. Click **Start→Control Panel** to display the Control Panel window shown in Figure 2-6.

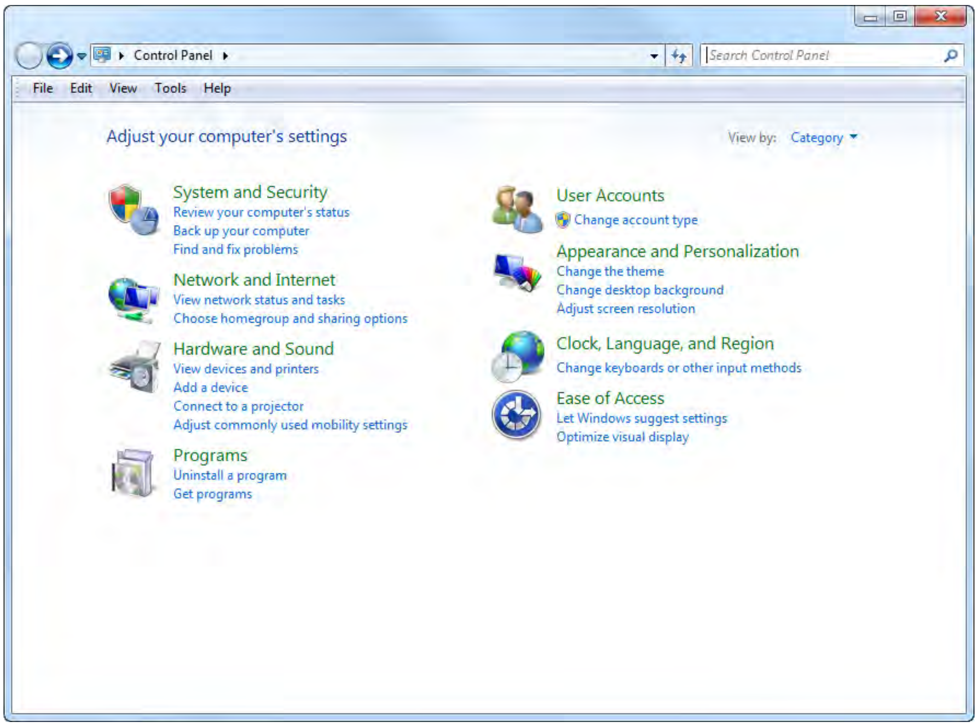


Figure 2-6. Control Panel Window

2. In the Control Panel window, click the **View network status and tasks** link to display the Network and Sharing Center window shown in Figure 2-7.

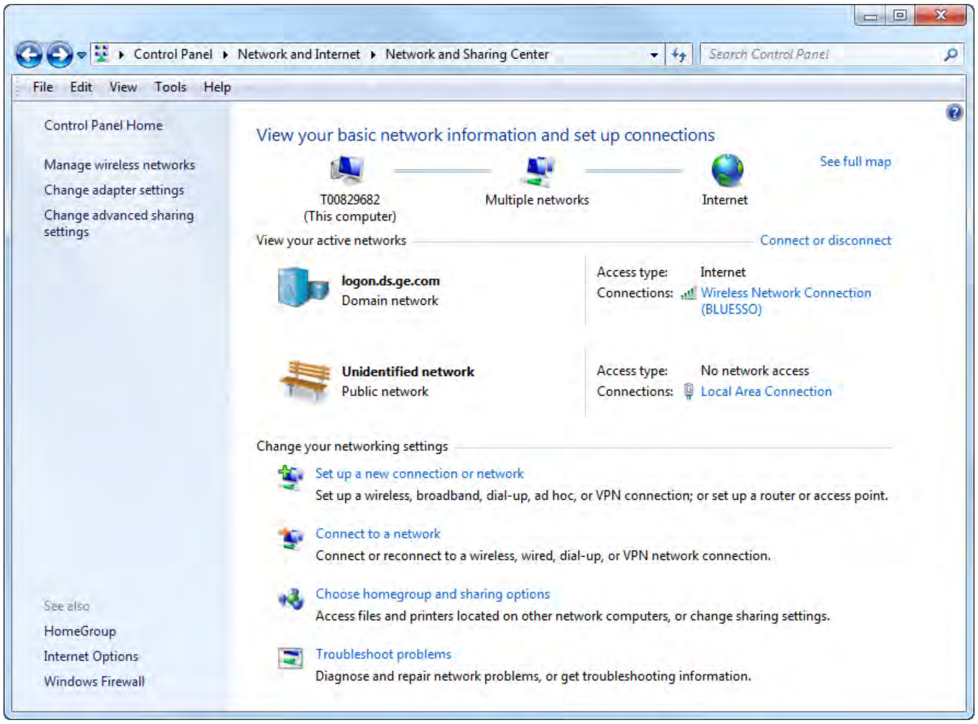


Figure 2-7. Network and Sharing Center Window

3. The Ethernet connection to the controller will be labeled as *Unidentified Network*. Click the **Local Area Connection** link next to this label to display the Local Area Connection Status window shown in Figure 2-8.

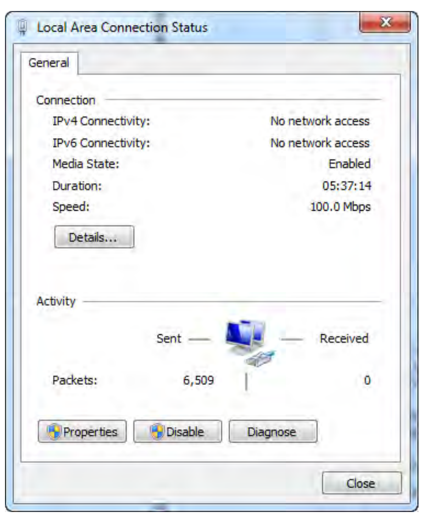


Figure 2-8. Local Area Connection Status Window

4. In the Local Area Connection Status window, click **Properties** to display the Local Area Connection Properties window shown in Figure 2-9.

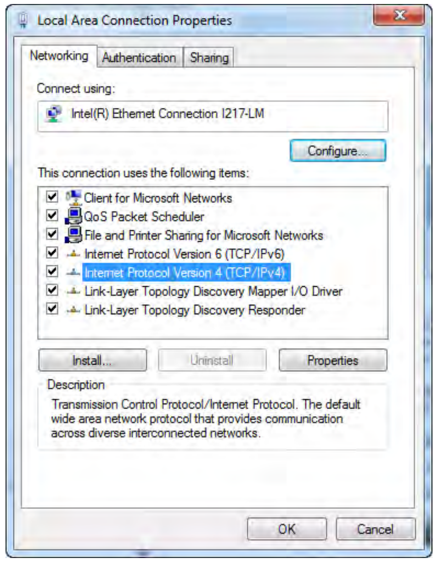


Figure 2-9. Local Area Connection Properties Window

5. In the Local Area Connection Properties window, click **Internet Protocol Version 4 (TCP/IPv4)** and then click **Properties**.

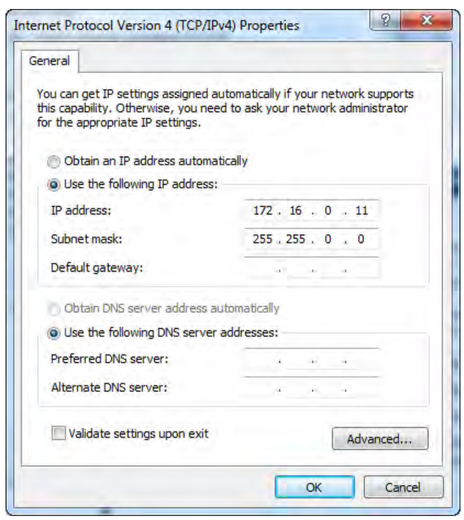


Figure 2-10. Internet Protocol Version 4 (TCP/IPv4) Properties Window

6. In the window that appears, double-click the last two digits in the IP address field. Type a different value in this field and then click **OK**.
7. Click **OK** to close the Local Area Connection Properties window.
8. Click **Close** to close the Local Area Connection Status window.
9. Close the Network and Sharing Center window.

Connecting a Laptop Computer through Wi-Fi

To connect a laptop computer using Wi-Fi, perform the following steps:

Note: These instructions assume that the laptop computer is using a Windows 7 operating system or later.

1. Click the network symbol in the lower right corner of the computer screen as shown below.

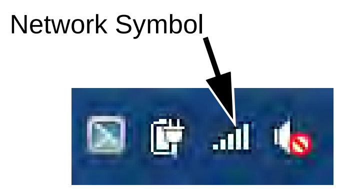


Figure 2-11. Windows Network Symbol

2. In the pop-up window that appears, click the SSID for your controller and then click **Connect**.

Figure 2-12. Available Wi-Fi Network List Window

Note: To automatically connect to the controller whenever it is in range, keep the **Connect automatically** box checked. Otherwise, uncheck this box.

3. In the window that appears next, type the network key and then click **OK**.

Figure 2-13. Network Security Key Pop-Up Window

The network connection is established after a few seconds.

4. Open an Internet browser window and type **192.168.102.15/index.php** into the location field. (This is the default Wi-Fi IP address of the controller.)

   The controller's Main Menu screen should appear as shown in Figure 2-5 on page 2-11.

Smartphones and Tablets

To connect a mobile device such as a smartphone or a tablet, perform the following steps:

Apple Devices

1. Tap the **Settings** icon to open the Settings screen.
2. Tap the **Wi-Fi** icon to open the Wi-Fi screen.
3. Tap the **Wi-Fi** toggle switch to turn on Wi-Fi and then select the SSID for your controller from the **Choose a Network** list.
4. Type the controller's Wi-Fi password and then press **Connect**.
5. After the connection has been established, tap the **Safari** icon and type **192.168.102.15/index.php** into the Location field. The Main Menu screen will be displayed on the screen.

Android Devices

1. Tap the **Wi-Fi** button to open the Wi-Fi screen.
2. From the list of available networks, tap the SSID for your controller.
3. Type the controller's Wi-Fi password and then press **Connect**.
4. After the connection has been established, open a browser window and type **192.168.102.15/index.php** into the Location field. The Main Menu screen will be displayed on the screen.

Internal System Components

The internal system components in the LWM 2.0 controller are as follows:

- Communication Gateway Module
- Controller Module
- HMI Module
- Remote communication device (optional)
- Power Supply
- Terminal Blocks

Figure 2-14 shows the location of these components.

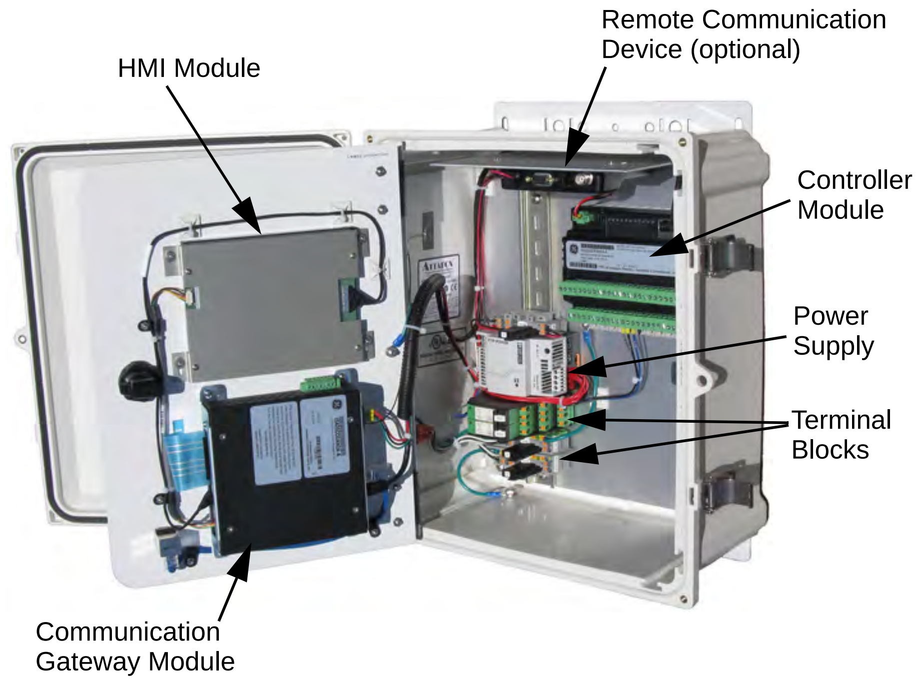


Figure 2-14. LWM 2.0 Controller Internal Components

These components are discussed in the following paragraphs.

Communication Gateway

The Communication Gateway Module (GE Part # IS420CCGAH2A-A), mounted on the door inside the LWM 2.0 controller enclosure, is a Remote Terminal Unit (RTU) that provides communication options for the Modbus devices used in this system. This module relays all keypad and SCADA commands to the controller module through a dedicated Ethernet port (ENET0) and displays the controller data on the HMI screen. (See “Controller Module” on page 2-19 for details on the controller module.)

Figure 2-15. Communication Gateway Module

The communication gateway module also has the following connectivity options:

- One USB port
- One MicroSD Card slot
- Four Ethernet ports
- One RS232 serial port
- One RS485 serial port
- Built-in Wi-Fi router
- Remote communication device (Not available in this release.)

Refer to the *CCGA Communication Gateway Instructions for GE Lufkin* document (GE Document # GEK-SA-1045) for details on this module.

Controller Module

The controller module is a GE Mark* VIe UCPA controller platform (GE Part # IS420UCPAH2A-A) that runs the control logic functions for the pumping system. This module has both integral I/O capabilities and can communicate with external I/O packs through a simplex I/O network. The UCPA controller is mounted on the back panel inside the LWM 2.0 enclosure.

Figure 2-16 shows the controller module.

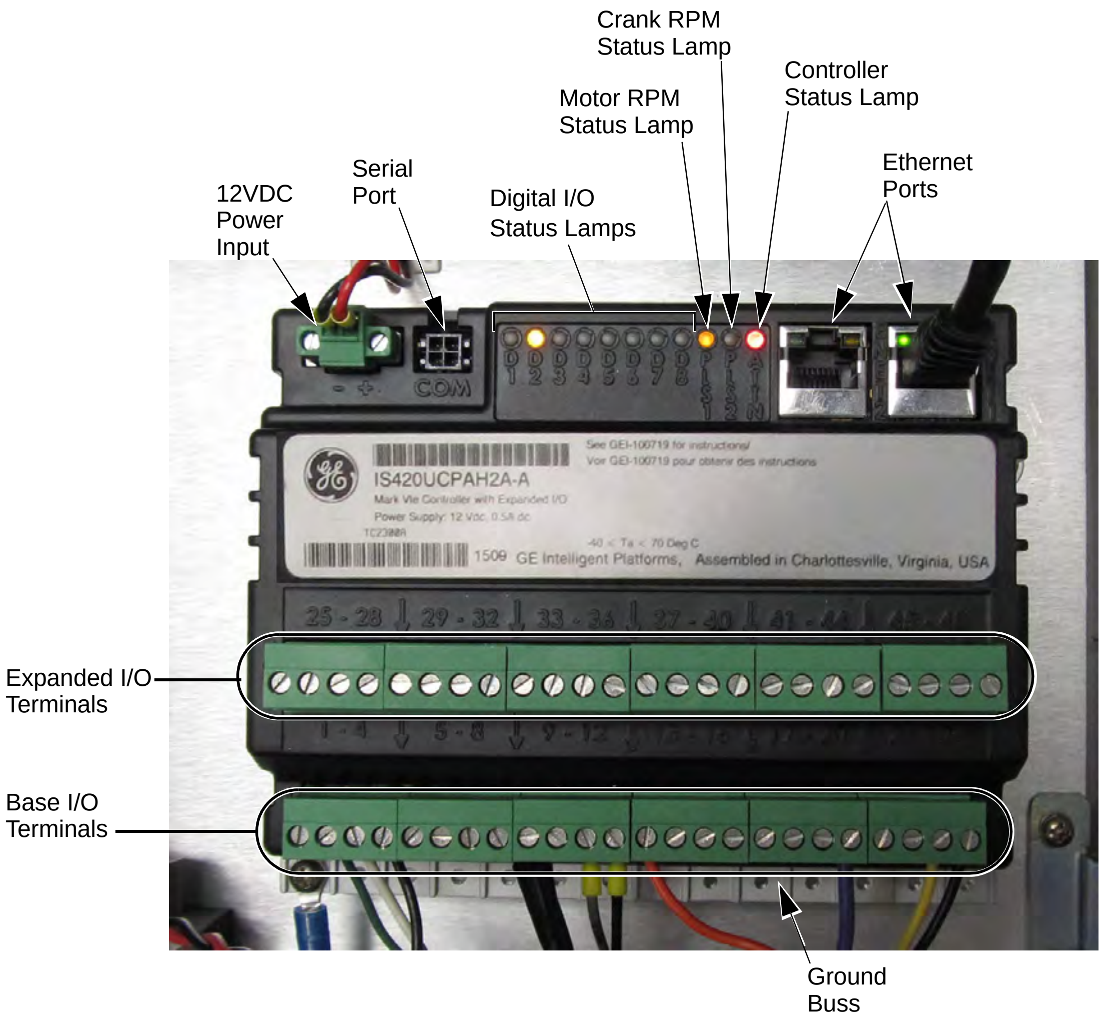


Figure 2-16. Controller Module

The components of this module are described below:

- **12VDC Power Input**: Power is supplied to the controller at this input.
- **Serial Port**: This port is for Engineering use only.
- **Digital I/O Status Lamps**: These lamps indicate the status of each digital input/output channel. The default assignments for each channel are as follows:
  - **D1** – Indicates the MCC (Motor Control Center) is active.
  - **D2** – Indicates a hardware fault has occurred.
  - **D3** – Indicates a motor start alert.

- **D4** – Indicates a malfunction error in the pumping system.
- **D5** – Indicates the HOA switch is in Hand position.
- **D6** – Indicates the HOA switch is in Auto position.
- **D7** – Indicates an ESD (Emergency Shutdown) has occurred.
- **D8** – Not used

These channel assignments can be disabled and reassigned to other digital input/output devices as needed.

- **PLS1 (Pulse 1)**: This is the Motor RPM status lamp. It blinks rapidly when a signal is being received from the Hall-Effect transducer mounted on the motor shaft.
- **PLS2 (Pulse 2)**: This is the Crank RPM status lamp. It blinks rapidly when a signal is being received from the Hall-Effect transducer mounted on the crank arm speed.
- **ATTN**: This is the controller status lamp. It indicates the status of the controller's processor during operation. When no problems are detected, this lamp flashes green during normal operation. When a problem is detected, the lamp flashes red.
- **Ethernet Ports**: These ports are used to connect the controller module with other system components (such as the communication module).
- **Base I/O Terminals**: These terminals are used for connecting the pumping system's main digital input/output devices.
- **Expanded I/O Terminals**: These terminals provide additional inputs for connecting other system input/output devices.
- **Ground Buss**: Used as a ground point for all input/output devices.

Refer to the *Mark* VIe Controller UCPA Instruction Guide* (GE Document # GEI-100719) for more details on this controller module.

HMI Module

This module connects the LCD display and keypad to the communication gateway module. See "Operator Interface" on page 2-7 for more information on the LCD display and keypad.

Power Supply

All LWM 2.0 controllers use a power supply for converting AC power to 12VDC power. This power supply has an input range of 100 – 240VAC, 50/60 Hz, and 240W.

Terminal Blocks

Terminal blocks are provided for field termination of all transmitter leads, including individual shield termination points. The terminal blocks are front-access compression-clip type, so the field leads do not require crimp lugs.

Digital Transducers

The LWM 2.0 controller is designed to work with input signals for polished rod load and surface stroke position. The polished rod load cell and Hall-Effect transducer combination is preferred for downhole percent fillage control and in-depth analysis of the pump cards when accurate surface dynagraph data needs to be obtained.

These transducers are discussed below.

Polished Rod Load Cell

The polished rod load cell (PRLC) is a load input transducer that is used to measure the polished rod load. A low-level load signal is generated by the PRLC and transmitted through a cable to the controller. In the LWM 2.0 controller, the load signal is amplified and conditioned for use.

The PRLC provides a quantitative measurement of the load on the rod string. It is mounted on top of the carrier bar under the rod clamp. The PRLC directly measures the weight of the rod string and fluid column on the pump plunger. A spherical washer set between the PRLC and the carrier bar ensures concentric loading even if the carrier bar is tilted. It is available in full load ratings of 30K or 50K pounds. It is the most accurate of the two load options and requires no field calibration during installation. Disadvantages are that a long working loop is required for the signal cable, damage to the device by service crews is possible, and loss of accuracy due to fluid pound or floating rods is possible.

Hall-Effect Transducers

Hall-Effect transducers are magnetic sensors that sense the passage of magnets mounted on the motor shaft and the pumping unit crank arm. The LWM 2.0 controller uses these two digital inputs and pumping unit dimension data to calculate polished rod position.

Two Hall-Effect transducers are used in this system. One transducer measures precise motor speed and the second transducer marks the crank arm passage at the bottom of each stroke. These two digital signals, coupled with user-entered precise pumping unit dimensional data, allow the controller to accurately calculate surface stroke position. As additional advantages, they can monitor for belt slippage, and instantaneously shut down the pumping unit when a “locked rotor” equipment failure occurs. Their disadvantages are that proper alignment must be maintained between the sensor and magnets, and pumping unit dimensional data must be entered during installation and commissioning.

Section 3: Technical Specifications

This page is intentionally blank.

Section Overview

This section lists all the technical specifications for the Lufkin Well Manager Field Controller.

Enclosure

The enclosure specifications are listed below:

Enclosure Type:	NEMA4X polycarbon or steel enclosure, hinged door with lockable hasp.
Height:	16.63 inch (42.2 cm)
Width:	13.41 inch (34.1 cm)
Depth:	7.4 inch (18.8 cm)
Weight:	Approximately 22 lbs (10 kg) including controller, operator interface, and data radio

Caution: The Lufkin Well Manager 2.0 controller is not rated for hazardous area use.

Environmental Operating Range

The Lufkin Well Manager 2.0's environmental operating range is as follows:

Operating Temperature:	-40° to +158° F (-40° to +70° C) without optional LCD. With LCD, de-rate the maximum to +140° F (+60° C).
Humidity:	95% non-condensing

Power Requirements

Primary power to the switching power supply:	100 to 240VAC, 50/60 Hz.
Power supply:	Rated for 240 Watts continuous.
Fuse AC input line:	3.15 amps, Slo-Blo

Communication Gateway and HMI

Processor	TI AM3354 32-bit ARM processor, 600MHz
Memory	512MB DDR3 RAM
	1GB on-board flash
Temperature/Humidity Rating	-40°C to +70°C, 5 TO 95% non-conductive
Battery backup	Battery backup for RTC, 6 yrs
External Memory Storage	1 USB port
	1 MicroSD Card Slot for firmware upgrade, configuration downloading and uploading event records
Connectivity	4 Ethernet ports, 10/100 Mbps
	1 RS232 Serial Port (RJ12)
	1 RS485 Serial Port (pluggable screw terminal)
	Serial Protocols: Modbus master/slave RTU
	Ethernet protocols: Modbus TCP client/server, EGD
	Wireless options: Wifi, 3G CMDA/GSM via mPCIe site.
Software	Gateway Configuration: ControlST/Toolbox ST
	Operating System: Embedded Linux (Well Manager / Comm Gateway)
LCD / Keypad Support	Supports Lufkin 640x480 TFT Display (LT065AC57500 or equiv)
	Lufkin custom keypad for LWM 2.0 controller
Power requirements	Operating voltage: 9V – 16V DC, nominal 12V DC
	Power consumption: 12.2 Watts (estimated)
Dimensions	158mm X 137mm X 34mm
Mounting	Base Mount

Mark VIe GP Controller with Local I/O

Processor	Freescale 3308 processor, 332 MHz, (BPPC based controller)
Memory	64 MB RAM
	256 MB on-board flash
	32 KB NVRAM
Temperature/Humidity Rating	-40° C to +70° C, 5 TO 95% non-conductive
Connectivity	2 Ethernet ports, 10/100 Mbps, Enet1 for UDH, Enet2 for IONet IO expansion
	Ethernet protocols: EGD, Modbus TCP slave, NTP Server
Software	Controller Configuration: ControlST/Toolbox ST
	Operating System: QNX (Mark VIe Controller)
Discrete inputs/outputs (DIO)	Up to 8 DIOs. Four 12VDC digital inputs or digital outputs on base controller and four additional 12VDC digital inputs or digital outputs with option expansion IO board. 4-16V IO (4Vmin for input hi, 1Vmax for input lo, 16VDC max in). Up to 500mA sink on Digital Outputs. Accumulates counts, frequency up to 500Hz.
Analog Inputs (AI)	2 Analog Inputs in base controller
	Programmable Gain: 1 to 128
	Voltage In: 0V to 5V gain 1. -39mV to 39mV gain 128.
	Current (option Channel 2): 0 to 20mA, 4 to 20mA
	Accuracy: 0.1% of full range
	6 additional Analog Inputs on option expansion board
	Voltage In: 0V to 5V, fixed gain 1.
	Current (option channels 6, 7, & 8): 0 to 20mA, 4 to 20mA
	Accuracy: 0.1% of full range
Analog Outputs (AO)	2 Analog Outputs on Controller optional expansion board
	Voltage: 0 to 10V
	Current: 0 to 20mA, 4 to 20mA
	Accuracy: 0.3% of full range
Pulse inputs	2 Pulse Inputs
	20mA sink current required, 5V DC source provided (for Hall Effect sensor)
	Accumulates counts & measures Time between pulses, frequency up to 1kHz
Expansion I/Os	Expansion IO via Mark VIe I/O packs and I/O Net. Options include Contact Input, Contact Output, Analog IO, Thermocouple, and RTD.
SOE	No
Power requirements	Operating voltage: 9V – 16V DC, nominal 12V DC
	Power consumption: 4 watts
Dimensions	162 mm X 115 mm X 72 mm
Mounting	Base Mount, option to add Din Rail Mounting

Certifications

The following certifications are current as of November, 2015:

- Conforms to UL STD 508A certified to CSA STD C22.2 No. 14

  (Certified by Intertek/ETL C/US under Right to Mark 3188006)
- RoHS 2 directive (2011/65/EU) compliant
- Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC Compliant
- NEMA 4 Enclosure: NEMA 4X Polycarbonate
- IEC61010-1 US/CAN: This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:
  - This device may not cause harmful interference.
  - This device must accept any interference received, including interference that may cause undesired operation.
- Wi-Fi equipped controllers:
  - Contains Transmitter Module FCC ID: TFB-TIWI1-01
  - Contains Transmitter Module IC: 5969A-TIWI101

Note: This device may be used in mobile-only configurations in which the antennas used for this transmitter must be installed to provide a separation distance of at least 20 cm from all personnel and not be co-located with any other transmitters except in accordance with FCC and Industry Canada multi-transmitter product procedures.

Section 4: Installation and Wiring

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Section Overview

The Lufkin Well Manager 2.0 system is typically installed inside the power unit enclosure supplied by Lufkin Automation. In case the system requires a separate installation (such as a retrofit), this section provides installation instructions for the Lufkin Well Manager 2.0 system.

Warning: This system should only be installed by a qualified technician who has experience working with the motor control box and its high-voltage circuits.

System Components

A Lufkin Well Manager 2.0 system installation includes the following system components:

- Lufkin Well Manager 2.0 controller
- Telemetry system (optional)
- Mounting post
- Motor control relay
- Auto default relay (optional)
- Start Alert safety device (optional)
- Stepdown transformer
- Load and position transducers
- Ground rod

Site Selection

When selecting a site for installing the Lufkin Well Manager 2.0 system, keep the following conditions in mind:

- Mount the controller in a location near the pumping system so that it can be easily accessed by the operator.
- Keep the transducer signal wires as short as possible to reduce signal attenuation and extraneous noise that can affect the operation of the control system. Lufkin Automation recommends that the load and position signal cables be a maximum of 300 feet.

Note: If local operational or code requirements dictate that the controller be mounted at the edge of the well pad away from the pumping unit and/or the motor starter panel, contact your Lufkin Automation representative for design assistance.

- Make sure there is a clear radio signal path from the well to the base radio location. The Yagi antenna for the controller should not point directly at the pumping unit structure.

Installing the Mounting Post

WARNING: Be very careful near power cables buried around the motor control box. Striking them will cause serious injury or death.

Make sure that the mounting post structure can support the following:

- 40 pounds if only the controller will be installed
- 75 pounds if a radio and antenna system will be included

Required Tools

The following tools are required for this procedure:

- Shovel or post hole digger
- Ground rod driver
- Level

Installation Procedure

Follow the steps below to properly mount the mounting post.

1. Place the mounting post near the control panel so that it is convenient for electrical hookup.
2. Use a shovel or post hole digger to dig a hole at least two feet deep with 30 inches being a preferred depth.
3. Place the mounting post in the hole and position it facing outward so that it is accessible to the monitor.
4. Pour concrete in the hole.
5. Use a level to verify that the mounting post is positioned upright.
6. Allow sufficient time for the concrete to cure.
7. Within two feet of the motor starter panel, drive an eight-foot copper grounding rod into the earth, if one is not already present.

The mounting post and ground rod are now installed.

Installing the Lufkin Well Manager 2.0 Controller

The Lufkin Well Manager 2.0 controller can be used as a stand-alone unit or with an optional radio or wire line interface board as part of a SCADA system. The optional radio or wire line interface board is used to communicate with a master terminal unit (MTU).

This section describes how to mount the controller to the mounting post described on page 4-4. Instructions for mounting the controller with a radio communications unit are included in the procedure

Note: If possible, orient the controller so that the LCD display is not subject to prolonged direct sunlight. In the northern hemisphere, this would indicate that the window for LCD viewing should face to the north. This practice will optimize the performance of the LCD.

The required tools and recommended wiring specifications are discussed on the following pages.

Required Tools

- One U-bolt with nuts
- Two wrenches
- Wire cutters
- Wire strippers
- Small flat-bladed (slotted) screwdriver
- Voltage/ohmmeter (VOM)
- Slip joint or water pump pliers

Recommended Wiring Specifications

Local codes and/or company standard procedures will dictate where conduit or EMT must be used to protect the cable and personnel. The table on the next page lists the recommended wire types that should be used.

Caution: Special considerations should be taken for the type of wire used in hazardous or highly corrosive environments.

Recommended Wire Types

Signal Type	Minimum Wire Size	Number of Conductors	Shield	Comments
Power	16 AWG, 600VAC rated	2	No	Separate from signal wires
Earth Ground	#2 stranded, 600VAC rated	1	No	Keep short as possible
Analog Inputs	16 AWG	2	Preferred	Twisted pair preferred
Digital Inputs	18 AWG	2	Preferred	Twisted pair preferred
Digital Outputs	16 – 18 AWG	2	No	–
Hardwire Communications	22 AWG	2	No	Twisted pair
Hardwire with Repeater	22 AWG	4	No	Twisted pair
Modem-to-Radio Communications	18 – 20 AWG	4	Preferred	–

Shielding

Shielded cables must be used for the signal leads from the pressure and displacement transducers. Shields should be terminated inside the enclosure at the ground buss bar on the bottom of the controller module.

Figure 4-1. Controller Module Ground Buss

The shield of each cable must be connected at only the controller end. The transducer end of the shield should be left unconnected; otherwise a ground loop could form causing erroneous signals to develop.

Signal Wiring

Signal wiring for analog inputs should be kept as short as possible. These wires must be installed independent of any AC power wiring; otherwise noise may be induced into the controller causing erroneous signals. The cabling should be a twisted pair shielded type.

Note: Analog signal common connections should be kept separate from earth ground connections.

Terminals work better with leads that are not “tinned” with solder. Clip off the “tinned” ends of the two Hall Effect cables and strip the insulation to expose the stranded wire.

Installation Procedure

Follow the steps below to install the Lufkin Well Manager 2.0 controller. Refer to the mounting diagram on the next page when performing this procedure.

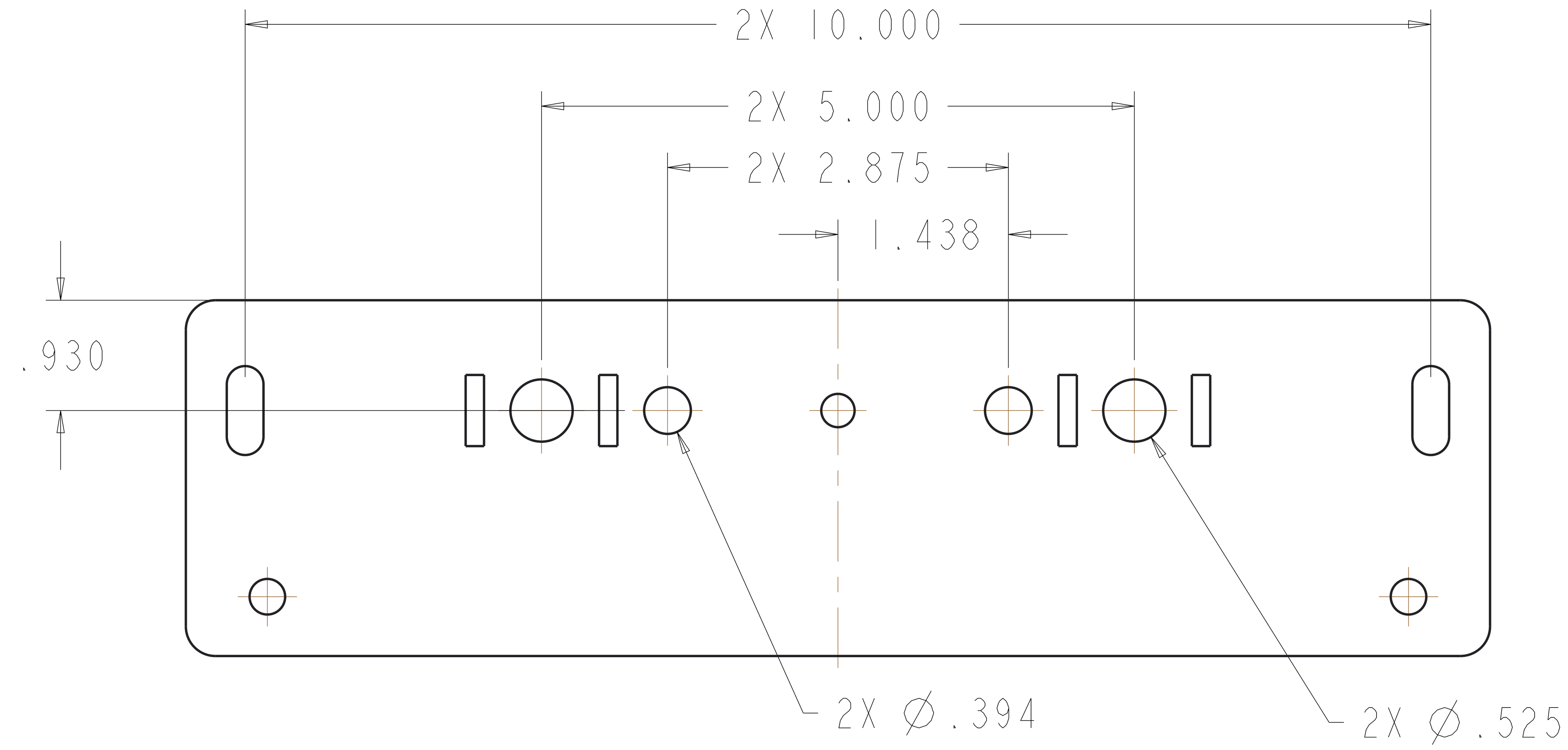
1. Mount the controller at a height that allows easy access for the operator.
2. Use a U-bolt and nuts (user supplied) to mount the controller to the mounting post or mounting bracket assembly.
3. Use Unistrut C-Channel for flexibility when mounting and positioning the controller.
4. If a radio unit is to be used, perform the following steps:
    a. Install the antenna mast, antenna, and lightning rod (optional) to the mounting post or mounting bracket above the controller.
    b. Install the Yagi antenna on the antenna mast and connect the coaxial downlead to the antenna before raising the mast. Be sure to seal the antenna-to-coaxial connection properly to prevent moisture entry.
    c. Secure the coaxial cable at several places along the mast as the cable is dressed down the mast.
5. Connect the ground bolt on the controller to the ground rod with #2 AWG stranded copper wire with green insulation.

Note: Lufkin Automation can provide a copper grounding lug (Part No. 151.0285) for connection at the controller. Grounding must meet ANSI/IEEE C37.90.1 Surge Protection Standards. Proper earth grounding of the controller is critical to minimize transient voltages that can damage the control system electronics. For additional information, ask your Lufkin Automation representative for a copy of Technical Bulletin TB-07-1019: “Recommended Grounding Practices for Lufkin.”

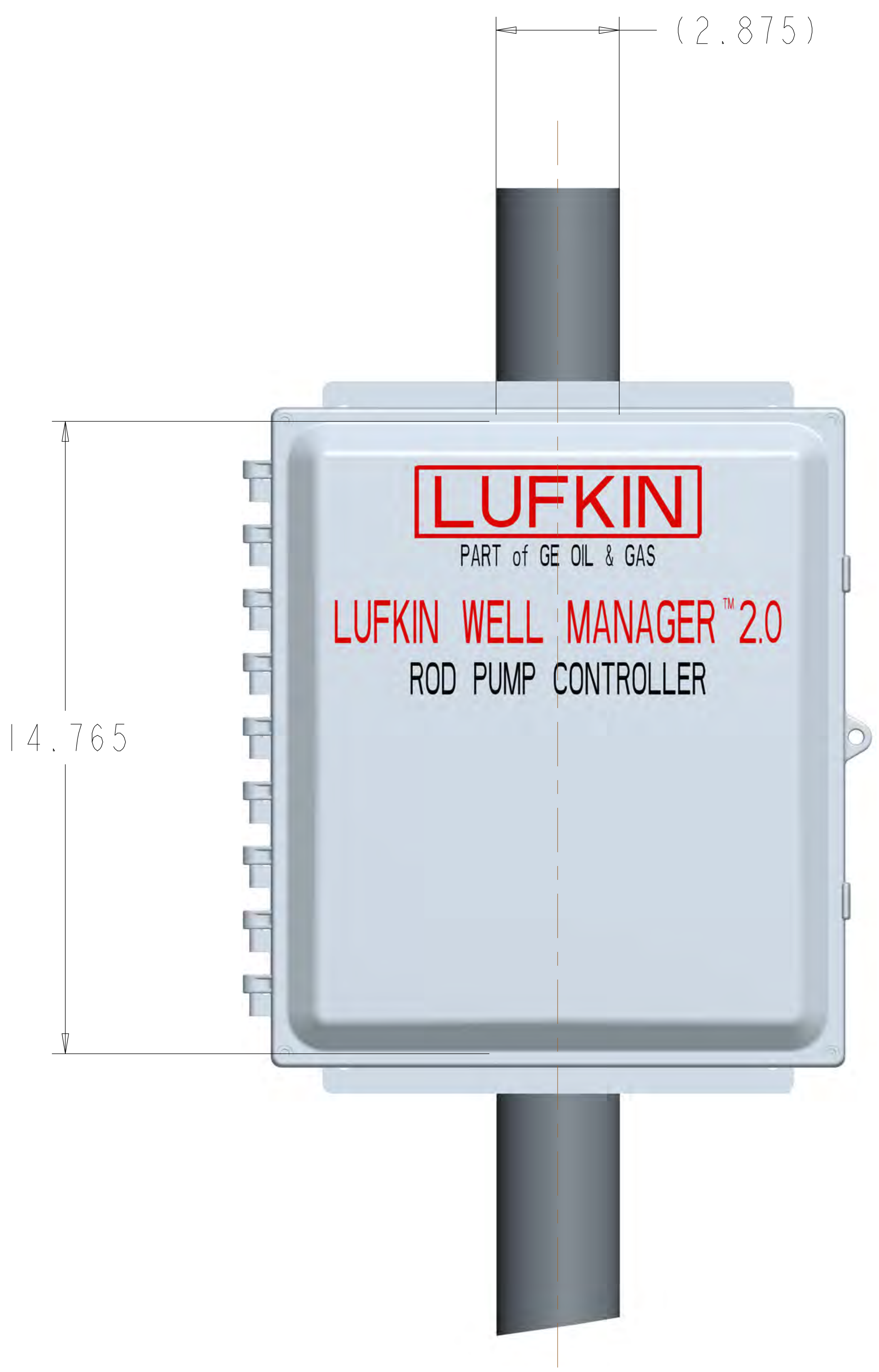
NOTES:

1. ALL DIMENSIONS ARE NOMINAL.

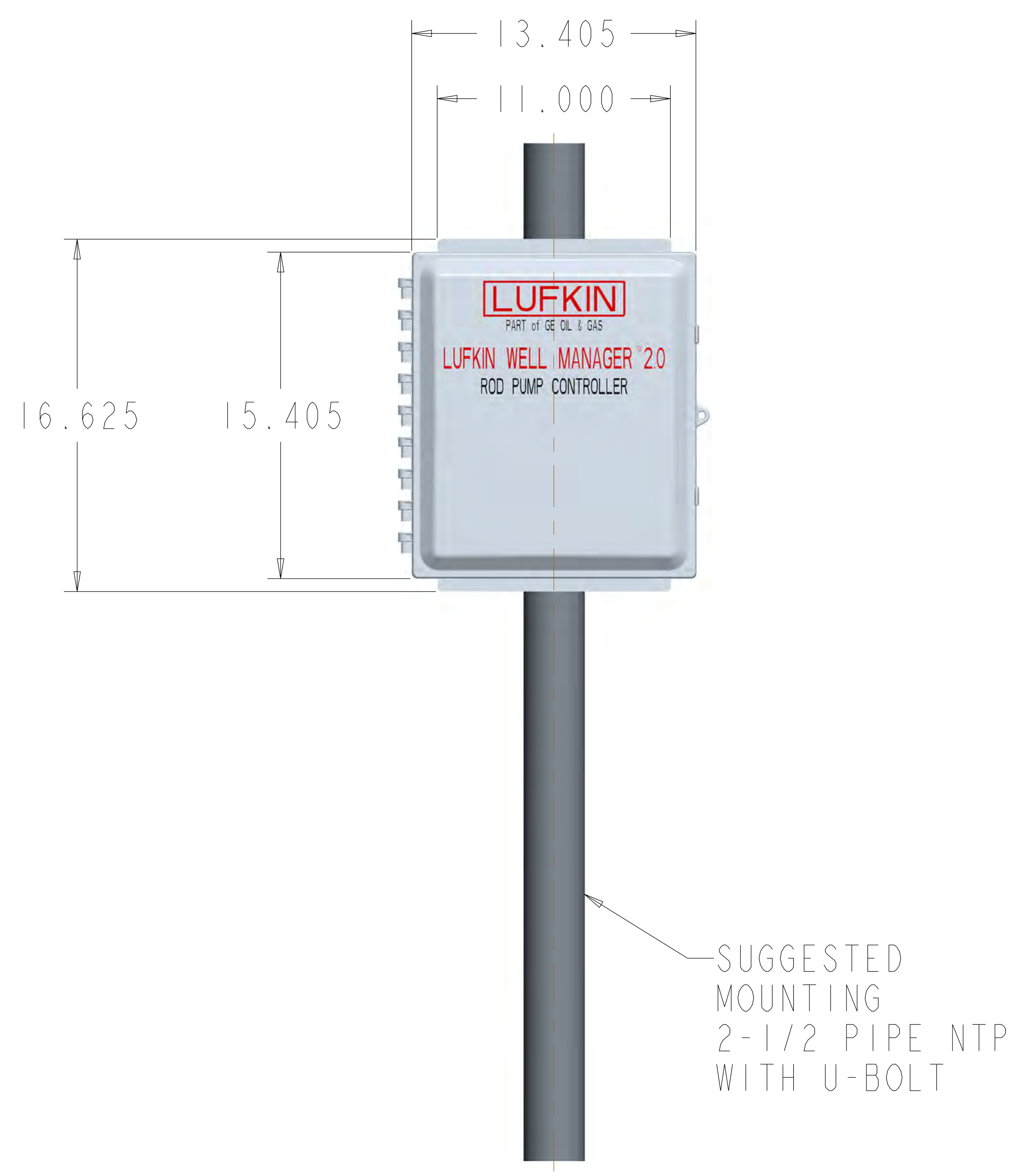
2. ENCLOSURE IS POLYCARBONATE.
UL/CSA/CE NEMA 4X/IP66.



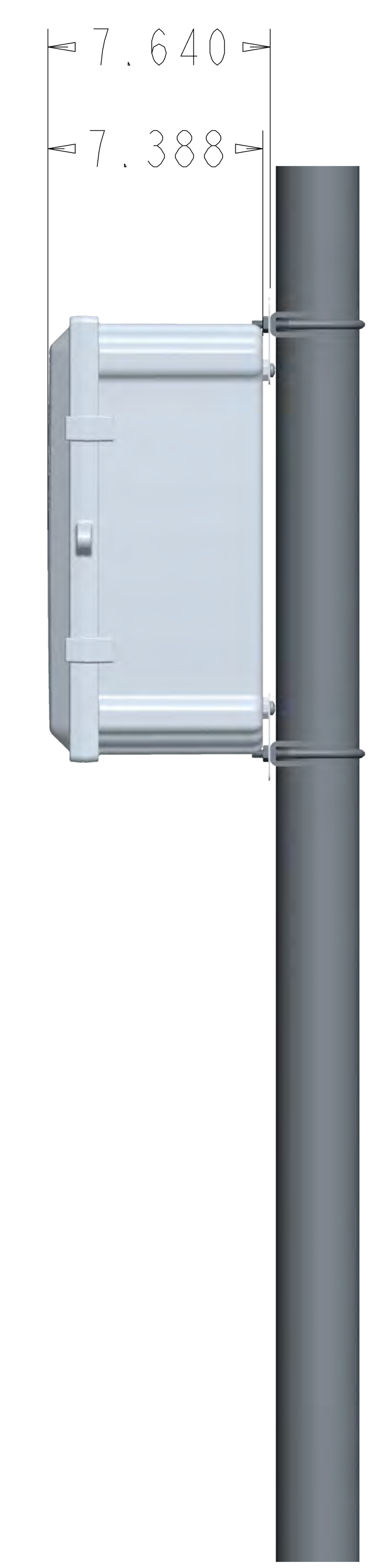
MOUNTING BRACKET



SCALE 0.400
MOUNTING FLANGE
DETAIL - CENTERED



FRONT VIEW



RIGHT SIDE VIEW

LUFKIN MOUNTING DETAIL FOR THE LUFKIN WELL MANAGER 2.0

Installing Motor Control Relay and Optional Relays

The motor control relay is used to start and stop the prime mover. The optional fault relay will automatically switch control of the pumping unit to a mechanical time clock if the LWM 2.0 RPC fails. The optional Start Alert relay may be wired to a siren or light beacon to warn personnel that the unit is about to start. Several options are available for inserting control relays. The installation method selected depends on the type of motor starter control circuit. Variables include the control voltage being switched, “smart” motor starters with solid-state inputs, or a PLC included in the starter panel.

Lufkin Automation offers the following motor control and fault relay options:

- **Part No. 179.0000** – Solid-state relay (SSR) with input voltage of 12VDC nominal and output rated to switch 480VAC. It may not be compatible with a PLC or “smart” motor starter. It has only one normally open output contact; therefore it is not suitable as a fault relay.
- **Part No. 179.3000** – SSR with input voltage of 12VDC nominal and output rated to switch 660VAC. This SSR is more reliable because the output circuit has internal transient protection and the voltage rating is higher.
- **Part No. 530.4670** – Electro-mechanical 12VDC relay with a panel-mount socket, and voltage transient suppression diode. Output contacts are rated 12 Amp at 240VAC maximum, and therefore are not suitable if the motor starter control voltage is 480VAC. Output contacts are Form C (DPDT), so therefore it can be used as either motor control or as a fault relay.
- **Part No. 840.0050** – Panel-mount electro-mechanical relay with a 12VDC coil. SPDT output contacts are rated to switch up to 600VAC. They are suitable for direct connection to the LWM 2.0 RPC. A transient voltage suppression diode should be used across the relay coil. It is suitable as either motor control or a fault relay.
- **Part No. 840.0017** – Panel-mount electro-mechanical relay with a 120VAC coil. SPDT output contacts are rated to switch up to 600VAC. It can be used as an auxiliary relay in conjunction with one of the SSR options for either motor control or fault relay. It is not suitable for direct connection to the LWM 2.0 RPC.

Contact a Lufkin Automation representative for assistance selecting a control relay.

Lufkin Automation also offers a factory-installed start alert kit (Part No. 530.4453) that provides a pre-wired audible beeper alarm.

Use the installation procedure below to install the control relay(s) from Lufkin Automation.

Tools Required

The following tools are required for this procedure:

- Voltmeter
- Two #8 screws
- Phillips and/or flat blade screw driver

Installation Procedure

Follow the steps below to properly install the motor control relay.

1. Turn off all power at the main power supply.

2. Lock out the master disconnect so that no one can turn on the power.
3. Open the starter panel.
4. Measure the incoming power legs with a voltmeter to verify that the power is off.
5. Select an appropriate empty space on the back panel of the starter panel.
6. Use two #8 screws to mount the control relay(s). Drill holes as necessary.

The motor control relay is now installed.

Installing the Polished Rod Load Cell

The polished rod load cell (PRLC) is installed between the polished rod clamp and the carrier bar as shown in Figure 4-2. A spherical washer set must be installed between the carrier bar and the PRLC to ensure an accurate load signal. When the load cell is properly installed, the load cell supports the full load of the rod string. The PRLC provides a quantitative signal that is directly proportional to the load changes occurring at the polished rod.

For all load cell installations, a spherical washer set must be placed between the top of the carrier bar and the bottom flange of the load cell.

Tools Required

The following tools are required for this procedure:

- Polished rod clamp of correct size
- Wrenches for polished rod clamp
- Voltmeter
- Stuffing box protector
- Standoff spacer

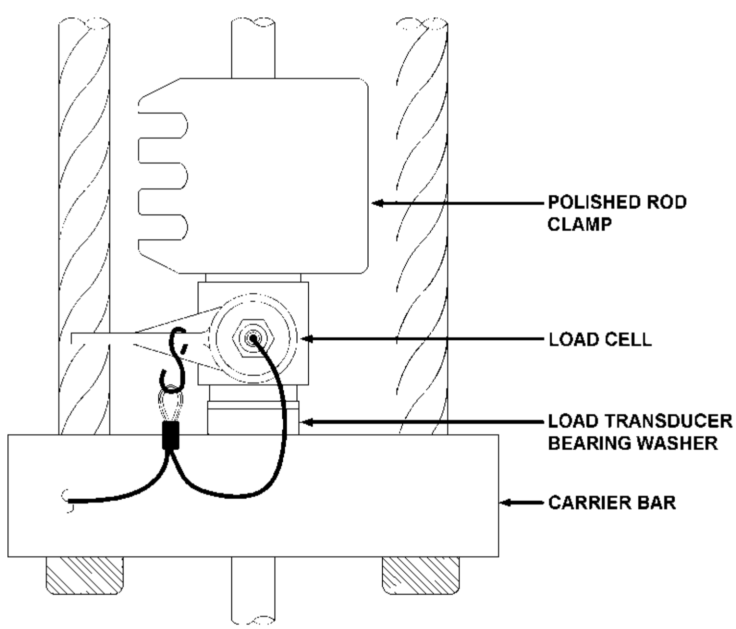


Figure 4-2. Polished Rod Load Cell Installed with a Spherical Leveling Washer Set

Installation Procedure

Follow the steps below to properly install the PRLC.

1. Stop the pumping unit on the downstroke.
2. Create a space between the carrier bar and the polished rod clamp for placing the load cell by stacking out the rod string on the wellhead (i.e., temporarily set the rod string on the wellhead). This can be done using a winch truck or by using the pumping unit prime mover. The following steps are suggested:
   a. Make sure the unit brake is holding securely.
   b. Install a temporary polished rod clamp on the polished rod below the carrier bar and above the polished rod liner using the following precautions:
      - Use the correct clamp size.
      - Tighten the clamp securely and use a handle extension as necessary. Use double-bolt clamps in deep wells with heavy rod strings.
      - On hard-faced polished rods, attempt to install the clamp on a portion of the polished rod that is not hard-faced.
   c. Protect the stuffing box using the following precautions:
      - Do not set down the weight of the rod string on the stuffing box packing. Use the proper stuffing box protectors.
      - Select the proper standoff length to avoid throwing too much slack in the bridle.
      - Throw slack at the carrier bar as gently as possible. Avoid “running” into the standoff.

Note: Installing the PRLC often requires climbing on the wellhead or using a ladder. Use extreme caution when climbing using a ladder. Set it on level ground. Some companies prohibit climbing on the wellhead.

WARNING: Keep fingers and hands out of harm’s way in case the polished rod clamp or unit brake slips.

3. After the rod string is independently supported, mark the position of the original rod clamp on the polished rod with a grease pencil or soapstone.
4. Turn off all power at the main supply. Use a voltmeter to ensure that no power is coming to the motor starter panel.
5. Turn off the LWM 2.0 AF-650 VSD RPC. If it has an optional battery, it may have the unit powered up even though the AC is no longer on.
6. Remove the original polished rod clamp from above the carrier bar.

7. Remove the pony rod or collar from the top of the polished rod.
8. Slide the spherical washer set down over the polished rod and position it on top of the carrier bar.
9. Place the load cell around the polished rod on top of the spherical washer set. Observe the Up arrow on the side of the PRLC, and be sure that it points up.
10. Check that the load-bearing surface of the PRLC rests on the surface of the spherical washer set.
11. Position the PRLC so that the signal wire socket faces the pumping unit.

Note: The PRLC must be installed below the rod rotator if one is present or severe damage can occur to the load cell and/or cable.

12. Replace the pony rod or collar on the polished rod.
13. Replace the original rod clamp above the PRLC. Remember to move the clamp up from the original marked position by the height of the load cell and spherical washer set so that the same downhole pump spacing is maintained.
14. GENTLY release the unit brake to transfer the weight of the rod string back to the carrier bar and bridle. DO NOT drop the rod string abruptly onto the load cell. A shock loading can introduce a zero offset in the transducer, making the load cell calibration ineffective. Reset the brake after obtaining a small amount of standoff clearance. Remove the standoff and the temporary polished rod clamp installed below the carrier bar.
15. Operate the unit slowly during the first pump cycle to check for possible problems. Examples include:
    - Bridle slipping off the horsehead due to poor horsehead alignment
    - Polished rod liner (if installed) being pulled out of the stuffing box packing, which will create a hazardous leak
    - Inadequate clearance between the horsehead and polished rod clamp when the unit is at the top of stroke

The PRLC is now installed.

Installing the Motor RPM Hall-Effect Transducer

The magnet assembly must be mounted on the motor shaft and the Hall-Effect transducer probe must be mounted so that the magnet passes within about 1/8 inch of the probe tip when it passes the probe. The installation procedure provided below assumes that the belt sheave is far enough out on the motor shaft to mount the magnet between the motor and the sheave. This will work for the majority of installations. The installation technician may need to be innovative on some locations. Contact a Lufkin Automation representative if problems occur. Extra T-brackets are available if needed.

Tools Required

- Socket set or wrench set
- Screwdriver

Parts Required

- Transducer assembly with motor bracket and T-bracket
- Magnet assembly
- Hose clamp

Installation Procedure

Follow the steps below to properly install the motor RPM Hall-Effect transducer.

1. Turn off the main power switch to the motor.
2. Set the brake on the pumping unit and chain off the unit sheave.
3. Attach the magnet (mounted in holder) to the motor shaft with a stainless steel hose clamp. Cut off excess hose clamp after it is tightened. See Figure 4-3.

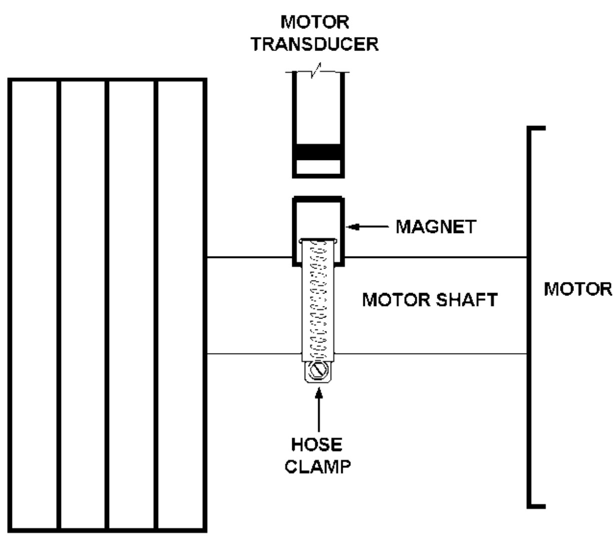


Figure 4-3. Motor Transducer Assembly Diagram Showing T-Bracket Linkage

4. Install the motor transducer bracket on a motor housing bolt. Select a housing bolt that will easily allow the transducer to align with the magnet.
5. Assemble and adjust the T-bracket linkage so that the magnet passes approximately 1/8 inch from the transducer. See Figure 4-4.

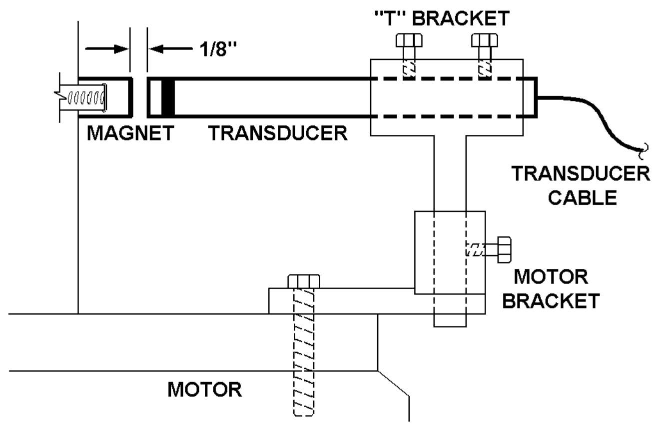


Figure 4-4. Motor Transducer Assembly

6. Tighten all bracket connections.

The RPM Hall-Effect transducer is now installed.

Installing the Crank Arm Hall-Effect Transducer

The crank transducer must be precisely installed to sense the leading edge of the magnet at bottom dead-center of the stroke. An error in this measurement will result in a shift in polished rod positions, which will cause distortions in the surface and downhole pump cards and errors in the diagnostic calculations. The LWM 2.0 controller units can make a firmware phase angle adjustment. If local safety regulations prevent mounting the transducer for bottom of stroke (counter weights up), the transducer can be mounted to sense the crank arm at or near the top of the stroke (with counterweights down) and the LWM 2.0 configuration can make the phase angle adjustment.

Tools Required

- Socket set or wrench set
- Screwdriver
- Silicon sealant/adhesive
- Parts Required
- Transducer assembly and brackets
- Magnet

Installation Procedure

Follow the steps below to properly install the crank arm transducer.

1. Position the unit cranks with the polished rod at the bottom center position.
    a. Align the crank and pitman. The centerlines of the pitman and the crank should be in perfect alignment. See Figure 4-5.
    b. Stop the unit near the bottom center position.
    c. With the motor turned off, release the brake slowly and observe the direction that the cranks rotate.
    d. With the direction of the crank rotation in mind, start the unit and then stop the unit with the polished rod near bottom. When the brake is released gently, the cranks will rotate slowly in the direction that will align the centerlines of the crank and pitman.

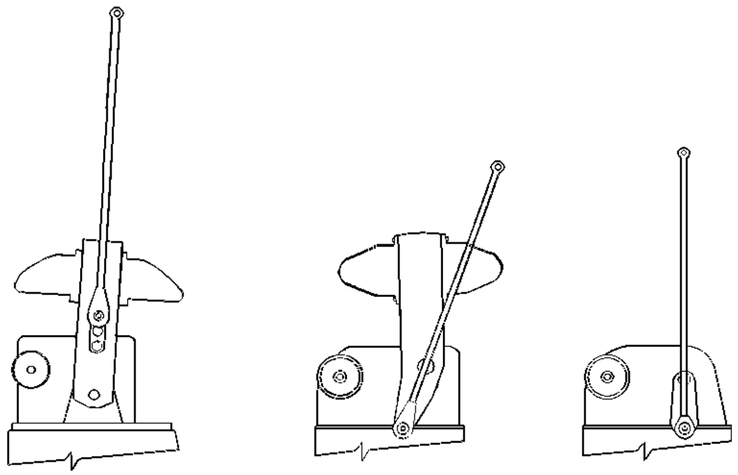


Figure 4-5. Crank/Pitman Alignment at Bottom Dead-Center

If one person is involved in the installation, this procedure can be done in steps by allowing the cranks to rotate a small amount, then set the brake and observe the alignment. Continue this method until the centerlines are in perfect alignment. If this method is not successful (unit behavior differs from well to well), consider stopping the unit slightly before bottom-dead-center, then partially set the brake and “bump” the unit by quickly turning the motor on and off. After each “bump,” observe the crank and pitman position until perfect alignment is obtained.

2. Turn off the main power switch to the motor.
3. Set the brake on the pumping unit and chain off the unit sheave.
4. Select a bolt on the gearbox slow speed shaft bearing cap that will allow the easiest and best alignment of the transducer and the magnet. Remove the bolt and mount the bracket of the Hall-Effect transducer. Reinstall and tighten the bolt to secure the bracket. See Figure 4-6 and Figure 4-7 on page 4-17.
5. Use either method described below to mount a magnet:
   - Bar magnet (see Figure 4-6) – Mount a bar magnet on the crank, and carefully inspect the backside of the crank arm to ensure that the transducer will not be hit by a portion of the crank that extends out further than the surface of the magnet. After making sure that the magnet facing the transducer has the correct polarity, glue the magnet to the crank with silicone.

Note: Incorrect polarity will result in no crank signal. Correct polarity can be determined by holding the bar magnet near a round magnet mounted in a holder used for measuring motor revolutions and speed. The side of the bar magnet attracted to the round magnet is the side glued to the crank.

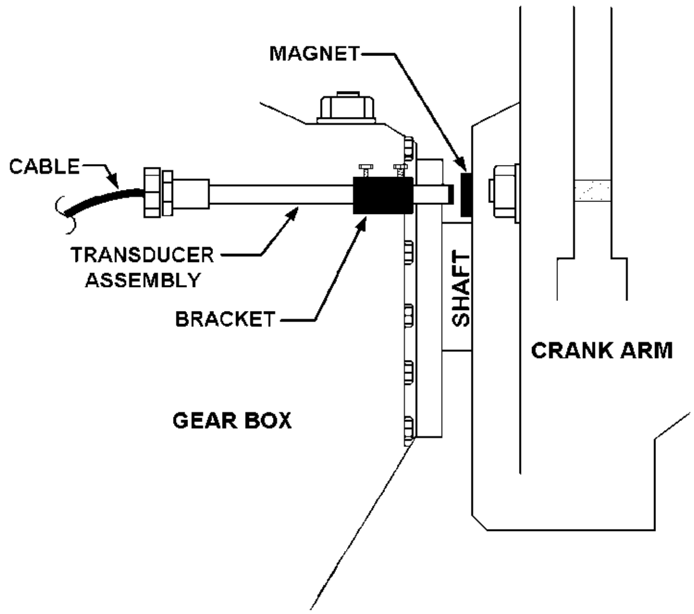


Figure 4-6. Bar Magnet Mounted on Back of Crank Arm

- Round magnet (see Figure 4-7) – Attach a round magnet (mounted in holder) to the slow speed shaft of the gearbox with a stainless steel hose clamp, similar to the motor transducer assembly. If insufficient space is available to mount the magnet between the crank and the gearbox bearing cap, mount a bar magnet on the crank as described above.

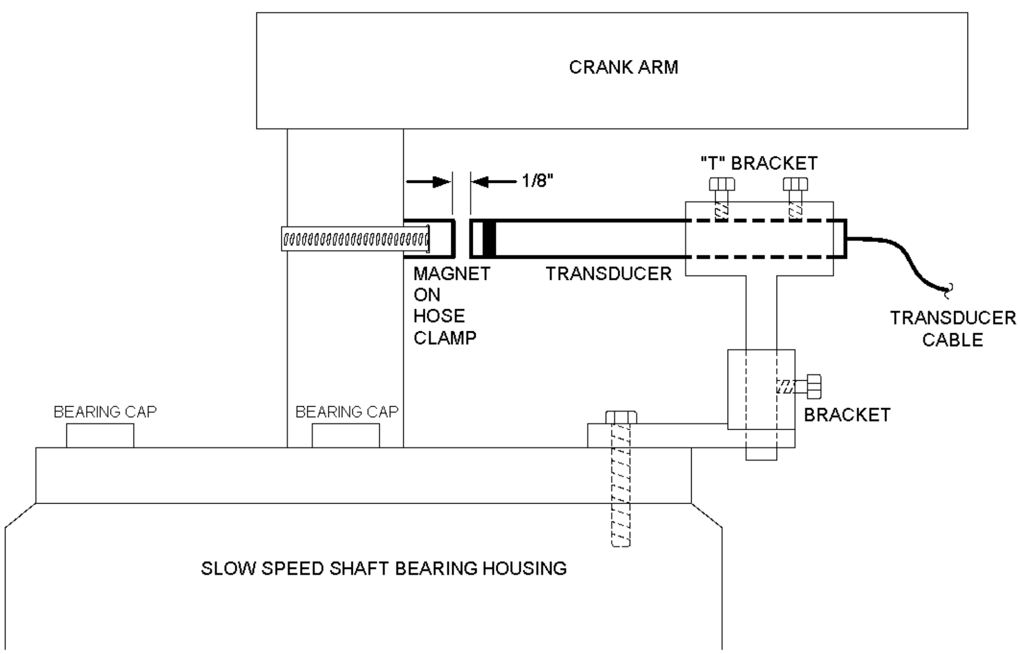


Figure 4-7. Round Magnet Mounted on Low Speed Shaft of Gearbox

6. The Hall-Effect transducer senses the magnet when the leading edge of the magnet is approximately at the center of the transducer probe. With this in mind and with the unit at

bottom dead-center, position the transducer or the magnet so that the center of the transducer is at the leading edge of the magnet and approximately 1/8-inch from the magnet. (See Figure 4-8 for proper magnet alignment.) Tighten all connections securely.

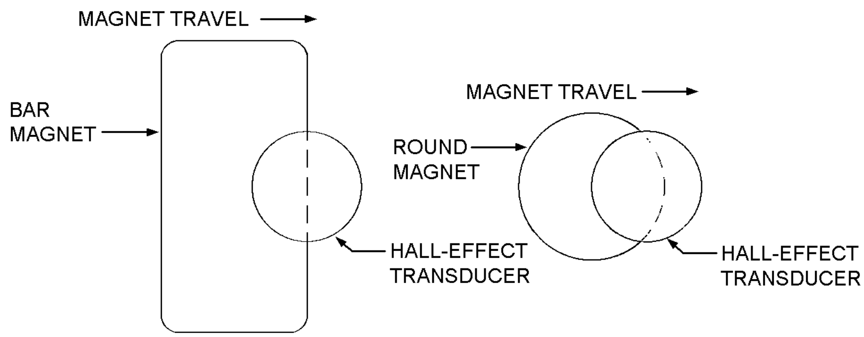


Figure 4-8. Proper Magnet Alignment

The crank arm Hall-Effect transducer is now installed.

Power Wiring

The LWM 2.0 controller must be wired to an external circuit breaker or an equivalent external disconnect switch that is rated for the controller's power requirements. (Refer to "Power Requirements" on page 3-3 for details.) This switch must be mounted in a location that is easily accessed by the operator.

System Grounding

Proper earth grounding of the Lufkin Well Manager 2.0 system is critical to minimize transient voltages that can damage the control system electronics and to prevent high frequency noise from interfering with the signal inputs.

The following points should be considered when grounding the system:

- As a general rule, the larger and shorter the ground lead used, the better the ground. It is best practice to avoid any sharp bends in a ground lead.
- Connect the ground wire to the ground terminal on the bottom of the enclosure.
- Terminate the other end at the wellhead with an approved pipe ground clamp rated for the wire size used. See Figure 4-9 on page 4-19.

Note: The connection spot at the wellhead must be cleaned down to bare metal before the clamp is installed, and it must be sufficiently coated afterward to prevent corrosion.

- All signal cable shields should be terminated at the hinge mount screw on the controller front panel where the green ground wire is connected.

For additional information about system grounding, ask your Lufkin Automation representative for a copy of *Technical Bulletin TB -07-1019: Recommended Grounding Practices for Lufkin*.

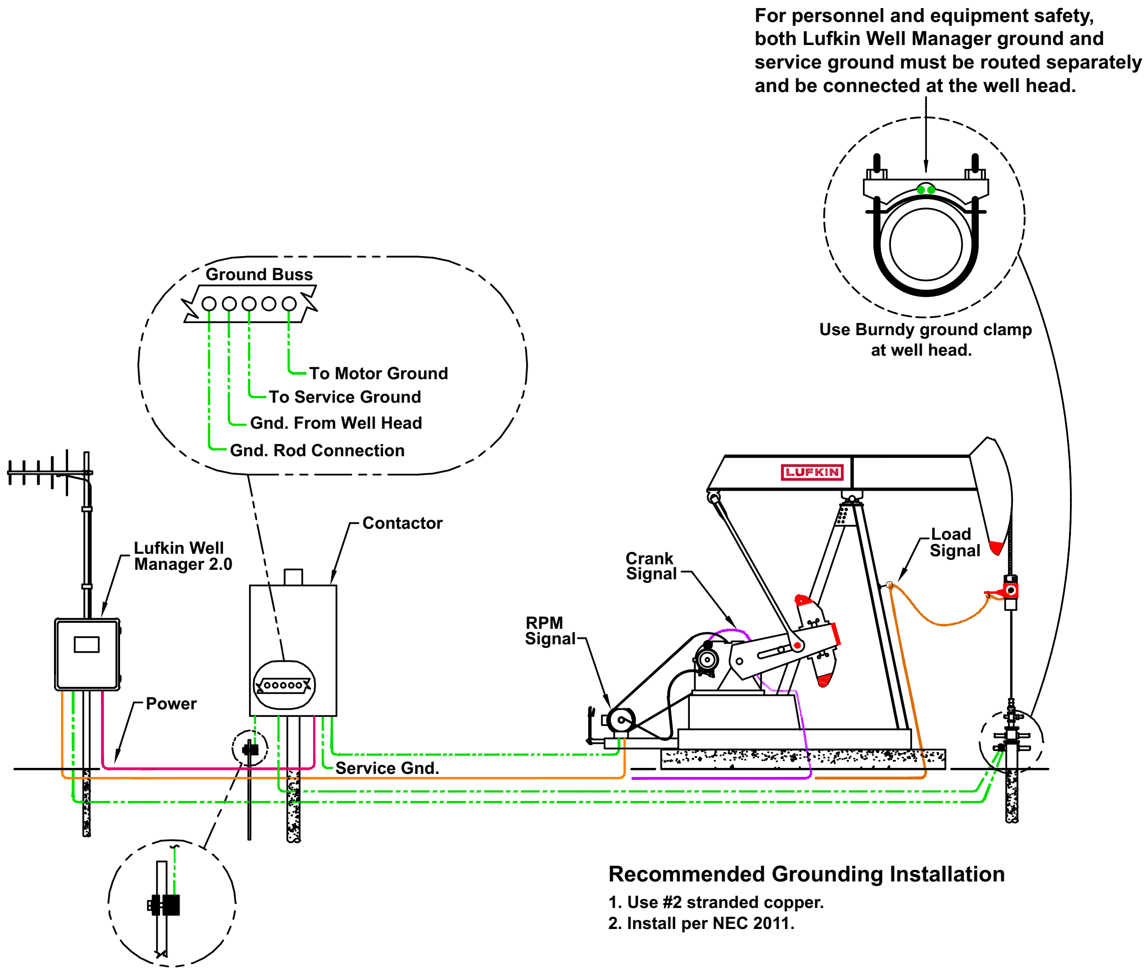


Figure 4-9. LWM 2.0 System Grounding Diagram

Signal Wiring

Typical system signal wiring includes running and terminating the cables for the load cell and for the two Hall-Effect transducers. Optional transmitters to monitor other wellhead process variables, such as tubing pressure and/or casing pressure can also be included.

Signal wiring for analog inputs should be kept as short as possible. These wires must be installed independent of any AC power wiring; otherwise noise may be induced into the controller causing erroneous signals. The cabling should be a twisted pair shielded type.

Note: Analog signal common connections should be kept separate from earth ground connections.

The terminal blocks for connecting the load cell and Hall-Effect transducer cable leads are located on the bottom of the LWM 2.0 controller module inside the controller enclosure. To access this module, press the button on the enclosure latch and pull outward. The controller module is shown in Figure 4-10 below.

Figure 4-10. LWM 2.0 Controller Module

A field wiring diagram is attached to the inside of the LWM 2.0 RPC front cover. Refer to this diagram when performing the following procedures.

Load Cell Cable

The load cell cable leads must be terminated at terminals 1 – 4 on the controller module. See Figure 4-11.

Figure 4-11. Terminals for Load Cell Cable Connection

Hall-Effect Transducer Cables

Terminals work better with leads that are not “tinned” with solder. Clip off the “tinned” ends of the two Hall Effect cables and strip the insulation to expose the stranded wire.

The two Hall-Effect transducer cables must be terminated at the following terminals on the controller module:

- RPM transducer: Terminals 19 – 21
- Crank transducer: Terminals 22 – 24

See Figure 4-12 below.

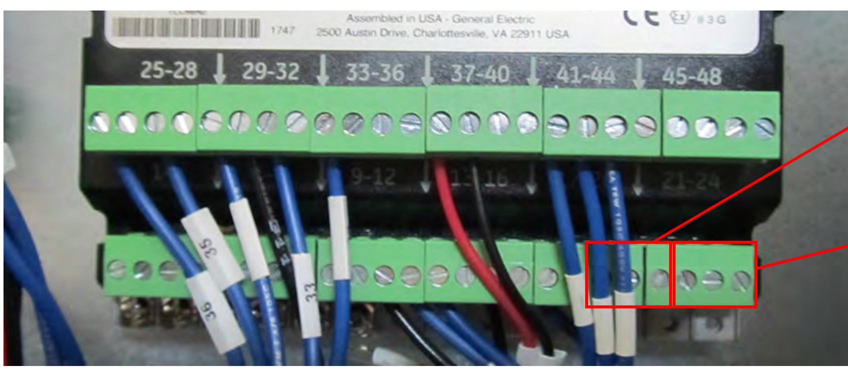


Figure 4-12. Terminals for Hall-Effect Transducer Cable Connections

Shielded Cables

Shielded cables must be used for the signal leads from the load cell and the Hall-Effect sensors. Shields should be terminated inside the enclosure at the ground buss bar on the bottom of the controller module.

Figure 4-13. Controller Module Ground Buss

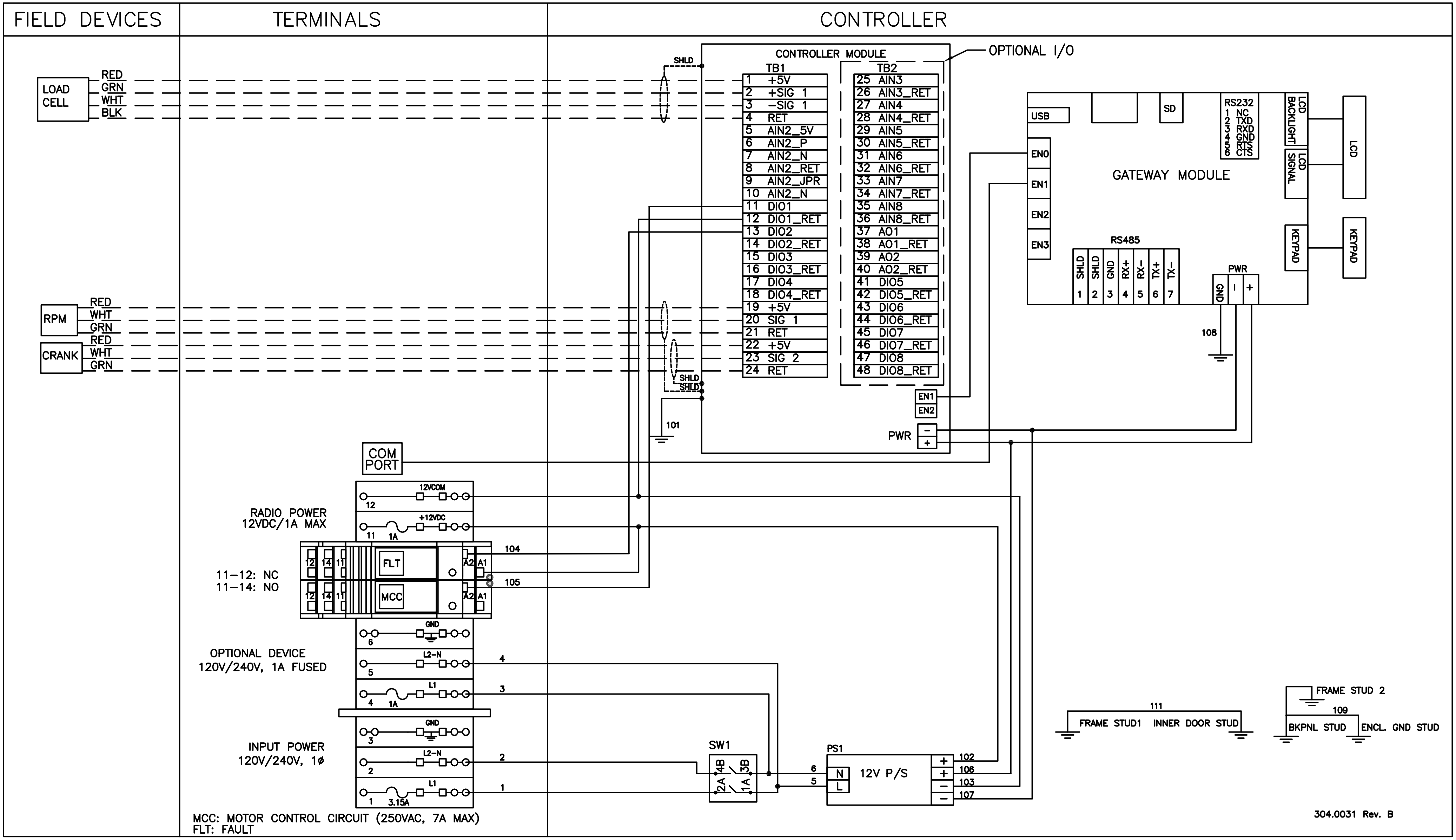
The shield of each cable must be connected only at the controller end. The transducer end of the shield should be left unconnected; otherwise a ground loop could form causing erroneous signals.

Relay Wiring

Refer to the wiring diagram on the next page for guidelines on wiring a motor relay and optional fault relays.

Wiring Diagram

Refer to the wiring diagram on the next page for typical Lufkin Well Manager 2.0 system installations.



FIELD DEVICES
TERMINALS
CONTROLLER
LOAD CELL
RED
GRN
WHT
BLK
RPM
RED
WHT
GRN
CRANK
RED
WHT
GRN
COM PORT
RADIO POWER
12VDC/1A MAX
11–12: NC
11–14: NO
OPTIONAL DEVICE
120V/240V, 1A FUSED
INPUT POWER
120V/240V, 1Ø
MCC: MOTOR CONTROL CIRCUIT (250VAC, 7A MAX)
FLT: FAULT
12VCOM
+12VDC
GND
L2–N
L1
1A
3.15A
FLT
MCC
104
105
SHLD
101
CONTROLLER MODULE
OPTIONAL I/O
TB1
1 +5V
2 +SIG 1
3 –SIG 1
4 RET
5 AIN2_5V
6 AIN2_P
7 AIN2_N
8 AIN2_RET
9 AIN2_JPR
10 AIN2_N
11 DIO1
12 DIO1_RET
13 DIO2
14 DIO2_RET
15 DIO3
16 DIO3_RET
17 DIO4
18 DIO4_RET
19 +5V
20 SIG 1
21 RET
22 +5V
23 SIG 2
24 RET
TB2
25 AIN3
26 AIN3_RET
27 AIN4
28 AIN4_RET
29 AIN5
30 AIN5_RET
31 AIN6
32 AIN6_RET
33 AIN7
34 AIN7_RET
35 AIN8
36 AIN8_RET
37 AO1
38 AO1_RET
39 AO2
40 AO2_RET
41 DIO5
42 DIO5_RET
43 DIO6
44 DIO6_RET
45 DIO7
46 DIO7_RET
47 DIO8
48 DIO8_RET
EN1
EN2
PWR
GATEWAY MODULE
USB
SD
RS232
1 NC
2 TXD
3 RXD
4 GND
5 RTS
6 CTS
LCD BACKLIGHT
LCD SIGNAL
LCD
KEYPAD
KEYPAD
EN0
EN1
EN2
EN3
RS485
SHLD 1
SHLD 2
GND 3
RX+ 4
RX– 5
TX+ 6
TX– 7
PWR
GND
108
SW1
4B
3B
2A
1A
PS1
12V P/S
N
L
6
5
102
106
103
107
111
FRAME STUD1
INNER DOOR STUD
FRAME STUD 2
109
BKPNL STUD
ENCL. GND STUD
304.0031 Rev. B

Section 5: Quick Start Feature

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Section Overview

The Quick Start configuration feature is designed to help you quickly enter the basic programming parameters necessary to configure the Lufkin Well Manager 2.0 controller and get it into operation. This feature sets certain default parameters for the controller to operate in normal pumping conditions. These parameters use values that are designed to work for most pumping unit systems.

This section covers the use of the Quick Start feature to program the RPC parameters of the Lufkin Well Manager 2.0 RPC. For information about programming VSD parameters, contact your local Lufkin Automation representative.

The LWM 2.0 Quick Start configuration procedure is discussed on the following pages.

Note: This manual describes the functions included in Version 1.34 of the LWM 2.0 firmware.

Parameter Programming

Control parameters are edited (programmed) on a data field basis. To program a parameter, press the arrow keys to highlight the desired parameter field, press <**ENTER**>, and then choose one of the following methods:

- To select an option from a drop-down list, use the arrow keys to highlight the desired option and then press <**ENTER**> again.
- When the parameter is a numerical entry, use the number keys to enter the desired value and then press <**ENTER**> again.

When parameter values are changed, the green **Discard** and **Save** buttons will appear at the bottom of the screen as shown in Figure 5-1.

Figure 5-1. Menu Bar with Discard and Save Buttons

Press the **Save** button to save the programming change or the **Discard** button to discard the change. The **Discard** and **Save** buttons will then be replaced with the **Previous** and **Next** buttons.

Starting the Quick Start Procedure

Note: Make sure the pumping unit is operational before starting the Quick Start procedure.

From the Main Menu screen, press the **Quick Start** button to start the Quick Setup procedure.

The Quick Start Welcome screen appears as shown in Figure 5-2.

Figure 5-2. Quick Start Welcome Screen

To exit the Quick Start screen and return to the Main Menu screen, press the **Exit Quick Start** button.

Press the **Next** button to begin the Quick Start configuration procedure. This procedure is discussed on the following pages.

Operational Limits 1

The Operational Limits 1 screen is the first screen displayed. The contents of this screen are discussed below.

Figure 5-3. Quick Start: Operational Limits 1 Screen

The following parameters are configured on this screen:

- **Control Mode**: Select the desired control mode from the drop-down list. The available VSD options are:
  - **Surface** – The LWM 2.0 RPC controls the well from analysis of surface dynagraph shape using the Pump off setpoint.
  - **Downhole** – The LWM 2.0 RPC controls the well from analysis of the calculated downhole dynagraph using the Pump Fillage setpoint.
  - **DH Pressure** – In this control mode, the controller shuts down the pump when the current downhole intake pressure drops below the defined downhole pressure limit value. The time the system stays in this downtime state is controlled by the Downtime Mode parameter. See “Downtime Mode” for details.

  To change the control mode, use the arrow keys on the keypad to highlight that field and then press <**ENTER**>. Use the up or down arrow keys to change the type and then press <**ENTER**> again.
- **Start Alert Delay (s)**: This parameter provides control of an optional audible or visible start alarm device. The Start Alert output is held ON (low) for the number of seconds programmed in this field. The controller delays starting the pumping unit until the Start Alert Delay time has elapsed. The default value is 10 minutes.
- **Operation Mode**: Select the desired mode of operation from the drop-down list. The available options are:
  - **Normal** – The controller performs all of the enabled safety and control functions. This mode takes full advantage of the LWM 2.0 controller’s capabilities.
  - **Host** – The controller ignores load and position input and makes no control decisions. The pump or downtime decision is made by the operator and requires operator intervention to change. Typical use would be when several wells need to be shut down due to a power

company request. A global data message can be sent to all LWM 2.0 RPC units on the radio network to place them in the Downtime-Host Mode well state. The LWM 2.0 RPC controls would stop the wells and keep them down until receiving a command to restart.

- **Timed** – The LWM 2.0 RPC can be programmed to cycle on/off for user set times. Limited control functions by the LWM 2.0 RPC include peak and minimum load checking. Typical use might be to temporarily operate a well while waiting for one of the signal input end devices to be repaired.

- **Minimum Pump Strokes**: When a pumping cycle starts, the controller will not perform any dynagraph analysis for this number of initial strokes. Peak and minimum load protection is provided during Minimum Pump Strokes mode.

  Many pumping systems may need a few strokes to clear gas or trash from the pump at the start of a pump cycle. As a result, this number should be programmed at a fairly low value because the controller has very limited capabilities during Minimum Pump Strokes mode.

  The allowed range is 0 to 999, and the default is 3. Use the keypad to define this value.

- **Start Up Option**: This option allows the controller to automatically restart the pumping unit after the user-defined time delay has passed.

  To enable this option, select **AutoRestart On** from the drop-down list. To disable this option, select **AutoRestart Off**.

- **Power On Delay (s)**: (This parameter is only visible when the **AutoRestart On** option is selected.) When power is applied to the controller, the initial control state is Downtime Power On Delay. The controller delays starting the pumping unit for this number of seconds specified. This feature allows the operator to stagger the startup of pumping units on a transformer bank or distribution line after a power outage.

  The default value is 1 second. If a different value is desired, use the keypad to define the number of seconds for this value.

- **Downtime Mode**: This parameter determines how long the pumping unit stays in a downtime state. The available options are **Manual** and **Pressure**.

Note: For **Surface** and **Downhole** control modes, **Manual** downtime mode is the only available option.

The downtime mode options are described below:

- **Manual** downtime mode uses a user-defined idle time after a stop for pump off (surface setpoint or downhole pump fillage) or a pumping equipment malfunction. The controller automatically restarts the pumping unit when the specified downtime elapses.

  Select **Manual** downtime mode initially until the well has pumped for a few days to stabilize and the cycle run time stability has been observed.

- **Pressure** downtime mode is selected, the pump restarts when the downhole pressure has built up to a predetermined pressure level.

Select the desired mode from the drop-down list.

Note: If the motor is a gas engine, the engine has to be manually restarted by an operator.

- **Manual Downtime (HH:MM)**: This value defines the initial downtime period used when the controller is in Manual Downtime mode. (See “Downtime Mode” above for description.)

  Program this value short enough to prevent the fluid level in the well bore from reaching the static fluid level, but long enough to allow good pump fillage for more than the minimum pump strokes. (The default value is 30 seconds.)
- **DH Pressure Recovery Target (psi)**: This value defines the downtime period for the **Pressure** option of Downtime Mode and 2ry Downtime Mode only.) Use the keypad to define this value and then press <**ENTER**>.
- **2ry Downtime Mode**: (This parameter is only visible when the **Secondary Pump Fillage** setpoint is enabled at the bottom of the screen.) Select one of the following downtime modes from the drop-down list:
  - **Manual**: In this mode, the controller stays in a Downtime/Pump-Off state until the **Manual Downtime** period expires. See “Manual Downtime (HH:MM)” above for details.
  - **Pressure**: In this mode, the controller stays in a Downtime/Pump-Off state until the **Downhole (DH) Pressure Recovery Target** pressure is reached.

The bottom half of the screen contains controls for configuring parameter setpoints for malfunctions, pump off, fluid load, and pump fillage. Use the arrow keys to select **Enable** or **Disable** from the drop-down list to enable or disable these setpoints and then press <**ENTER**>. Use the keypad to define the Allowed Limit, Consecutive Allowed, and Strokes Allowed values (where applicable) for these setpoints and then press <**ENTER**> to save these values.

- **Malfunction Setpoint**: This parameter sets the number of malfunctions allowed before the controller shuts down the pumping unit. Select **Enabled** or **Disabled** from the drop-down list. The values that apply to this setpoint are described below:
  - **Malfunction Setpoint Consec Allowed**: The controller allows for re-tries for all of the malfunction types of control actions. For example, if the maximum allowed peak load is violated, the controller counts that as a peak load violation and initially shuts down the pumping unit in a downtime state. After the programmed downtime elapses, the controller tries to restart the pumping unit. If the peak load violation is repeated before a normal pump off cycle occurs, the controller counts that as the second consecutive peak load violation and again shuts down the pumping unit in a downtime state. Subsequent violations of the peak load limit increment the consecutive violation counter until the allowed consecutive for peak load is exceeded. The controller at that point shuts down the pumping unit in a malfunction state and operator intervention is required to clear alarms and re-start the unit. This column allows an operator to program the consecutive allowed for malfunction control action.

    Use the keypad to define this value.

  - **Malfunction Setpoint Strokes Allowed**: The number of consecutive strokes that the surface malfunction setpoint must be violated before the controller shuts down the pumping unit for one of the consecutive malfunctions allowed.

    The default value is 2 strokes. Use the keypad to define this value.

- **Pump Off Setpoint**: (This parameter is only used in **Surface** control mode.) Select **Enabled** or **Disabled** from the drop-down list.

  The **Pump Off Strokes Allowed** value sets the number of consecutive strokes that the **Pump Off** control parameter must be violated before the controller shuts down the pumping unit. Use larger numbers for gassy wells or wells with trash interference with pumping action.

  The default value is 2 strokes. Use the keypad to define this value.

- **Fluid Load**: (This parameter is only used in **Downhole** and **DH Pressure** control modes.) The controller analyzes the realtime downhole dynagraph and uses this data to calculate fluid load for each pump stroke. If the fluid load drops below this limit, the pumping unit is stopped for a downtime cycle early in the next upstroke.

  The values that apply to this parameter are as follows:

  - The **Allowed Limit** value defines the allowed fluid load limit described above. Use the keypad to define this value.
  - The **Consecutive Allowed** value defines the number of times the fluid load can drop below the limit before the controller shuts down the pumping unit.
  - The **Strokes Allowed** value defines the number of pump strokes allowed in a low fluid load situation before the controller shuts down the pumping unit.

- **DH Press Low Limit**: (This parameter is only used in **DH Pressure** control mode.) When the downhole pressure drops below this limit, the controller will shut down the pumping unit.

  The values that apply to this parameter are as follows:

  - The **Allowed Limit** value defines the allowed pressure limit described above. Use the keypad to define this value.
  - The **Strokes Allowed** value defines the number of pump strokes allowed in a low pressure situation before the controller shuts down the pumping unit.

- **Secondary Pump Fillage**: (This parameter is only used in **Downhole** and **DH Pressure** control modes.) When the current pump fillage drops below this limit, the controller will accumulate the number of times this drop occurs. When the number of occurrences exceeds the defined limit, the controller will stop the pump and then switch to a Downtime/Pump-Off state. It will stay in this state until the Manual Downtime period expires.

  Note: This feature is supported in the Normal operation mode only.

  Select **Enabled** or **Disabled** from the drop-down list and then press <**ENTER**>.

The Secondary Pump Fillage parameter uses the following values:

- The **Allowed Limit** value defines the allowed fillage limit described above. Use the keypad to define this value.

Note: The **Allowed Limit** value for the Secondary Pump Fillage parameter must be set below the deadband range in order to function properly.

- The **Strokes Allowed** value defines the number of pump strokes allowed in a limit violation situation before the controller shuts down the pumping unit.

- **Pump Fillage Setpoint**: (This parameter is only used in **Downhole** control mode.) Select **Enabled** or **Disabled** from the drop-down list.

  The values that apply to this parameter are as follows:

  - The **Allowed Limit** value defines this setpoint. If the calculated downhole pump card fillage is equal to or less than this value for the number of allowed strokes, the pumping unit is stopped for a downtime cycle. Use the keypad to define this value.
  - The **Strokes Allowed** value sets the number of consecutive strokes that the pump fillage setpoint can be violated before the controller shuts down the pumping unit. Use larger numbers for gassy wells or wells with trash interference with pumping action.

  The default value is 2 strokes. Use the keypad to define this value.

Press the **Next** button to continue.

Operational Limits 2

The Operational Limits 2 screen is the next screen displayed. This screen is used to enable or disable violation setpoints for use during pumping operation. It also displays the current operation mode, control mode, load transducer type, and position transducer type.

Select **Enable** or **Disable** from the drop-down list to enable violation limit parameters. Using the keypad, define the desired values for **Allowed Limit**, **Consecutive Allowed**, and **Start Delay** parameters where applicable.

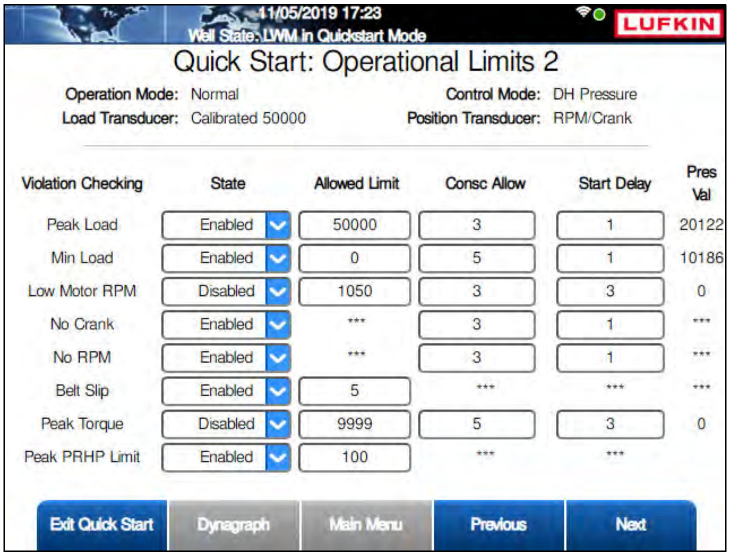


Figure 5-4. Quick Start: Operational Limits 2 Screen

The available violation limits are:

- **Peak Load (lbs)**: The maximum allowed value for load input. If the load exceeds this limit, the controller instantly shuts down the pumping unit with no consecutive stroke delay. Units are in pounds. The default value will be the full scale of the programmed load end device.
- **Min Load (lbs)**: The lowest allowed value for load input. If the load falls below this value, the controller instantly shuts down the pumping unit with no consecutive stroke delay. The default value is zero.
- **Low Motor RPM**: The lowest motor RPM at which the controller will continue to run the pumping unit. This is a time delay setpoint, measured in seconds. It is designed to allow the pumping unit time to accelerate up to operating speed. When the unit starts up, the controller waits a predefined number of seconds before checking for Low Motor RPM violations.
- **No Crank**: Triggers an alarm when a crank switch input is not detected.
- **No RPM**: Triggers an alarm when there is no RPM signal from the pumping unit. This is a time delay setpoint, measured in seconds. It is designed to allow the pumping unit time to accelerate up to operating speed. When the unit starts up, the controller waits a predefined number of seconds before checking for No RPM violations.
- **Belt Slip**: The maximum allowed value for belt slippage. When in the Pumping Normal mode well state, the controller counts the Motor Rev/Stroke for each stroke. At the end of each stroke, the count is compared to the Reference Rev number programmed above. If the current Motor Rev/Stroke count is greater than the Reference Rev by greater than this Belt Slippage percentage, the controller sets an alarm flag to indicate possible belt slippage. No other control action is taken. The default value is 5%.
- **Peak Torque**: The maximum allowed torque value in thousands of inch-pounds. If the controller calculates a torque value greater than this limit at the completion of a stroke, the pumping unit shuts down early in the next upstroke.
- **Peak PRHP Limit**: Specify a value at which the controller will set an alert flag to advise the operator that a paraffin treatment may be required. This value is a high limit.

Press the **Next** button to continue.

Operational Limits 3

The Operational Limits 3 screen is the next screen to be displayed.

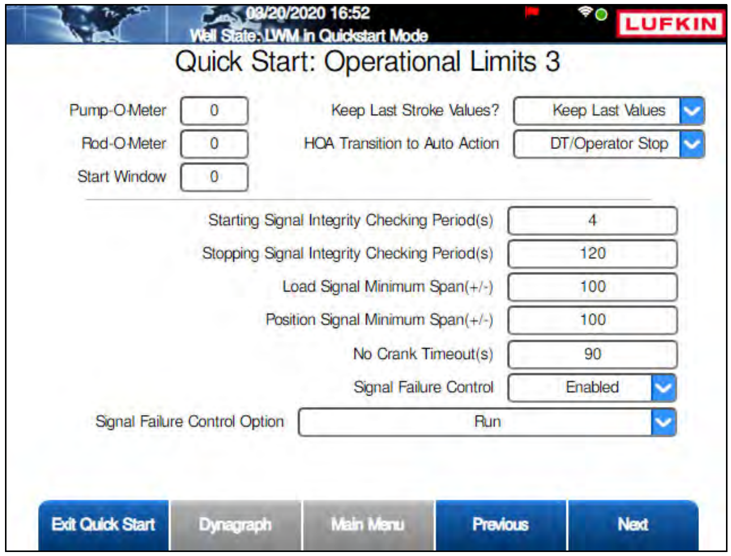


Figure 5-5. Quick Start: Operational Limits 3 Screen

Using the keypad, define the desired values for the following parameters:

- **Pump-O-Meter**: Use this field to clear the counter for rod pump activity. The controller counts and accumulates the number of strokes since the last time pump work was performed. These counts give operators a tool to measure pump life.
- **Rod-O-Meter**: Use this field to clear the counter for rod stroke activity. The controller counts and accumulates the number of strokes since the last time rod string work was performed. These counts give operators a tool to measure rod life.
- **Start Window**: Specify an additional delay time, in seconds, after the well start output is energized before the controller begins checking load and position inputs. This time may be necessary to allow a gas engine prime mover to start and run up to speed or for a clutch to engage. Typically, installations with electric motors do not need an additional delay.
- **Keep Last Stroke Values?**: Use the arrow keys to select one of the following options:
  - Keep Last Values
  - Clear Last Values
- **HOA Transition to Auto Action**: This parameter determines the action the controller takes when the HOA switch is turned to the Auto position. Available options are **DT/Operator Stop** and **Restart**.

  Use the arrow keys to select the desired option and then press <**ENTER**>.
- **Starting Signal Integrity Checking Period(s)**: This field displays the system-defined value for this parameter and cannot be changed by the operator.
- **Stopping Signal Integrity Checking Period(s)**: Use the keypad to define this value.
- **Load Signal Minimum Span (+/–)**: Use the keypad to define this value.
- **Position Signal Minimum Span (+/–)**: Use the keypad to define this value.

- **No Crank Timeout(s)**: Use the keypad to define this value.
- **Signal Failure Control**: (Not available in **DH Pressure** control mode.) This parameter provides control options for handling signal failure situations. To enable or disable this parameter, select **Enabled** or **Disabled** from the drop-down list and then press <**ENTER**>.
- **Signal Failure Control Option**: (This field is only visible when the **Signal Failure Control** parameter is set to **Enable**.) When a signal failure is detected in the system, the controller has several control options for handling this situation. These options are described below:
    - **Malfunction** – With this option, the controller treats the signal failure as a malfunction and shuts down the pumping unit. This malfunction state must be cleared by the user before the controller will restart the unit.
    - **Downtime** – With this option, the controller shuts down the pumping unit for a designated period of time when a signal failure is detected.

      Use the arrow keys to highlight the hours and minutes fields and then press <**ENTER**>. Use the keypad to define the desired downtime period and then press <**ENTER**> again.
    - **Run** – With this option, the controller continues to run normally when a signal failure is detected.

  The next two options allow the pumping unit to run for a user-defined time period when a signal failure is detected.

    - **Timer 1 - User Define** – This option uses user-defined time limits to control the length of time the pumping unit should run in a signal failure situation.

      Use the arrow keys to highlight the hours and minutes fields and then press <**ENTER**>. Use the keypad to define the desired on and off periods and then press <**ENTER**> again.
    - **Timer 2 - % Run Time – since GOT**: This option sets a minimum and maximum time period the pumping unit can run since the last gauge-off time event.

      Use the arrow keys to highlight the hours and minutes fields for the **Off**, **Minimum On Period**, and **Maximum On Period** parameters and then press <**ENTER**>. Use the keypad to define the desired time period for each parameter and then press <**ENTER**> again.

Press the **Save** button to save changes made on this screen. Press the **Next** button to continue.

Operational Limits 4

The Operational Limits 4 screen is displayed next. Use this screen to configure a downhole gauge.

Figure 5-6. Quick Start: Operational Limits 4 Screen

Configure the downhole gauge using the following parameters:

- **DH Gauge Source**: Use the arrow keys to select the downhole gauge source from the drop-down list:
    - **Unavailable**: Select this option if a downhole gauge is not present in the system.
    - **Zenith DH Gauge**: Select this option for Zenith downhole gauges.
    - **AI 8**: Select this option for downhole gauges from other manufacturers.
- **Zenith DH Gauge Model**: (This parameter applies to the **Zenith DH Gauge** Source option only.) Select the desired downhole gauge model from the drop-down list:
    - Model C2
    - Model C5
    - Model C6
- **Intake Pressure Type**: (This parameter applies to the Zenith **Model C5** gauge option only.) Select the desired intake pressure type from the drop-down list. Available options are **Tubing** and **Annulus**.

For Zenith downhole gauge configuration, press or click the **COMM** button to display the Zenith DH Gauge configuration screen shown in Figure 5-7.

For configuration of other downhole gauges by other manufacturers, press the **Analog Input** button to display the Analog Input Configuration screen.

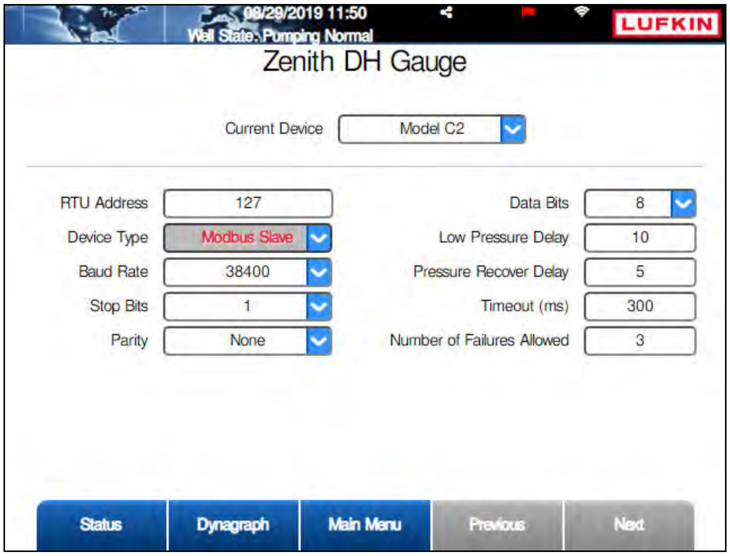


Figure 5-7. Zenith DH Gauge Configuration Screen

The following parameters are configured on this screen:

- **RTU Address**: Each downhole gauge must have a different address number. Address numbers of less than 247 are indicated by the standard Modbus guidelines. The address must match the downhole gauge setting.
- **Device Type**: As of this release, Modbus Slave is the only available option for device type.
- **Baud Rate**: Select from a range of options from 300 to 115,200 baud. The value must match the slave device setting.
- **Stop Bits**: This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Parity**: This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Data Bits:** This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Low Pressure Delay**: (Applies to the **Pressure** mode for Secondary Downtime Mode only.) Use the keypad to define this value and then press <**ENTER**>.
- **Pressure Recover Delay**: (Applies to the **Pressure** mode for Secondary Downtime Mode only.) Use the keypad to define this value and then press <**ENTER**>.
- **Timeout**: Specify the time, in milliseconds, that the controller waits after sending a poll message to check the reply message buffer.
- **Number of Failures Allowed**: Specify the number of times that the controller will continue to try to poll a downhole gauge once that gauge is enabled. If the controller does not receive a valid response after this number of consecutive polling attempts, a communication failure alarm is flagged for the downhole gauge to alert the operator that data from the gauge is not current. Communication failure flags are displayed in red at the top of the screen.

Press the **Save** button to save changes made on this screen, and then press the <**ESC**> button to return to the Operational Limits 4 screen.

Press the **Next** button to continue to the next screen.

Load and Position Configuration

The Load/Position configuration screen is the next screen to be displayed. This screen is used to configure the transducer types and indicate the location of the crank sensor.

Figure 5-8. Quick Start: Load/Position Setup Screen

The following parameters are configured on this screen:

- **Load Transducer Type**: Select the load transducer type from the drop-down list.
- **Intrinsic Safety Barrier Support**: When an I.S. barrier is used in the pumping system, a voltage drop can occur in the excitation wiring to the load cell. This feature allows the user to define the compensation method for this voltage drop. Select one of the following options from the drop-down list:
  - **Disabled**: Select this option if compensation is not required (e.g. if a barrier is not installed or the barrier type does not introduce a voltage drop).
  - **Analog**: Select this option if the voltage drop will be compensated automatically (e.g. by measuring the drop at Analog Input #2).
  - **Manual**: Select this option if the voltage drop will be compensated with a fixed value.

    With this option selected, the **Load Cell Excitation Volts** field is displayed. Use the keypad to define the measured voltage value at the load cell and then press <**Enter**>.
- **Position Transducer Type**: Select the position transducer type from the drop-down list.
- **Crank Sensor Location**: Select the crank sensor location from the drop-down list.
- **Crank Sensor Adjustment Direction**: Select the crank sensor adjustment direction from the drop-down list.
- **Additional Crank Sensor Adjustment Angle**: Using the keypad, define this value.
- **Phase Angle Adjustment:** This field displays the current phase angle adjustment value.
- **Total Phase Angle Adjustment**: This field displays the total phase angle adjustment value.

Press the **Save** button to save the new values and then press the **Next** button to continue.

Prime Mover Configuration

The Prime Mover configuration screen is the next screen displayed.

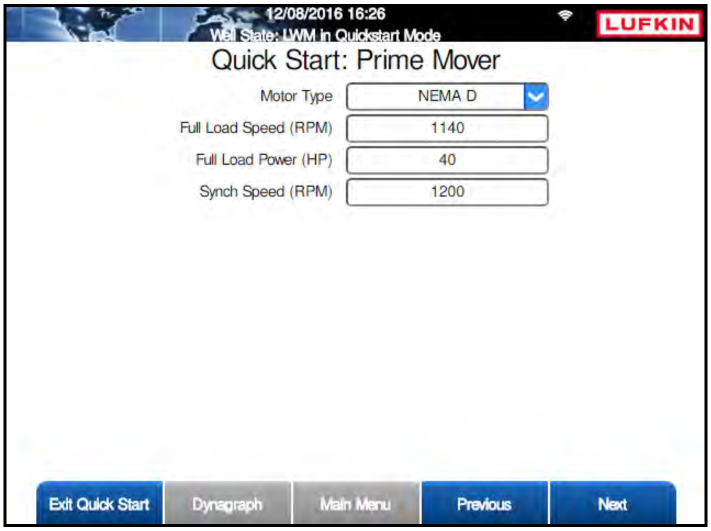


Figure 5-9. Quick Start: Prime Mover Configuration Screen

The following parameters are configured on this screen:

- **Motor Type**: Select the motor type from the drop-down list.
- **Full Load Speed (RPM)**: Use the keypad to specify the full load RPM rating of the prime mover.
- **Full Load Power (HP)**: Use the keypad to specify the horsepower of the prime mover.
- **Synch Speed (RPM)**: Use the keypad to specify the no-load speed of the motor.

Note: These values are usually listed on the side of the motor.

Press the **Save** button to save the new values and then press the **Next** button to continue.

Pumping Unit Configuration

The Pumping Unit Configuration screen is displayed next.

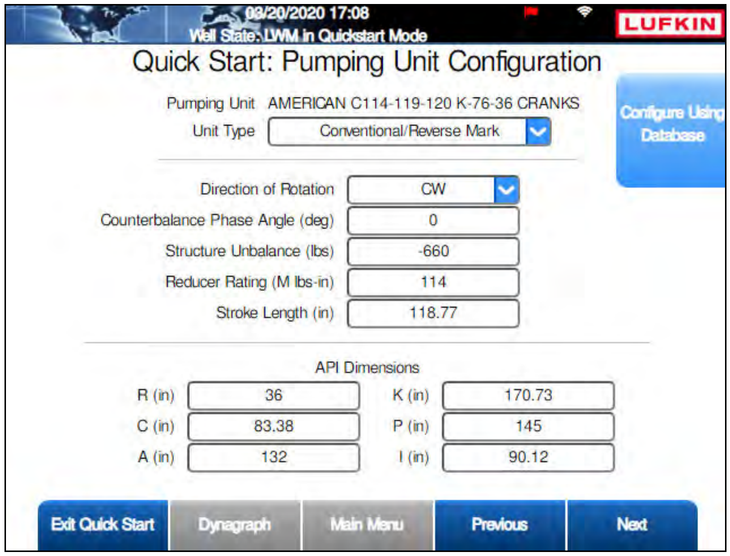


Figure 5-10. Quick Start: Pumping Unit Configuration Screen

1. With the **Unit Type** field highlighted, press <**ENTER**> to display the drop-down list. Using the down arrow key, select the pumping unit type and press <**ENTER**> again.
2. Press the down arrow to highlight the **Direction Of Rotation** field. Press <**ENTER**> to display the drop-down list. Using the down arrow key, select **CW** (clockwise) or **CCW** (counterclockwise) and then press <**ENTER**> again.
3. Press the down arrow to highlight the **Counterbalance Phase Angle (deg)** field. Use the keypad to define this value.
4. Press the down arrow to highlight the **Stroke Length (in)** field. Use the keypad to define this value.
5. Press the down arrow to highlight the **API Dimensions** fields. Use the keypad to define these dimensions.

The **Configure Using Database** button allows a user to select a pumping unit from that database and automatically fill the required dimensional data fields. The database presently contains dimensional data for 1,570 pumping units.

To use this feature, perform the following steps:

1. Press the **Configure Using Database** button to display the Pumping Unit Database screen shown in Figure 5-11 on page 5-18.
2. Select the pumping unit type using one of the following methods:
   - With the **Search** field highlighted, press <**ENTER**>. Use the keypad to input the unit type into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
   - Use the down arrow key to highlight the box next to the desired unit type and then press <**ENTER**>.

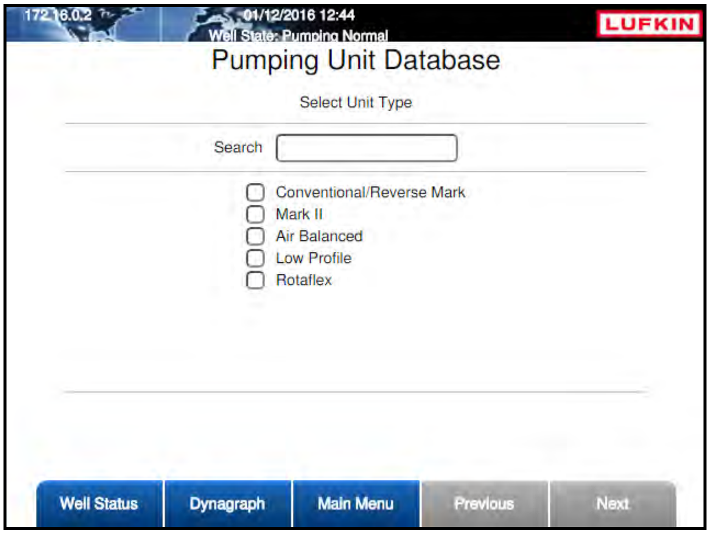


Figure 5-11. Pumping Unit Database – Select Unit Type

Press **Next** to continue.

3. The next screen enables you to select the direction of rotation for the pumping unit.

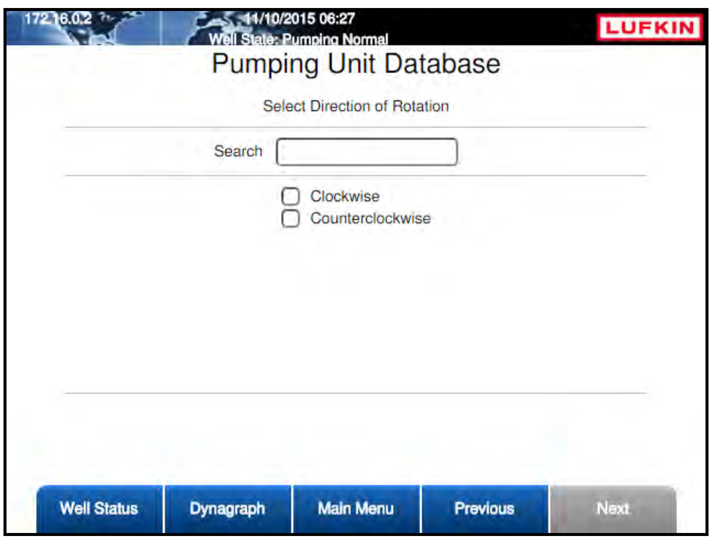


Figure 5-12. Pumping Unit Database – Select Direction of Rotation

Select the direction of rotation using one of the following methods:

- With the **Search** field highlighted, press <**ENTER**>. Use the keypad to type the direction into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
- Use the down arrow key to highlight the box next to **Clockwise** or **Counterclockwise** and then press <**ENTER**>.

Press **Next** to continue.

4. The next screen is used to select the pumping unit's manufacturer code.

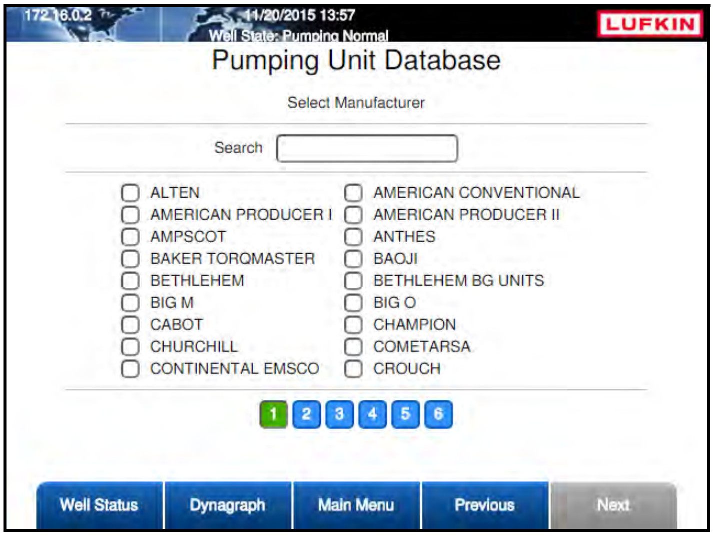


Figure 5-13. Pumping Unit Database – Select Manufacturer Code

Select the manufacturer code using one of the following methods:

- With the **Search** field highlighted, press <**ENTER**>. Use the keypad to type the manufacturer's name into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
- Use the arrow keys to highlight the box next to the manufacturer's name in the list and then press <**ENTER**>. To select a different page of names, use the arrow keys to highlight the page number and then press <**ENTER**>.

Press the **Next** button to continue.

5. The next screen is used to select the pumping unit's ID number.

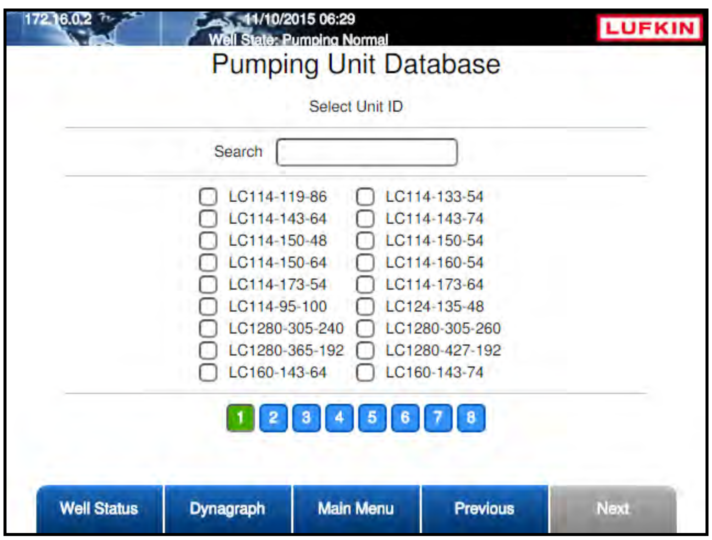


Figure 5-14. Pumping Unit Database – Select Unit ID

Select the unit ID using one of the following methods:

- With the **Search** field highlighted, press <**ENTER**>. Use the keypad to type the unit ID number into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
- Use the arrow keys to highlight the box next to the manufacturer's name in the list and then press <**ENTER**>.

Press the **Next** button to continue.

6. The next screen is used to select the number of crank holes on the pumping unit.

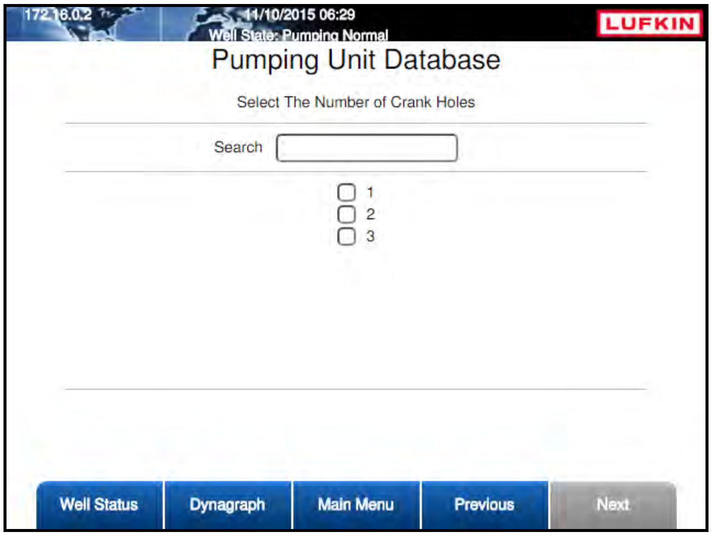


Figure 5-15. Pumping Unit Database – Select Number of Crank Holes

Select the number of crank holes using one of the following methods:

- With the **Search** field highlighted, press <**ENTER**>. Use the keypad to type the number into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
- Use the arrow keys to highlight the box next to the correct number in the list and then press <**ENTER**>.

Press the **Next** button to continue.

7. The next screen displays the results of the database search. Figure 5-16 on page 5-21 shows an example.

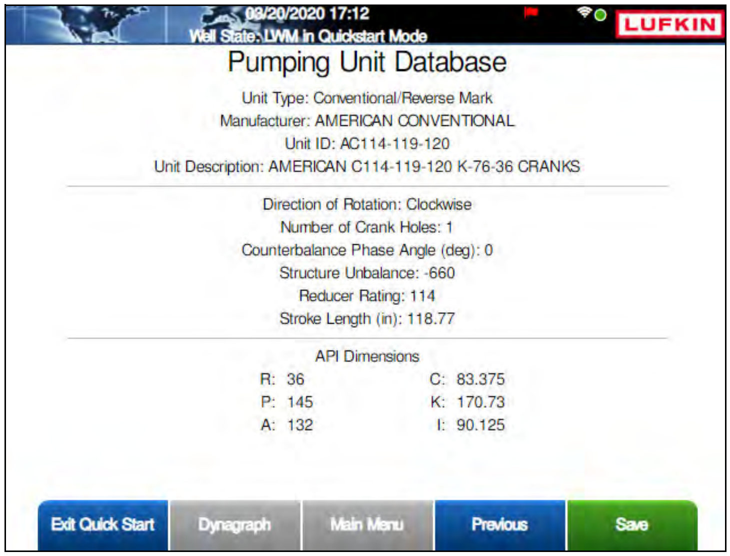


Figure 5-16. Pumping Unit Database – Search Results

Press the **Save** button to save the pumping unit parameters and return to the Pumping Unit Configuration screen.

Press the **Next** button to continue.

Rod Taper Configuration

The Rod Taper Configuration screen is the next screen displayed. The controller must have rod string and pump diameter data to calculate the downhole pump card for each stroke. This screen includes default rod data that applies to most pumping configurations.

Figure 5-17. Quick Start: Rod Taper Configuration Screen

To make changes to this list, press the **Rod Design** button to display the Rod Design screen shown in Figure 5-18.

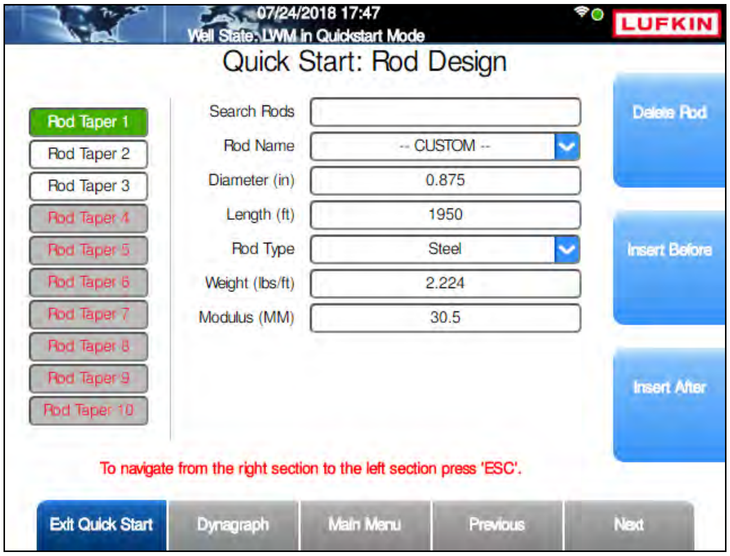


Figure 5-18. Quick Start: Rod Design Screen

This screen allows the operator to change existing rod data, add new rod data, and delete rod data in the rod string list. These procedures are discussed below.

Change Existing Rod Data

To change existing rod data, perform the following steps:

1. Use the arrow keys to highlight the rod to be changed and then press <**ENTER**>. The rod field will turn green.
2. Use the **Search Rods** field to search the database for rods by manufacturer. Type the desired name in the field and press <**ENTER**>. The **Rod Name** field automatically shows all the available rod options listed for that manufacturer.
3. Select the desired rod name from the **Rod Name** drop-down list and then press <**ENTER**>. The database automatically fills the remaining fields with the default values for that rod name.

Note: If the desired rod name is not listed, select the **CUSTOM** option and manually input the rod data in each field.

4. Select the desired rod diameter (measured in inches) from the **Diameter** drop-down list and then press <**ENTER**>.
5. Type the desired rod length (measured in feet) in the **Length** field and then press <**ENTER**>.
6. **(CUSTOM rods only)** With the **Rod Type** field highlighted, press <**ENTER**>. Use the up or down arrow keys to select **Steel** or **Fiberglass** from the drop-down list and then press <**ENTER**> again.
7. **(CUSTOM rods only)** Type the rod weight (measured in pounds per foot) in the **Weight** field and then press <**ENTER**>.
8. **(CUSTOM rods only)** Type the rod modulus in the **Modulus** field and then press <**ENTER**>.

9. Press the **Save** button to save the changed values.

Press the **ESC** button to return to the Rod Taper Configuration screen.

Add New Rod Data

The Rod Design screen allows the operator to insert new rod data anywhere in the rod string list.

Note: A maximum of 12 rods can be used in this system.

To add new rod data, perform the following steps:

1. Select one of the following options:
   - To insert a new rod at the top of the rod string list, use the arrow keys to highlight the **Rod 1** field and then press the **Insert Before** button.
   - To insert a new rod in the middle of the rod string list, use the arrow keys to select the **Rod 1** or the **Rod 2** field and then press the **Insert After** button.
   - To insert a new rod at the end of the rod string list, use the arrow keys to highlight the **Rod 3** field and then press the **Insert After** button.

   The new rod field appears with the Rod Type field highlighted.
2. Use the **Search Rods** field to search the database for rods by manufacturer. Type the desired name in the field and press <**ENTER**>. The **Rod Name** field automatically shows all the available rod options listed for that manufacturer.
3. Select the desired rod name from the **Rod Name** drop-down list and then press <**ENTER**>. The database automatically fills the remaining fields with the default values for that rod name.

Note: If the desired rod name is not listed, select the **CUSTOM** option and manually input the rod data in each field.

4. Select the desired rod diameter (measured in inches) from the **Diameter** drop-down list and then press <**ENTER**>.
5. Type the desired rod length (measured in feet) in the **Length** field and then press <**ENTER**>.
6. **(CUSTOM rods only)** With the **Rod Type** field highlighted, press <**ENTER**>. Use the up or down arrow keys to select **Steel** or **Fiberglass** from the drop-down list and then press <**ENTER**> again.
7. **(CUSTOM rods only)** Type the rod weight (measured in pounds per foot) in the **Weight** field and then press <**ENTER**>.
8. **(CUSTOM rods only)** Type the rod modulus in the **Modulus** field and then press <**ENTER**>.
9. Press the **Save** button to save the changed values.

Press the **ESC** button to return to the Rod Taper Configuration screen.

Delete Rod Data

To delete rod data, perform the following steps:

1. Use the arrow keys to highlight the rod field to be deleted and then press <**ENTER**>. The rod field will turn green.
2. Press the **Delete Rod** button to delete the rod data.
3. Press the **Save** button to save the change.

Press the **ESC** button to return to the Rod Taper Configuration screen.

Press the **Next** button to continue.

LWT/PIP Parameters

The next three screens allow the operator to use Lufkin's patented algorithms that can calculate pump intake pressure (PIP) and make automated fluid volume adjustments for pump slippage, fluid shrinkage, and tubing movement to determine the pump fluid load (LWT). These screens are described in the following paragraphs.

LWT/PIP Parameters 1/3 Screen

The first of three LWT/PIP Parameters screens is displayed next.

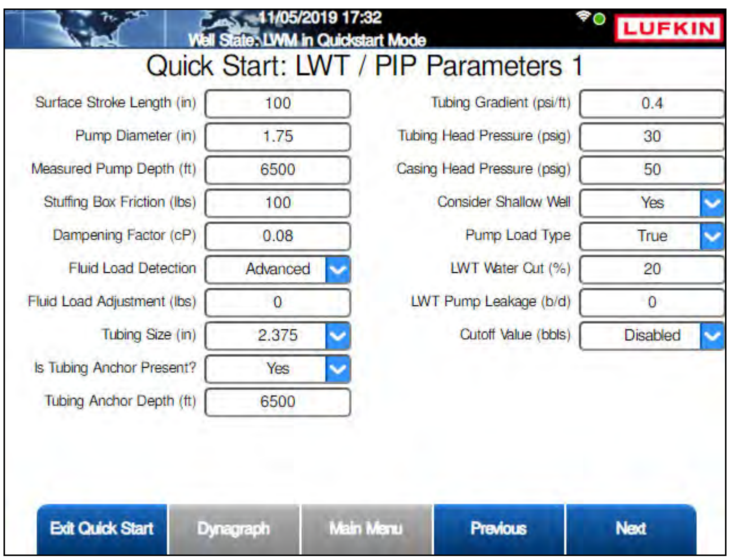


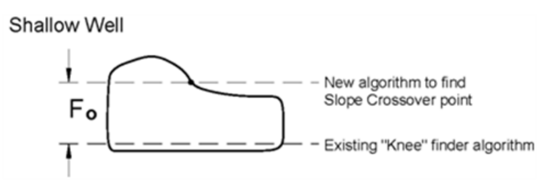
Figure 5-19. Quick Start: LWT/PIP Parameters Screen

The following values are configured on this screen:

- **Surface Stroke Length (in)**: Specify the correct surface stroke length in inches. The length needs to be precise to get accurate results, so use a tape measure when in doubt.
- **Pump Diameter (in)**: Specify the diameter of the pump plunger in inches.
- **Measured Pump Depth (ft)**: Specify the true vertical depth from the surface to the pump intake, in feet.

- **Stuffing Box Friction**: This factor is used to compensate for surface friction due to tight stuffing box seals. Enter in pounds.
- **Dampening Factor**: If the tubing string is not anchored at all, or if the tubing anchor is more than a few hundred feet above the pump intake, specify **Yes**.
- **Fluid Load Detection**: Select **Basic** or **Advanced** from drop-down list.
  - If **Basic** is selected, the controller calculates fluid load by subtracting the average downstroke load from the average upstroke load without making any attempt to analyze the pump card shape for friction loads.
  - If **Advanced** is selected, the controller uses more advanced techniques of PIP calculation theory for calculating fluid load.
- **Fluid Load Adjustment (lbs)**: The fluid load that the controller calculates by either the Basic or Advanced fluid load detection method can be adjusted by using this field.
- **Tubing Size (in)**: Specify the API tubing size in inches.
- **Is Tubing Anchor Present?**: Select **Yes** or **No** from the drop-down list. If the tubing string is not anchored at all, or if the tubing anchor is more than a few hundred feet above the pump intake, select **Yes**.
- **Tubing Anchor Depth (ft)**: (This field is only visible when the **Is Tubing Anchor Present?** parameter is set to **Yes**.) The tubing should be secured or "anchored" at the surface as a minimum. Therefore, if no tubing anchor is present, specify a value of 0 for the anchor depth. If an anchor is present up hole from the pump intake, specify the depth of the anchor in feet along the tubing (as opposed to true vertical depth).
- **Tubing Gradient (psi/ft)**: Specify the gradient for the fluid in the tubing in psi/feet.
- **Tubing Head Pressure (psig)**: Specify the gauge pressure at the well head tubing in PSI.
- **Casing Head Pressure (psig)**: Specify the pressure in PSI gauge of the casing at the surface.
- **Consider Shallow Well**: Select **Yes** or **No** from the drop-down list. No generally accepted exact definition of a "shallow well" exists. As a general rule, a shallow well is a well with a pump depth of less than 3,000 feet or a deeper well with a large diameter pump. The primary indicator is the shape of the downhole pump card.

  If the pump card has the general shape as illustrated in the example below, select **Yes**.



- **Pump Load Type**: Select **True** or **Effective** from the drop-down list.
- **LWT Water Cut (%)**: Specify the percentage of the produced fluid that is water.
- **LWT Pump Leakage (b/d)**: Specify the amount of leakage around the pump plunger in barrels per day.
- **LWT Cutoff Control**: Select **Enabled** or **Disabled** from the drop-down list.
- **Cutoff Value (bbls)**: (This parameter is only visible when the **LWT Cutoff Control** parameter is set to **Enabled**.) Use the keypad to specify a daily production cutoff value in barrels.

Press the **Save** button to save new or changed values, and then press the **Next** button to display the next screen.

LWT/PIP Parameters 2/3 Screen

This is the second of three LWT/PIP Parameters screens.

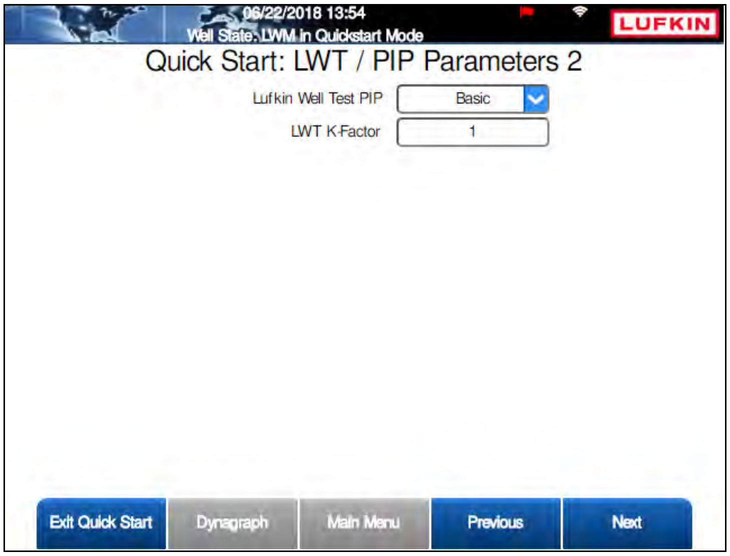


Figure 5-20. Quick Start: LWT/PIP Parameters Screen (2 of 3)

Details of this screen are discussed below.

Lufkin Well Test PIP Configuration

Select the desired Lufkin Well Test PIP configuration. The two drop-down list options are **Basic** or **Advanced**. These options are discussed below:

- When the **Basic** option is selected, the basic calculation for PIP uses only the pump depth and diameter, tubing fluid gradient, and tubing head pressure. No adjustments are made for effects of gas in solution.

  The Basic option uses the LWT K-Factor parameter as a calibration factor to correct for slippage and shrinkage. Use the keypad to define this value.

- When the **Advanced** option is selected, the following parameters are displayed:
  - **Oil Density Degree API**: This is the oil density expressed in degrees API. Use the keypad to define this value.
  - **Water Specific Gravity**: This is the specific gravity of the produced water. Use the keypad to define this value.
  - **Gas Specific Gravity**: This is the specific gravity of the produced gas. Use the keypad to define this value.
  - **Pump Temperature (°F)**: This is the fluid temperature at the pump intake. Use the keypad to define this value.
  - **Bubble Point Pressure (psia)**: This is the pressure at which gas that has been forced into solution by reservoir pressure will start to break out of solution and form gas bubbles. Use the keypad to define this value.

- **Formation Volume Factor (rb/stb)**: This is the volume of produced fluid will shrink as the ambient pressure decreases and solution gas breaks out of solution. The volume of fluid that passes through the pump barrel reservoir barrel (or rb) may therefore be greater than the volume of fluid production measured at a surface storage unit (stock tank barrel or stb). The shrinkage factor is pump volume divided by surface volume. The formation volume factor is a theoretical shrinkage factor when the fluid is at bubble point pressure rather than actual surface pressure. Use the keypad to define this value.
- **Solution GOR (scf/stb)**: This is a measure of how much gas is evolved from oil (at or above bubble point) as the oil goes from the reservoir pressure and temperature to separator conditions. The units are volume of gas divided by volume of oil at separator conditions. Use the keypad to define this value.

Figure 5-21 shows the Advanced option enabled. Use the keypad to define these values.

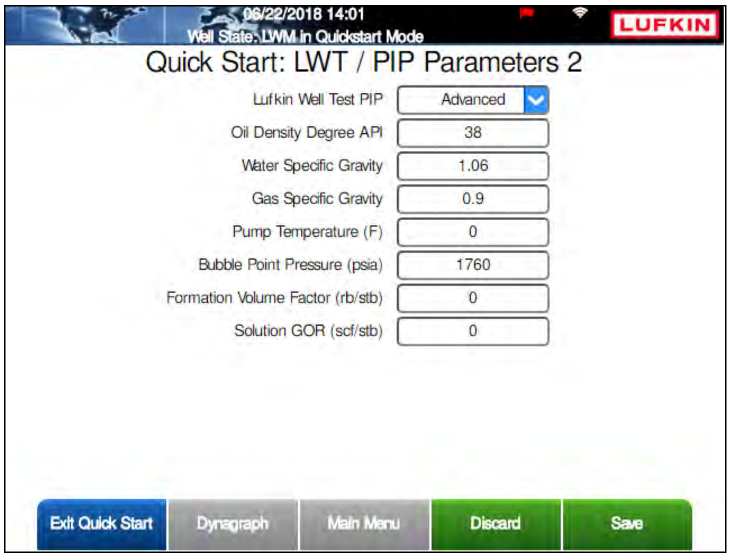


Figure 5-21. Quick Start: LWT/PIP Parameters Screen (2 of 3) – Advanced Option

Reinitialize PIP

This function is used to reinitialize the PIP calculation. It is best practice to execute this command any time that any of the parameters on these two programming screens are changed. To execute this command, use the down arrow key to highlight the button and then press <**ENTER**>. Using the down arrow key, select the **Reinitialize PIP** button and press <**Enter**>.

Press the **Save** button to save the new values.

Press the **Next** button to display the next screen.

LWT/PIP Parameters 3/3 Screen

This is the third LWT/PIP Parameters screen.

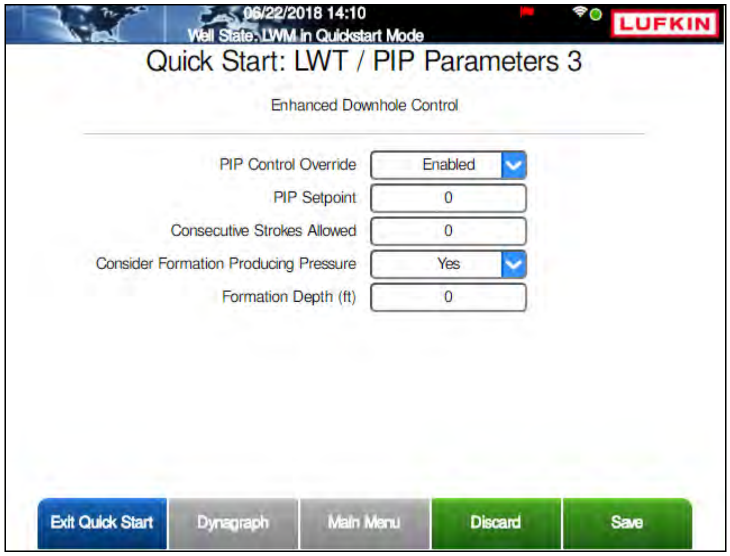


Figure 5-22. Quick Start: LWT/PIP Parameters Screen (3 of 3)

The LWM 2.0 RPC is capable of cycling the well based on the calculated PIP. If the calculated PIP falls below the PIP setpoint (described below), the pumping unit will be shut down for a downtime cycle even though the calculated pump fillage is greater than the fillage setpoint.

The PIP Control Override feature is disabled by default. Select **Enabled** to enable this feature. The following fields appear when this feature is enabled:

- **PIP Setpoint**: Specify the low limit for calculated PIP. If the calculated PIP falls below the specified number of strokes in the Consecutive Strokes Allowed field (see below), the pumping unit will be stopped for a downtime cycle.

  Use the keypad to define the pump intake pressure setpoint.

- **Consecutive Strokes Allowed**: Specify the number of consecutive pump strokes that the calculated PIP must be below the PIP setpoint before the pumping unit is stopped. Use the keypad to define the number of consecutive strokes allowed before the override is activated.

- **Consider Formation Producing Pressure**: Specify whether you want to use the Consider Formation Pressure query feature. Select **Yes** if the pump is set above “mid-perfs.”

Note: When **Yes** is selected, the Formation Depth field appears below it.

- **Formation Depth**: (This field is only visible when the **Consider Formation Producing Pressure** parameter is enabled.) Use the keypad to specify the depth of the topmost perforations in feet.

Press the **Save** button to save the parameter changes and then press the **Next** button.

Start Motor

The Start Motor screen is displayed next. This screen enables the operator to start or stop the pumping unit during the configuration process.

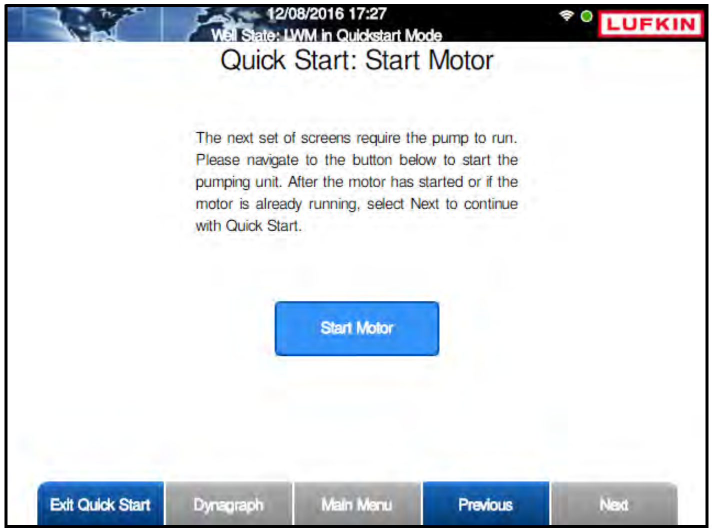


Figure 5-23. Quick Start: Start Motor Screen

WARNING: Make sure all personnel are clear of the pumping unit before starting the motor.

Press <**ENTER**> to start or stop the motor. Once the system detects the motor is running, the **Next** button will turn blue. Press the **Next** button to display the next screen.

Reference NREV Calibration

The Reference NREV screen is the next screen displayed as shown in Figure 5-24.

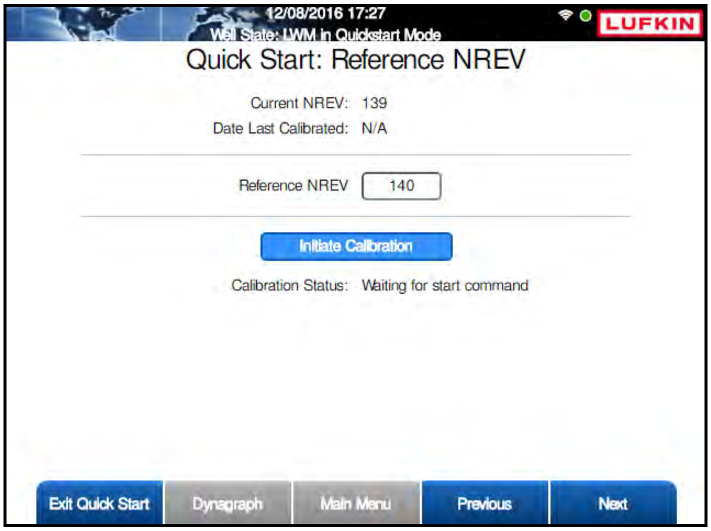


Figure 5-24. Reference Revolution Calibration Screen

In order for some control features to work properly, the LWM 2.0 RPC needs to know the number of motor revolutions required per pump cycle under normal pumping. If the diameter of either drive belt sheave is changed, the pumping speed will change, requiring recalibration of this reference revolution (Ref NREV) parameter.

The following status information is shown on this screen:

- Current Reference Revolution Reading
- Date of Last Calibration
- Reference NREV
- Reference Revolution Calibration Status
- Calibration Elapsed Time

If reference revolution calibration is needed, use the arrow keys to highlight the **Initiate Calibration** button. Press <**ENTER**> to start the calibration procedure. Watch the **Ref Rev Calibration Status** field to check progress of the automatic calibration operation. When the operation is completed, the status field reads SUCCESSFUL.

To stop the calibration operation, use the arrow keys to highlight the **Abort** button and then press <**ENTER**> on the keypad.

Press the **Next** button to display the next screen.

Dynagraph Configuration

The Dynagraph configuration screen is the next screen displayed.

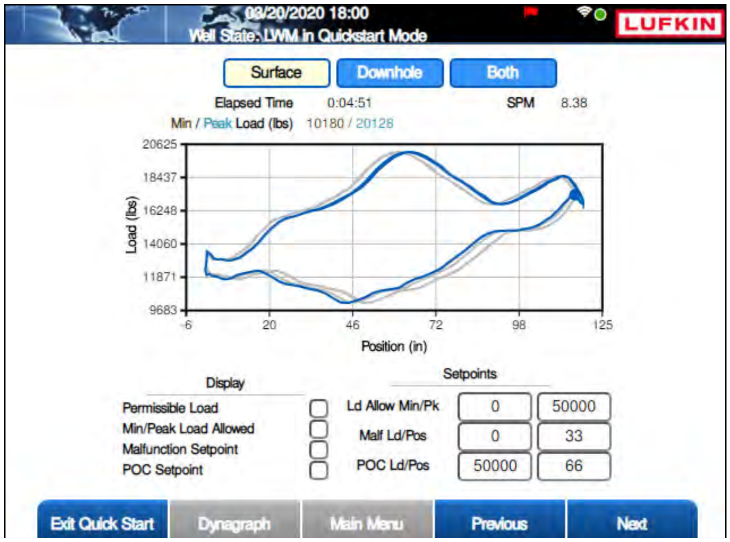


Figure 5-25. Quick Start – Dynagraph Card Configuration Screen

This screen shows a real-time dynagraph of the load and position data recorded during pumping operation. Three dynagraph display options are provided:

- **Surface**: This button displays the Surface card. This card and its functions are described below.
- **Downhole**: This button displays the Downhole card. See “Downhole Card” on page 5-34 for details on this card and its functions.
- **Both**: This button displays a combined view of the surface and downhole cards. See “Both Cards” on page 5-35 for more details.

Use the arrow keys to highlight the desired display option and then press <**ENTER**>.

Surface Card

The Surface Card shown in Figure 5-25 is displayed by default. This card shows a real-time dynagraph of the surface load and position data recorded during pumping operation. Relevant status information is also displayed.

Display Options

The Surface Card has several options for displaying load and setpoint data. These are described on the following pages.

- **Permissible Load**: This check box provides the option of displaying the defined permissible load values. See “Surface Card Setpoints” on page 5-32 for details on configuring these parameters.

  Press the down arrow to highlight the **Permissible Load** check box and then press <**ENTER**> to select this option. The Permissible Load data is displayed in red on the card.

  To hide these values, clear the **Permissible Load** check box using the same method described above.

- **Min/Peak Load Allowed**: This check box provides the option of displaying the minimum and the maximum allowed values for load input. See “Surface Card Setpoints” on page 5-32 for details on configuring these parameters.

  Press the down arrow to highlight the **Min/Peak Load Allowed** check box and then press <**ENTER**> to select this option. The Min/Peak Load Allowed values are displayed as horizontal lines on the card.

  To hide these values, clear the **Min/Peak Load Allowed** check box using the same method described above.

- **Malfunction Setpoint**: This check box provides the option of displaying the Malfunction Setpoint value on the dynagraph. See “Surface Card Setpoints” on page 5-32 for details on configuring the parameters for this setpoint.

  Press the down arrow to highlight the **Malfunction Setpoint** check box and then press <**ENTER**> to select this option. The Malfunction Setpoint value is displayed as a purple square on the card.

  To hide this setpoint, clear the **Malfunction Setpoint** check box using the same method described above.

- **POC Setpoint**: This check box provides the option of displaying the POC Setpoint value on the dynagraph. See “Surface Card Setpoints” for details on configuring the parameters for this setpoint.

  Press the down arrow to highlight the **POC Setpoint** check box and then press <**ENTER**> to select this option. The POC Setpoint value is displayed as a green diamond on the card.

  To hide this setpoint, clear the **POC Setpoint** check box using the same method described above.

Surface Card Setpoints

The configurable surface card setpoints are as follows:

- **Ld Allow Min/Pk**: These setpoints set the minimum and peak load allowed during operation. If the load exceeds the peak load setpoint or drops below the minimum load setpoint, the controller instantly shuts down the pumping unit with no consecutive stroke delay.

  The setpoint parameters are as follows:

  - **Allowed Minimum Load**: The left parameter field sets the minimum load allowed during operation. If the load drops below this limit, the controller instantly shuts down the pumping unit with no consecutive stroke delay.
  - **Allowed Peak Load**: The right parameter field sets the maximum load allowed during operation. If the load exceeds this limit, the controller instantly shuts down the pumping unit with no consecutive stroke delay.

  To change these parameters, do the following:

  a. Use the arrow keys to highlight the desired parameter field and then press <**ENTER**>.

b. Use the keypad to define the parameter value and then press <**ENTER**> again.

Note: The controller automatically scales the dynagraph screen to show both Allowed Peak and Allowed Min Load. If the programmed values are far above or below the actual working peak and minimum loads, the dynagraph trace on the screen will be fairly small. To obtain a larger dynagraph trace, configure the Allowed Peak and Allowed Min Load values to within 15 percent or 25 percent above/below the working loads.

- **Malf Ld/Pos**: These setpoints are used to check for rod parts or other pump malfunctions that cause no fluid load to be picked up by the pump. If the load falls below the Malfunction load setpoint in the upstroke, the controller counts that as a violation of the setpoint. The number of consecutive Malfunction Strokes Allowed can be configured on the Operational Limits 1 screen. (See “Operational Limits 1 Screen” on page 10-26 for details on this screen.)

  The configurable parameters are:

  - **Load** – The left parameter field sets the minimum load weight allowed during operation.
  - **Position (inches)** – The right parameter field sets the minimum distance the rod must move during operation.

  To change these parameters, do the following:

  a. Use the arrow keys to highlight the desired parameter field and then press <**ENTER**>.

  b. Use the keypad to define the parameter value and then press <**ENTER**> again.

  The malfunction setpoint is displayed as a black square on the dynagraph.

- **POC Ld/Pos Setpoint**: This setpoint is the pump off control **“**limit**”** for the Surface control mode. When the load goes above the POC setpoint in the downstroke, the controller counts that as a pump off stroke. The consecutive number of pump off strokes allowed is specified with the RPC Control Parameter programming screen.

  The parameters for this setpoint are:

  - **Load (lbs)** – the maximum load weight allowed during operation
  - **Position (inches)** – the maximum distance the rod can move during operation

  To change these parameters, do the following:

  a. Use the arrow keys to highlight the desired parameter field and then press <**ENTER**>.

  b. Use the keypad to define the parameter value and then press <**ENTER**> again.

  The POC setpoint is displayed as a round black dot on the dynagraph.

Downhole Card

The Downhole card displays a realtime live trace of the well's downhole activity. Relevant status data is also displayed at the top and lower left sides of the screen. Figure 5-26 shows an example of this card.

Figure 5-26. Quick Start – Dynagraph Configuration Screen (Downhole Card)

The configurable downhole card parameters are as follows:

- **Pump Fillage**: This value is the pump off shutdown level when Downhole Control mode is selected.
- **DH Press Low Limit (psi)**: This value sets the minimum downhole pressure level for the Downhole Pressure control mode.
- **2ry Pump Fillage**: This value is the secondary pump off shutdown level for the Downhole Control mode.
- **Fluid Load**: This value is the Low limit for the fluid load control function. See "Current Fluid Load" on the previous page.
- **Fill Base**: This value is the full range load percentage of the downhole card at which the controller, in the downstroke, starts to look for the slope change indicating plunger contact with fluid in the pump barrel. The adjustable fill base allows the controller to find accurate net stroke with a variety of unusual pump conditions. If net stroke calculation results do not appear to be reasonable, adjust the fill base up or down for more logical results. Zero percentage is the minimum load value for the downhole card. The default value of 45 will work for most wells.

To change these parameters, do the following:

1. Use the arrow keys to highlight the desired parameter and then press <**ENTER**>.
2. Use the keypad to define the parameter value and then press <**ENTER**> again.

Both Cards

The Both display option shows a split-screen realtime live trace of both surface and downhole activity.

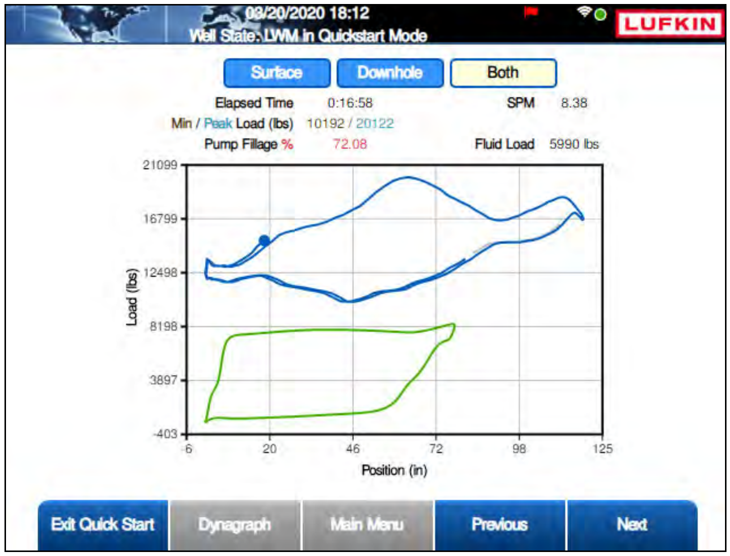


Figure 5-27. Both Cards Displayed

This screen displays status information only and is not configurable.

Press the **Next** button to display the next screen.

Completing the Quick Start Procedure

The next screen indicates successful completion of the Quick Start configuration process. Press the **Exit Quick Start** button to exit Quick Start and return to the Main Menu screen.

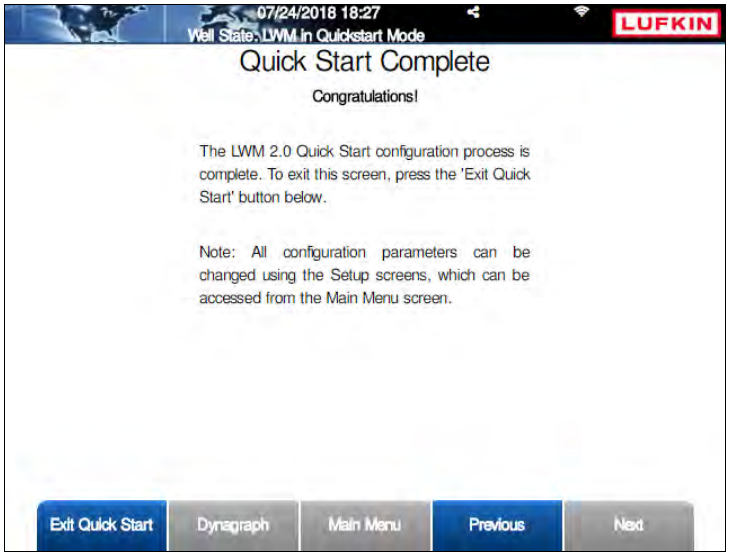


Figure 5-28. Quick Start Complete Screen

Note: The pumping unit will continue running after exiting the Quick Start process. Turn the HOL switch to the **OFF** position if the pumping unit is required to be off.

Section 6: Operation

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Section Overview

This section discusses operation of the LWM 2.0 controller. The functions discussed in this section are available on the Main Menu screen shown in Figure 6-1 below.

Figure 6-1. Main Menu Screen

System Starting and Stopping

The pumping system can be started or stopped at the controller using the **Normal Mode Start/ Stop** button on the Main Menu screen. (See Figure 6-1 above.) The action this command executes is based on the current state of the well. For example, if the well is pumping, this is a stop command; if the well is stopped, this is a start command.

After pressing the **Normal Mode Start/Stop** button from the Main Menu screen, one of the following messages displays for five seconds:

- When the system is operating, the **Motor Stop** message appears at the top of the screen, indicating that the system is shutting down.
- When the system is shut down, the **Motor Start** message appears at the top of the screen, indicating that the system is starting.
- When the system is stopped, the Well State field at the top of the screen reads **DT – Operator Stop**.

WARNING: The **DT-Operator Stop** well state is a temporary well state. The pumping unit will automatically restart after the programmed downtime elapses. Keep all personnel clear of the pumping unit when the controller is in this well state. Failure to heed this warning can result in severe injury or death.

When the controller starts the pumping system, the system goes through the following sequence of well states:

1. **Starting Alert**: The system sounds an audible alert and waits a programmed number of seconds before sending the command to start the pump motor.
2. **Starting Unit**: The controller sends the command to start the pump motor and waits for position input and load input signals to verify that the motor is running.
3. **Minimum Pump Strokes**: The controller waits for the pumping unit to pump for a programmed number of strokes before it starts analyzing the dynagraph data.
4. **Pumping-Normal Mode**: The system begins pumping with all enabled functions active. The controller remains in this well state until a setpoint violation or malfunction occurs.

Reset Malfunction

When the controller is in a malfunction state, the malfunction must be cleared. To reset malfunctions and restart the pumping system, press the **Reset Malfunction** button on the Main Menu screen. (See Figure 6-1 on page 6-3.)

WARNING: The pumping unit will immediately restart when the **Reset Malfunction** button is pressed. Keep all personnel clear of the pumping unit when the controller is in this well state. Failure to heed this warning can result in severe injury or death.

Log In/Log Out

The LWM 2.0 controller provides the option of restricting access to system configuration and well control functions. This feature is disabled by default. Refer to the section titled “Manage Users” on page 7-12 for information on setting up user access.

From the Main Menu screen, press the **Log In/Log Out** button to log in or log out of the system.

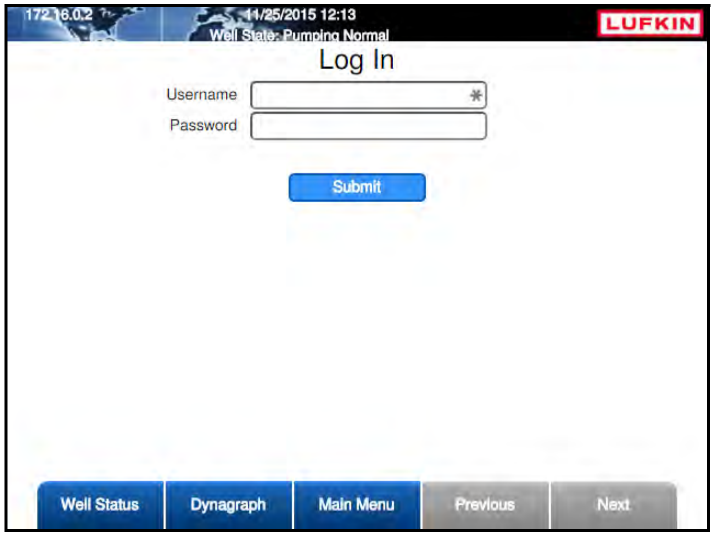

Figure 6-2. Log In Screen

If password protection is enabled, log into the system using the following steps:

1. With the **Username** field highlighted, press <**ENTER**>. Use the keypad to type the username and then press <**ENTER**> again. If logging in as an administrator, type **ADMINISTRATOR** as the username.

Note: Press the <**ALT**> key to switch the keypad input method from numbers to letters.

2. Press the down arrow to highlight the **Password** field and then press <**ENTER**>. Use the keypad to type the password and then press <**ENTER**> again.

You are now logged into the system.

Section 7: System Configuration

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Section Overview

This section discusses the system configuration of the LWM 2.0 controller. Basic functions like setting current date and time, units of measurement, password setup, and sleep configuration are all needed to ensure accurate data analysis by the controller.

Note: This manual describes the functions included in Version 1.34 of the LWM 2.0 firmware.

System Menu Screens

From the Main Menu screen, press the **System** button to display the first of two system configuration screens shown in Figure 7-1.

Figure 7-1. System 1 Menu Screen

From the first System menu screen, press the **Next** button to display the second System menu screen shown in Figure 7-2.

Figure 7-2. System 2 Menu Screen

The options available on these screens are discussed on the following pages.

Date and Time

From the System 1 screen, press the **Date/Time** button to display the Date/Time Configuration screen.

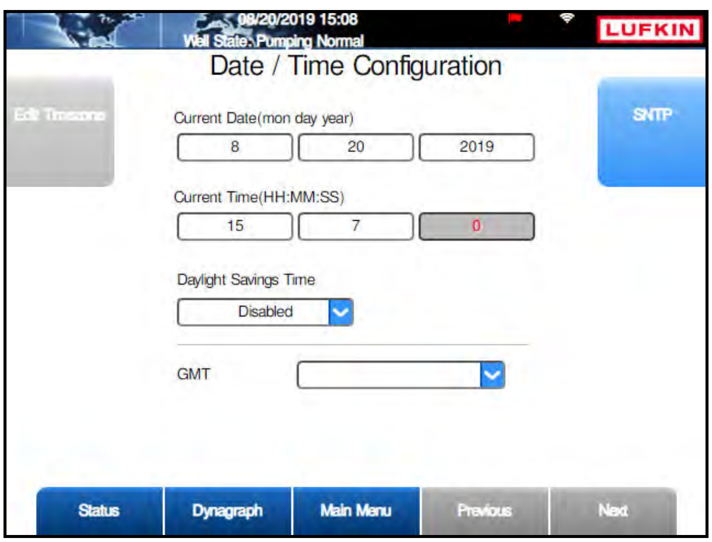

Figure 7-3. Date/Time Configuration Screen

Use the arrow keys to navigate to the desired field. Use the number keys to define the correct date and time and then press <**ENTER**>.

This screen provides two options for selecting time zones. These are discussed in the following sections.

Daylight Savings Time

To enable the Daylight Savings Time feature, use the arrow keys to highlight the **Daylight Savings Time** field and then press <**ENTER**>. Press the down arrow to select the **Enabled** option and then press <**ENTER**> again.

The **Edit Timezone** button will then become active. Perform the following steps to configure the time zone:

1. Press the **Edit Timezone** button to display the Time Zone Configuration screen shown in Figure 7-4.

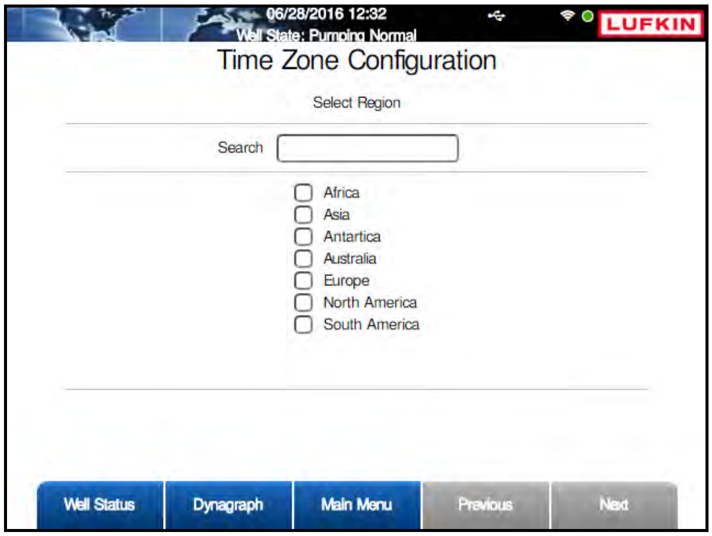

Figure 7-4. Time Zone Configuration Screen – Select Region

2. Select the appropriate region and then press the **Next** button.
3. In the screen shown in Figure 7-5, select the desired location and then press the **Next** button.

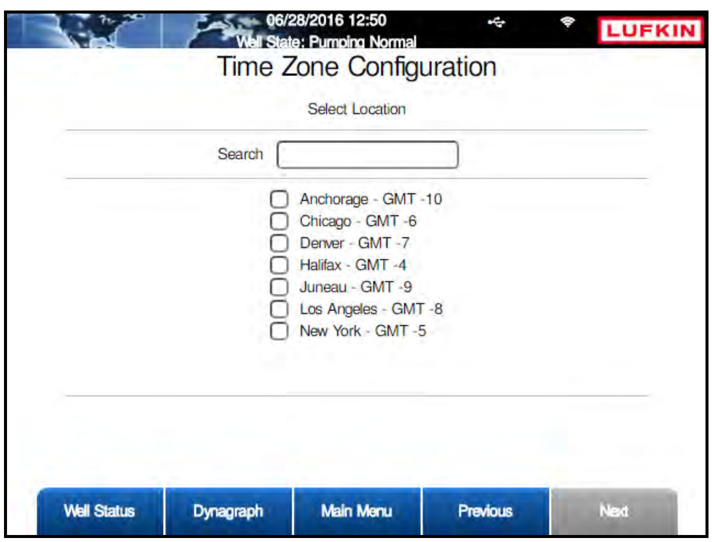

Figure 7-5. Time Zone Configuration Screen – Select Location

4. Press the **Save** button to save the selected time zone configuration.

Greenwich Mean Time (GMT)

Use the arrow keys to highlight the GMT drop-down list and then press <**ENTER**>. Use the down arrow to highlight the desired time zone and then press <**ENTER**> again.

Press the **Save** button to save the selected time zone configuration.

Simple Network Time Protocol (SNTP)

The Simple Network Time Protocol is used to synchronize the LWM 2.0 controller's clock when it is connected to a network.

From the Date/Time Configuration screen, press the **SNTP** button to display the SNTP Configuration screen shown in Figure 7-6.

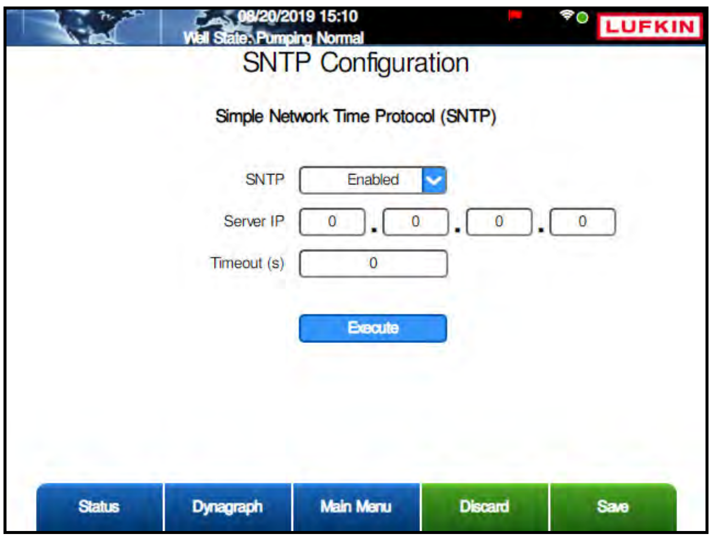

Figure 7-6. SNTP Configuration Screen

To enable the SNTP feature, use the arrow keys to highlight the **SNTP** field and then press <**ENTER**>. Press the down arrow to select the **Enabled** option and then press <**ENTER**> again.

The following parameters will appear:

- **Server IP**: Use the keypad to type the IP address of the SNTP server.
- **Timeout(s)**: Use the keypad to set the time, in milliseconds, that the controller waits after sending a poll message to the SNTP server.

Press the **Execute** button to send an initial poll message to the SNTP server.

Press the **Save** button to save the new values and then press <**ESC**> to return to the Date/Time Configuration screen.

Version and Serial Number

From the System 1 menu screen, press the **Ver and SN** button to display the Version and Unit Serial Number screen shown in Figure 7-7.

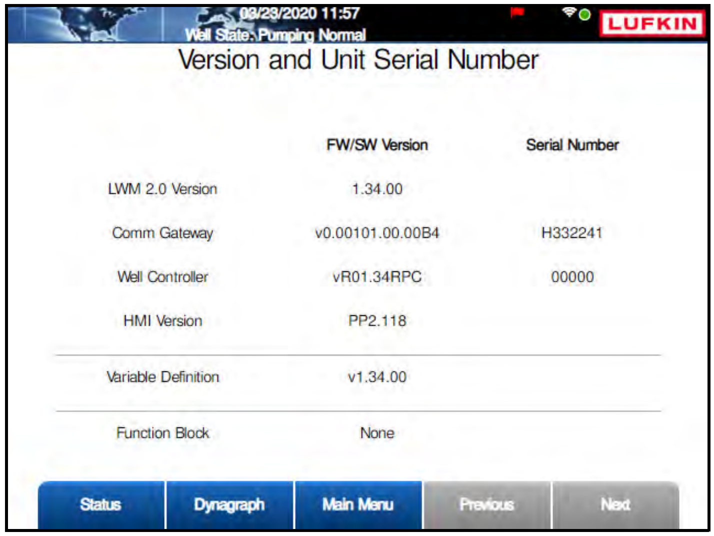

Figure 7-7. Version and Unit Serial Number Screen

This screen displays the firmware and software versions and serial numbers for the main components of the controller. The software variable definition version number and available function blocks are also displayed.

Press <**ESC**> to return to the System 1 menu screen.

Reset Settings

This screen provides options for resetting the controller’s parameters and alarms to a factory-default value. Normally, parameters and alarms do not need to be reset, but this feature is useful in some cases.

Note: This function erases all user-defined parameters. Once the controller is reset, each parameter must be reprogrammed one field at a time for your particular well application.

From the first System menu screen, press the **Reset Settings** button to display the Reset Settings screen shown in Figure 7-8 on page 7-8.

Figure 7-8. Reset Configurations Screen

Resetting Controller Parameters

With the **Reset Setting Options** field highlighted, press the <**ENTER**> key to display the drop-down list. There are two options:

- Reset to Manufacturer Settings
- Reset to Default Settings
- Reset to AGA Config Default Settings

Use the arrow keys to select the desired option and then press <**ENTER**>. In the pop-up window that appears, use the arrow keys to highlight **OK** and then press <**ENTER**> again. See Figure 7-9 for an example.

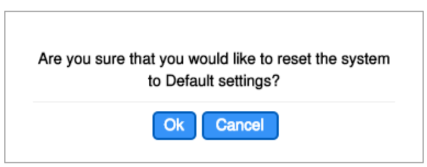

Figure 7-9. Reset Confirmation Pop-Up Window

Resetting Alarms

Use the down arrow to highlight the **Reset Alarm** field and then press <**ENTER**> to display the drop-down list. There are four options available:

- Clear App/Function Block
- Clear AI Alarms
- Clear DI Alarms
- Clear All Alarms

Use the arrow keys to select the desired option and then press <**ENTER**>. In the pop-up window that appears, use the arrow keys to highlight **OK** and then press <**ENTER**> again. See Figure 7-9 for an example.

Figure 7-10. Reset Alarm Pop-Up Window

Reset Event Log

Use the down arrow to highlight the **Reset Event Log** field and then press <**ENTER**> to display the drop-down list. There are five options available:

- Clear RPC Event Log
- Clear Alarm Event Log
- Clear RPC Timestamped Events
- Clear Shutdown Event Log
- Clear All Event Logs

Use the arrow keys to select the desired option and then press <**ENTER**>. In the pop-up window that appears, use the arrow keys to highlight **OK** and then press <**ENTER**> again. See Figure 7-11 for an example.

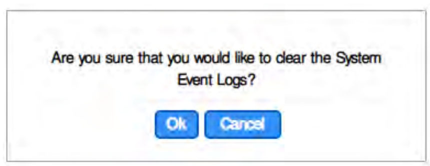

Figure 7-11. Reset Event Pop-Up Window

Unit Preferences

From the first System menu screen, press the **Unit Preferences** button to display the first of two Unit Preferences screens shown below. These screens enable the operator to set how measured values are displayed.

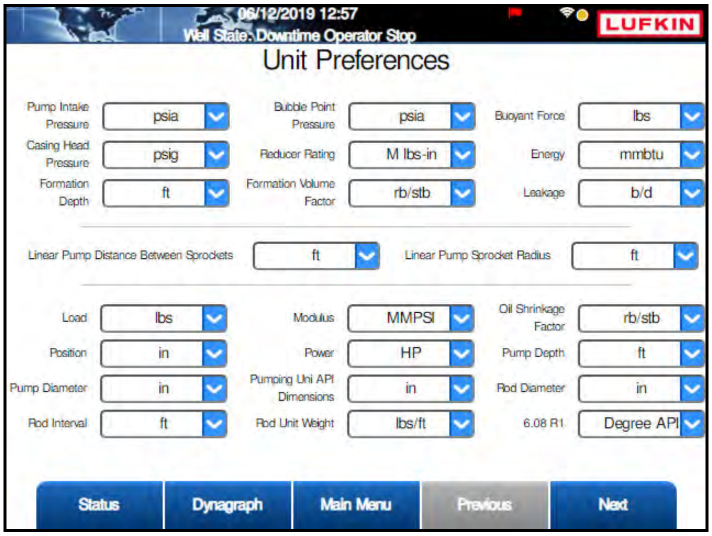

Figure 7-12. Unit Preferences Screen (1 of 2)

Press the **Next** button to display the second Unit Preferences screen shown in Figure 7-13.

Figure 7-13. Unit Preferences Screen (2 of 2)

When the controller is first commissioned, all operational parameters in the status screens display their values in engineering units specified at the factory. These screens can be used to change the engineering units displayed for many operational parameters. For example, length can be displayed in meters instead of feet and volume in cubic meters instead of barrels.

To change these values, use the arrow keys to highlight the parameter to be changed and then press <**ENTER**>. Select the desired value from the drop-down list and then press <**ENTER**>.

The table below lists the engineering units available for the following operational parameters.

Available Engineering Units

Operational Parameter	Engineering Units Available
Atmospheric Pressure	psia, MPa, bar, kg/cm^2, ATM, kPa
Bubble Point Pressure	psia, MPa, bar, kg/cm^2, ATM, kPa
Buoyant Force	lbs, N
Casing Head Pressure	psig, MPa, bar, kg/cm^2, ATM, kPa
Counter Balance	k in-lbs, N-m
Energy	MMBTU, gJ
Formation Depth	ft, m
Formation Volume Factor	rb/stb, m^3/m^3
Leakage	b/d, m3/d
Linear Pump Distance Between Sprockets	ft, m
Linear Pump Sprocket Radius	ft, m
Load	lbs, kg
Modulus	MMPSI, GPa
Oil API (density)	Degree API, kg/L, kg/m^3
Oil Shrinkage Factor	rb/stb, m^3/m^3
Position	in, cm
Power	hp, kW
Pump Depth	ft, m
Pump Diameter	in, cm, mm
Pump Intake Pressure	psi, MPa, bar, kg/cm^2, ATM, kPa
Pumping Unit API Dimensions	in, cm
Rod Diameter	in, cm, mm
Rod Interval	ft, m
Rod Unit Weight	lbs/ft, kg/m
Solution GOR	scf/stb, m^3/m^3
Stroke Length	in, cm, m
Stuffing Box Friction	lbs, N
LWT Cutoff Control	bbls, metric tonnes, m^3
LWT Fluid	bbls, metric tonnes, m^3
LWT Oil	bbls, metric tonnes, m^3
LWT Tubing Gas	mscf, m^3
LWT Water	bbls, metric tonnes, m^3
Temperature	degrees F, degrees C
Torque	k in-lbs, kN-m
Tubing Anchor Depth	ft, m
Tubing Gas Produced	cf, m^3
Tubing Gas/Liquid Ratio	scf/stb, m^3/m^3

Available Engineering Units (Continued)

Operational Parameter	Engineering Units Available
Tubing Gradient	psi/ft, MPa/m, bar/m, (kg/cm^2)/m, ATM/m
Tubing Head Pressure	psig, MPa, bar, kg/cm^2, ATM, kPa
Tubing Movement	in, cm, m
Tubing Size	in, cm, mm
Viscosity	cP, Pa-s

Press <**ESC**> to return to the System 1 menu screen.

Manage Users

From the first System screen, press the **Manage Users** button to access the user management functions. When this button is first pressed, the screen shown in Figure 7-14 is displayed.

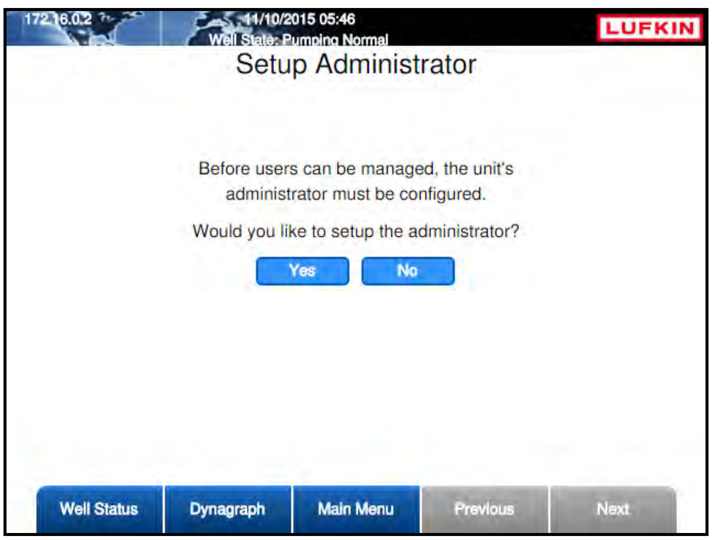

Figure 7-14. Set Up Administrator Screen

Administrator access must be configured before the user management functions can be accessed. With the **Yes** button highlighted on the screen, press <**ENTER**> to display the Setup Administrator screen shown in Figure 7-15.

Figure 7-15. Setup Administrator Screen

By default, the controller does not require a password. This screen allows the operator to set up administrator access privileges in order to prevent unauthorized changes being made to the system.

To create a new administrator password, perform the following steps:

1. With the **Default Password** field highlighted, press <**ENTER**> to edit the field. Use the keypad to type the default password (**PASS123**) and then press <**ENTER**> again.

Note: Press the <**ALT**> key to switch the keypad input method from numbers to letters.

2. Use the down arrow key to highlight the **New Password** field and then press <**ENTER**>. Use the keypad to type the desired password and then press <**ENTER**> again.

Note: There is no limit to the number of characters required for a password. Any combination of letters (A–Z) and numbers (0–9) can be used.

3. Use the down arrow key to highlight the **Confirm Password** field and then press <**ENTER**>. Using the keypad, retype the password that was used in the previous step and then press <**ENTER**> again.
4. Use the down arrow key to highlight the **Submit** button and then press <**ENTER**>.

This password will be used to log in on the main screen. See “Log In/Log Out” on page 6-5 for more information on this function.

Note: After the first password setup procedure has been performed, this password will be required to access or change the functions displayed on the System menu screen.

The user management functions are now available. These functions are discussed in the following sections.

Add User

Note: This function requires the administrator to be logged into the system. See “Log In/Log Out” on page 6-5 for details.

From the Manage Users menu screen, press the **Add User** button to display the Add User screen shown in Figure 7-16.

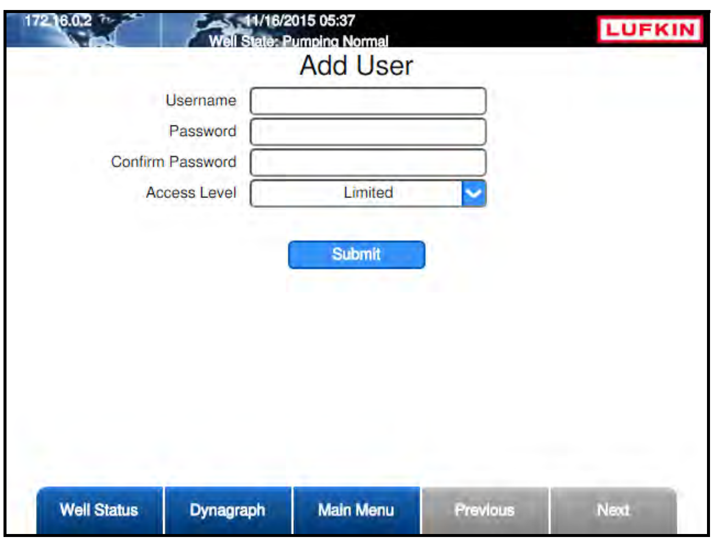

Figure 7-16. Add User Screen

This screen allows the administrator to set up controller access for individual users. Each user is assigned a username and password with limited or full access to system functions.

Perform the following procedure to add a new user profile:

1. With the **Username** field highlighted, press <**ENTER**> to edit the field. Use the keypad to type the username and then press <**ENTER**>.

Note: Press the <**ALT**> key to switch the keypad input method from numbers to letters.

2. Use the down arrow key to highlight the **Password** field and then press <**ENTER**>. Use the keypad to type the desired password and then press <**ENTER**> again.
3. Use the down arrow key to highlight the **Confirm Password** field and then press <**ENTER**>. Using the keypad, retype the password that was used in the previous step and then press <**ENTER**> again.
4. Use the down arrow key to highlight the **Access Level** field and then press <**ENTER**> to display the drop-down list. Two access levels are available:
   - **Limited** – Provides access to basic system functions and RPC parameters.
   - **Full** – Provides full access to all system functions and RPC parameters.

   Use the down arrow key to highlight the desired option and then press <**ENTER**> again.
5. Use the down arrow key to highlight the **Submit** button and then press <**ENTER**>.

Remove User

Note: This function requires the administrator to be logged into the system. See “Log In/Log Out” on page 6-5 for details.

From the Manage Users menu screen, press the **Remove User** button to display the Remove User screen shown in Figure 7-17.

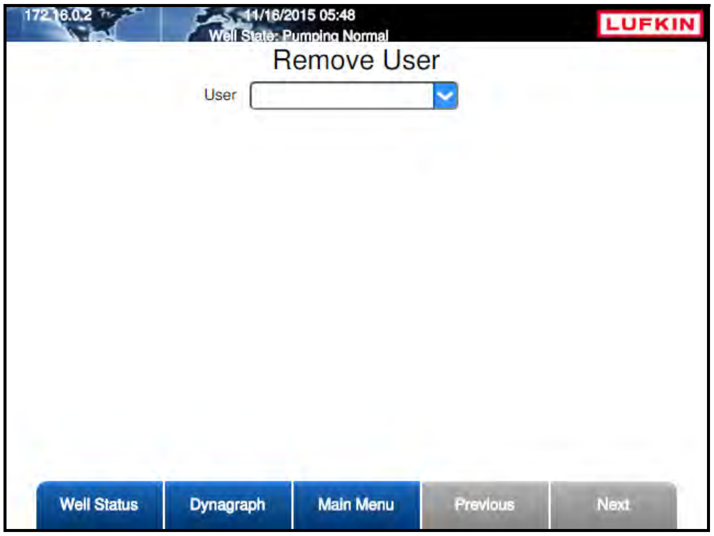

Figure 7-17. Remove User Screen

With the **User** field highlighted, press <**ENTER**> to display the drop-down list. Use the up or down arrow keys to select the user profile you wish to delete and then press <**ENTER**> again.

Use the down arrow key to highlight the **Submit** button and then press <**ENTER**>.

Edit User

From the Manage Users menu screen, press the **Edit User** button to display the Edit User screen shown in Figure 7-18.

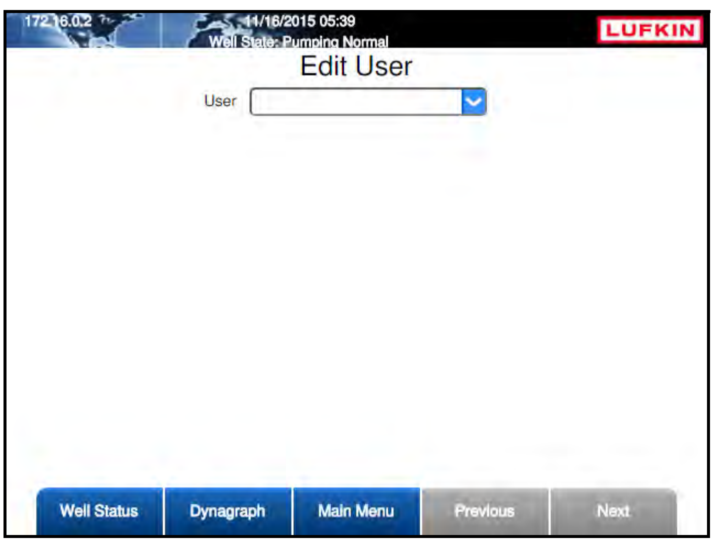

Figure 7-18. Edit User Screen

With the **User** field highlighted, press <**ENTER**> to display the drop-down list. Use the up or down arrow keys to select the user profile you wish to edit and then press <**ENTER**> again.

To change the user password, do the following:

1. Highlight the **Change Administrator Password** field and then press <**ENTER**> to display the drop-down list. Use the up or down arrow keys to select **Yes** then press <**ENTER**> again.

   The **New Password** and **Confirm Password** fields appear when the **Yes** option is selected.
2. Use the keypad to type the new password in the **New Password** field and then press <**ENTER**>.
3. Using the keypad, type the new password again in the **Confirm Password** field and then press <**ENTER**>.
4. Press the down arrow key to highlight the **Access Level** field and then press <**ENTER**> to display the drop-down list. Two access levels are available:
   - **Limited** – Provides access to basic system functions and RPC parameters.
   - **Full** – Provides full access to all system functions and RPC parameters.

   Use the down arrow key to highlight the desired option and then press <**ENTER**> again.
5. Press the down arrow key to highlight the **Submit** button and then press <**ENTER**>.

Edit Administrator Functions

Press the **Edit Admin** button to display the Edit Admin screen shown in Figure 7-19.

Figure 7-19. Edit Administrator Screen

This screen enables the operator to change the administrator password. The procedure is as follows:

1. Highlight the **New Password** field and then press <**ENTER**>. Use the keypad to type the new password in the **New Password** field and then press <**ENTER**>.
2. Use the down arrow key to highlight the **Confirm Password** field and then press <**ENTER**>. Using the keypad, type the new password again in the **Confirm Password** field and then press <**ENTER**>.
3. Use the down arrow key to highlight the **Submit** button and then press <**ENTER**>.

Enable/Disable Users

Press the **Enable/Disable Users** button to display the Enable/Disable Users screen shown in Figure 7-20 below.

Figure 7-20. Enable/Disable Users Screen

This screen allows the administrator to enable or disable user access to the controller. With this feature enabled, user profiles can be created with limited or full access to change system settings.

Perform the following steps to enable or disable user access:

1. With the **User Login** field highlighted, press <**ENTER**> to display the drop-down list. Use the arrow keys to select **Enabled** or **Disabled** and then press <**ENTER**> again.
2. Press the down arrow key to highlight the **Submit** button and then press <**ENTER**>.

Diagnostics

The LWM 2.0 RPC has diagnostic tools available for troubleshooting issues in the controller. From the first System menu screen, press or click the **Diagnostics** button to display the Diagnostics menu screen shown in Figure 7-21.

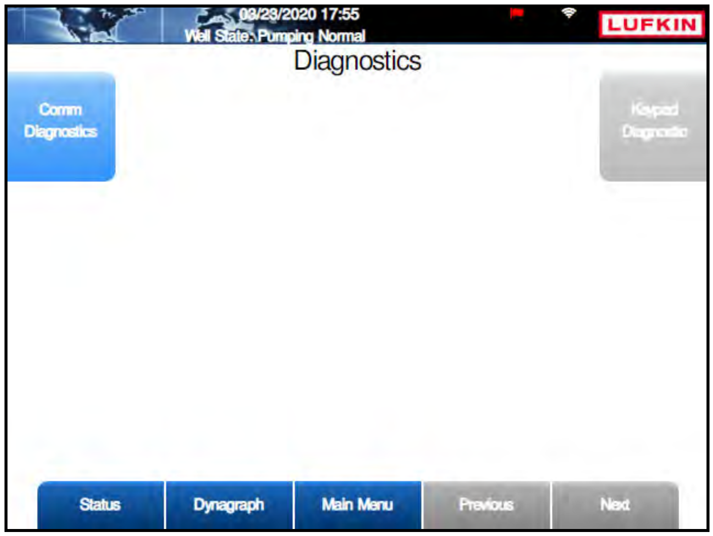

Figure 7-21. Diagnostics Menu Screen

The diagnostic functions are described on the following pages.

Communication Diagnostics

From the Diagnostics menu screen, press or click the **Comm Diagnostics** to display the Comm Diagnostics screen shown in Figure 7-22.

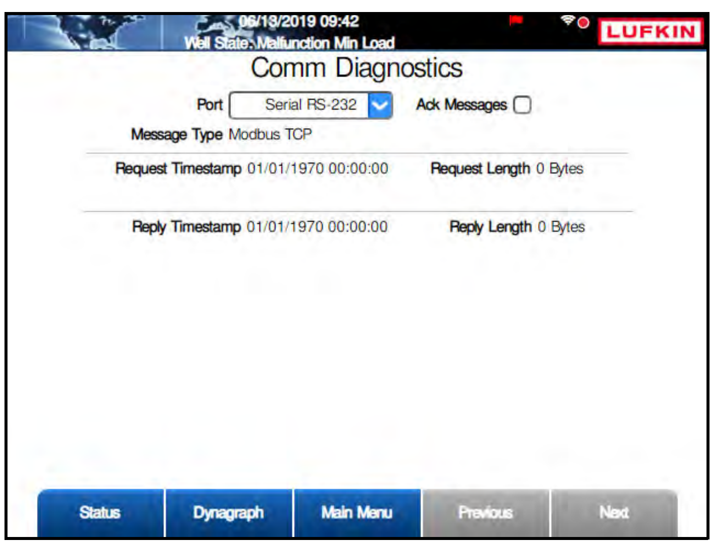

Figure 7-22. Comm Diagnostics Screen

The information displayed on this screen can be used to troubleshoot communication issues in the system.

To view data for each connected port, select **Serial RS-232** or **Ethernet** from the **Port** drop-down list. When finished viewing the data, select the **Ack Messages** checkbox to acknowledge the messages.

Keypad Diagnostic

From the Diagnostic menu screen, press the **Keypad Diagnostic** button to display the Keypad Diagnostic screen shown in Figure 7-23.

Figure 7-23. Keypad Diagnostic Screen

These screen helps you determine if all keys on the controller keypad are operating properly. As you press each key on the membrane keypad, the corresponding square on the Keypad Diagnostic screen lights up. When you press a key and the square representing it does not light up, you need to return the controller to Lufkin Automation for service.

To exit this screen, press and hold the <**ESC**> button for five seconds.

Sleep Configuration

From the second System menu screen, press the **Sleep Config** button to display the Sleep Configuration screen shown in Figure 7-24.

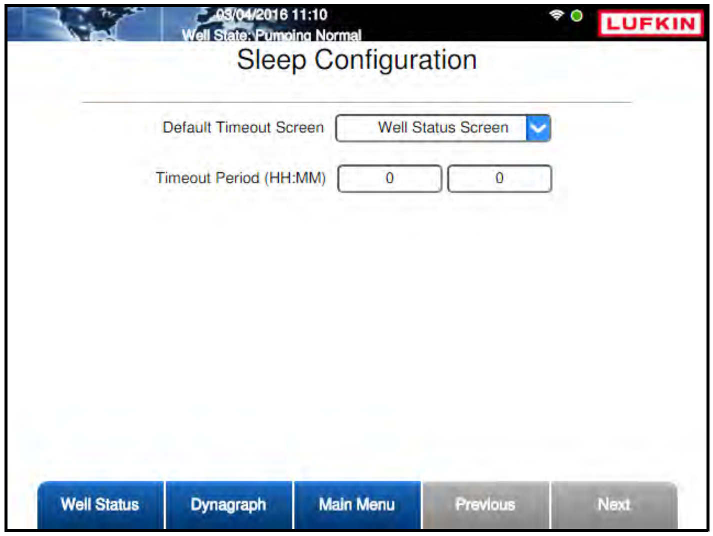

Figure 7-24. Sleep Configuration Screen

This screen sets the time period the controller will display a screen before it reverts back to a user-defined default screen. The default options are:

- Well Status Screen
- Dynagraph Screen
- Main Menu Screen

To select a default timeout screen, press the <**ENTER**> button to display the drop-down list. Use the arrow keys to highlight the desired screen and then press <**ENTER**> again.

The timeout period can be configured in hours or minutes or a combination of both. To configure the timeout period, perform the following steps:

1. Press the down arrow to highlight the hours field and press <**ENTER**>. Use the number keys to define this value and then press <**ENTER**> again. (Skip this step if the desired timeout period is less than one hour.)
2. Press the right arrow to highlight the minutes field and press <**ENTER**>. Use the number keys to define this value and then press <**ENTER**> again.

Press the **Save** button to save the changes.

Advanced Features

From the second System menu screen, press the **Advanced Features** button to display the Advanced Features screen shown in Figure 7-25.

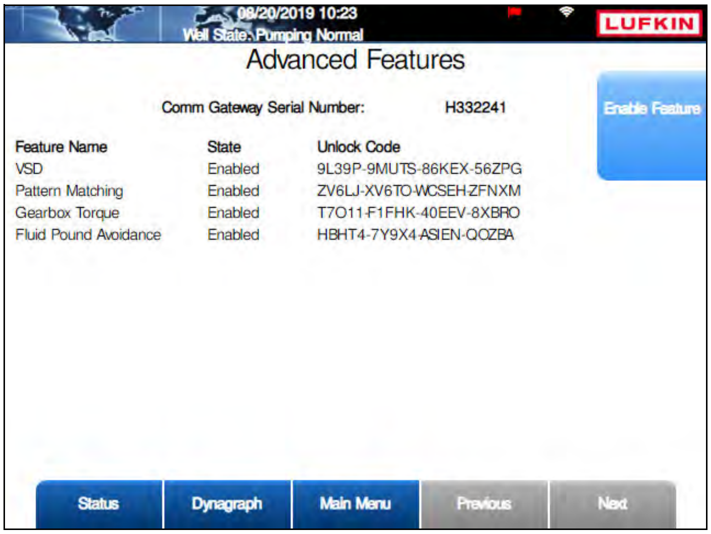

Figure 7-25. Advanced Features Screen

This screen provides access to the controller's advanced features. These features require an unlock code in order to be enabled.

To enable a feature, do the following:

1. Press the **Enable Feature** button to display the Enable Advanced Feature screen shown in Figure 7-26.

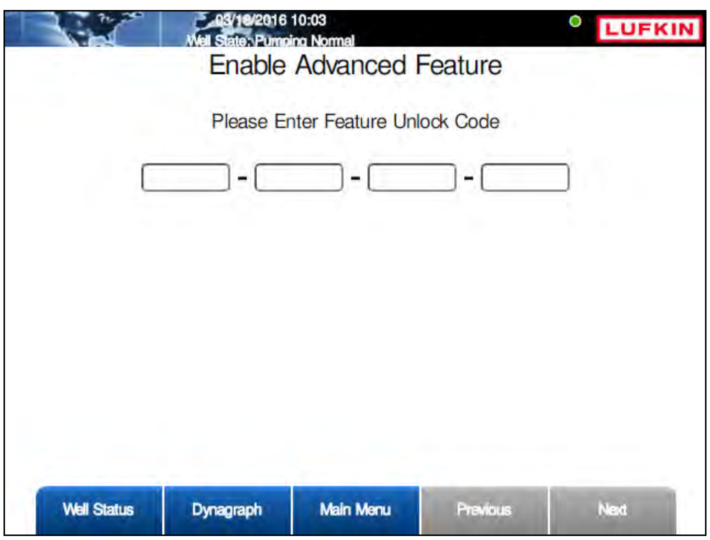

Figure 7-26. Enable Advanced Feature Screen

2. Use the keypad to input the necessary unlock code for the desired feature and then press the **Save** button.

   The feature is now enabled.

USB Card/Register Log

From the second System menu screen, press the **USB Card/Register Log** button to display the USB Card / Register Log screen shown in Figure 7-27.

Figure 7-27. USB Card / Register Log Screen

This screen enables the user to create and store dynagraph cards and register logs onto a removable USB card. These options are discussed below.

To create a register log, perform the following steps:

1. Use the arrow keys to highlight the **Register Log** button and then press <**ENTER**>. The following screen appears:

Figure 7-28. Register Log Screen

2. Use the keypad to define the register addresses to be logged and then press <**ENTER**>.
3. Use the keypad to define the log rate in milliseconds and then press <**ENTER**>.
4. Use the keypad to name the log file and then press <**ENTER**>.

5. Press the **Start Log** button to start recording register data.

To create a card log, perform the following steps:

1. Use the arrow keys to highlight the **Card Log** button and then press <**ENTER**>. The following screen appears:

Figure 7-29. Card Log Screen

2. Use the keypad to define the well state to be recorded and then press <**ENTER**>.
3. Use the keypad to name the log file and then press <**ENTER**>.
4. Press the **Start Log** button to start recording card data.

Press the **Stop Log** button to stop recording data.

Press the **Reset Screen** button to clear the text fields after the logging process is complete.

Section 8: Controller Programming

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Section Overview

Several parameters need to be defined in the LWM 2.0 RPC in order to obtain well control, end device calibration, and downhole calculations. This section describes the RPC programming screens for these parameters and how to access them. For information about VSD programming screens and their functions, contact your local Lufkin Automation representative.

Note: This manual describes the functions included in Version 1.34 of the LWM 2.0 firmware.

Overview of Parameter Programming

Several configuration screens are used to program general parameters that control operations at the well site. Some of the key parameters include:

- End device parameter configuration
- Pumping unit dimensions
- Rod string data
- Control mode (Surface, Downhole, or DH Pressure)
- Operation mode (normal, host, or timed)

General parameter programming must be completed regardless of the type of end devices used in the system or else effective well control, well monitoring, and well data accumulation is not possible.

Note: Lufkin Automation recommends that the initial programming be done using the Quick Start feature. These control parameters can be revised later by accessing the specific programming screens described in this section. For information about Quick Start, see "Quick Start Feature" on page 5-1.

Control parameters are edited (programmed) on a data field basis. To program a parameter, press the arrow keys to highlight the desired parameter field, press <**ENTER**>, and then choose one of the following methods:

- To select an option from a drop-down list, use the arrow keys to highlight the desired option and then press <**ENTER**> again.
- When the parameter is a numerical entry, use the number keys to enter the desired value and then press <**ENTER**> again.

When parameter values are changed, the green **Discard** and **Save** buttons will appear at the bottom of the screen as shown in Figure 8-1.

Figure 8-1. Menu Bar with Discard and Save Buttons

Press the **Save** button to save the programming change or the **Discard** button to discard the change. The **Discard** and **Save** buttons will then be replaced with the **Previous** and **Next** buttons.

All the functions described in this section are accessed from the Setup menu screens shown below. To display these screens, press the **Setup** button on the Main Menu screen.

Figure 8-2. Setup Menu Screen 1 of 2

Press the **Next** button to display the second Setup menu screen shown in Figure 8-3 below.

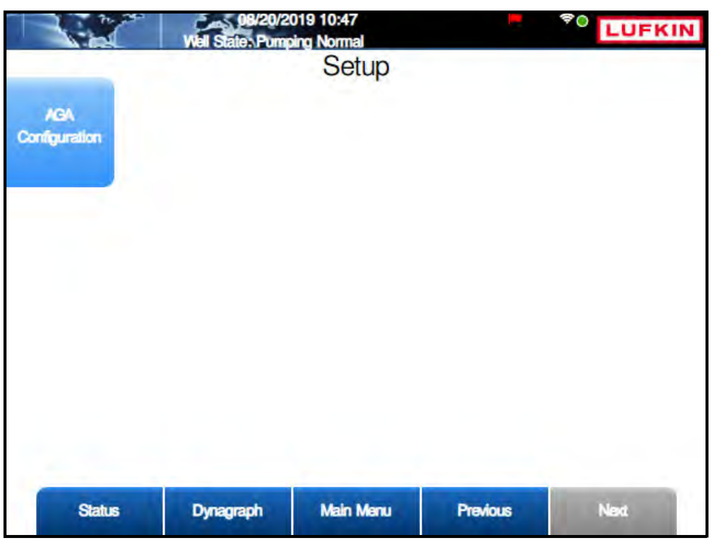


Figure 8-3. Setup Menu Screen 2 of 2

The functions listed on this screen are discussed on the following pages.

RPC Programming

From the first Setup screen, press the **RPC** button to display the RPC menu screen shown in Figure 8-4.

Figure 8-4. RPC Menu Screen

The RPC configuration options are discussed on the following pages.

Site Information

From the RPC menu screen, press or click the **Site Information** button to display the Site Information screen shown in Figure 8-5.

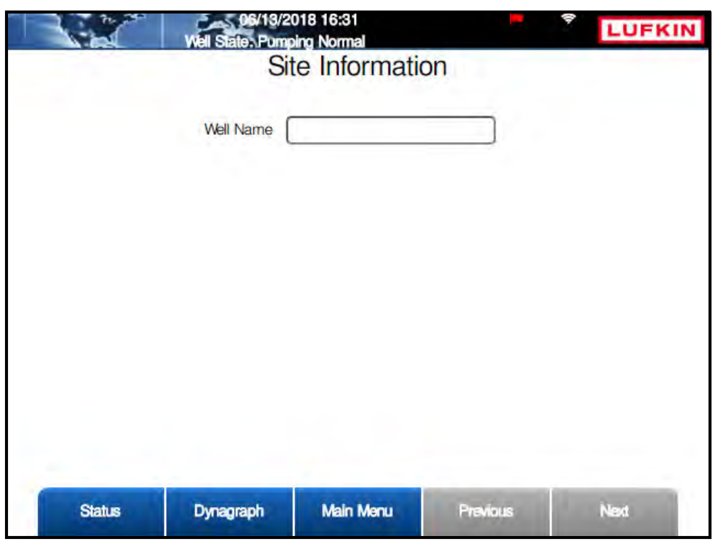


Figure 8-5. Site Information Screen

Type the desired well name in the field and then press or click the **Save** button.

Pumping System Configuration

Press the **Pumping System** button to display the Pumping System Configuration screens. These are discussed in the following paragraphs.

Prime Mover Configuration

The Prime Mover configuration screen is the first screen displayed.

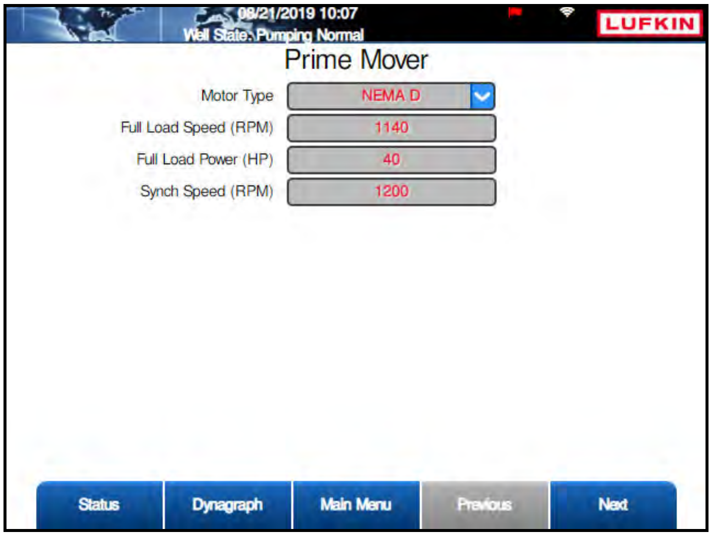


Figure 8-6. Prime Mover Configuration Screen

The prime mover parameters are described below:

- **Motor Type**: Select the motor type from the drop-down list. The available options are **NEMA D** and **Ultra High Slip**.
- **Full Load Speed (RPM)**: Specify the full load RPM rating of the prime mover.
- **Full Load Power (HP)**: Specify the horsepower of the prime mover.
- **Synch Speed (RPM)**: Specify the no-load speed of the motor.

Note: These values are usually listed on the side of the motor.

Press the **Save** button to save the new values, and then press the **Next** button to continue.

Pumping Unit Configuration Screen

This is the second configuration screen.

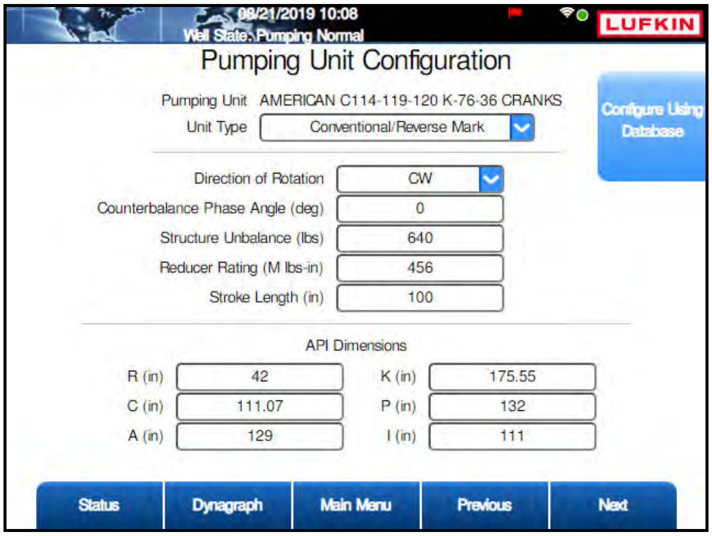


Figure 8-7. Pumping Unit Configuration Screen

The following pumping unit parameters are configured on this screen:

- **Unit Type**: Select the pumping unit type from the drop-down list.
- **Direction of Rotation**: Select the pumping unit's direction of rotation from the drop-down list. **CW** (clockwise) or **CCW** (counterclockwise) are the available options.
- **Counterbalance Phase Angle (deg)**: Use the keypad to define this value and then press <**ENTER**>.
- **Structure Unbalance (lbs)**: Use the keypad to define this value and then press <**ENTER**>.
- **Reducer Rating (lbs)**: Use the keypad to define this value and then press <**ENTER**>.
- **Stroke Length (in)**: Use the keypad to define this value and then press <**ENTER**>.
- **API Dimensions**: Use the keypad to define these values and then press <**ENTER**>.

The **Configure Using Database** button allows a user to select a pumping unit from that database and automatically fill the required dimensional data fields. The database presently contains dimensional data for 1,570 pumping units.

To use this feature, perform the following steps:

1. Press the **Configure Using Database** button to display the Pumping Unit Database screen shown in Figure 8-8 on page 8-8.
2. Select the pumping unit type using one of the following methods:
   - With the **Search** field highlighted, press <**ENTER**>. Use the keypad to input the unit type into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
   - Use the down arrow key to highlight the box next to the desired unit type and then press <**ENTER**>.

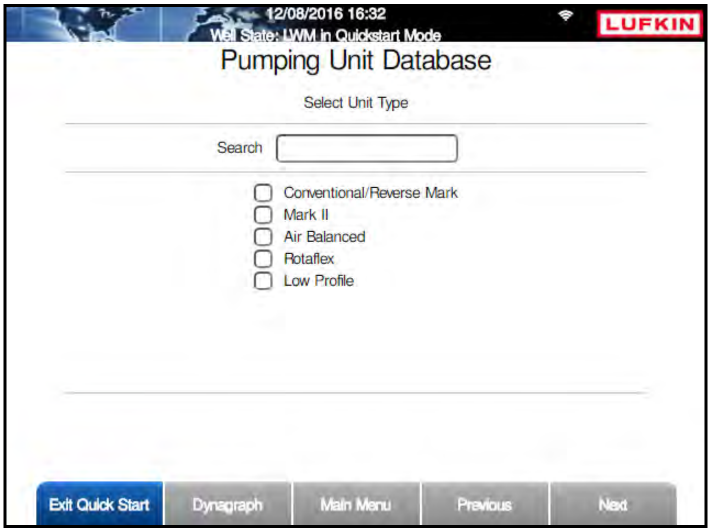


Figure 8-8. Pumping Unit Database – Select Unit Type

Press **Next** to continue.

3. The next screen enables you to select the direction of rotation for the pumping unit.

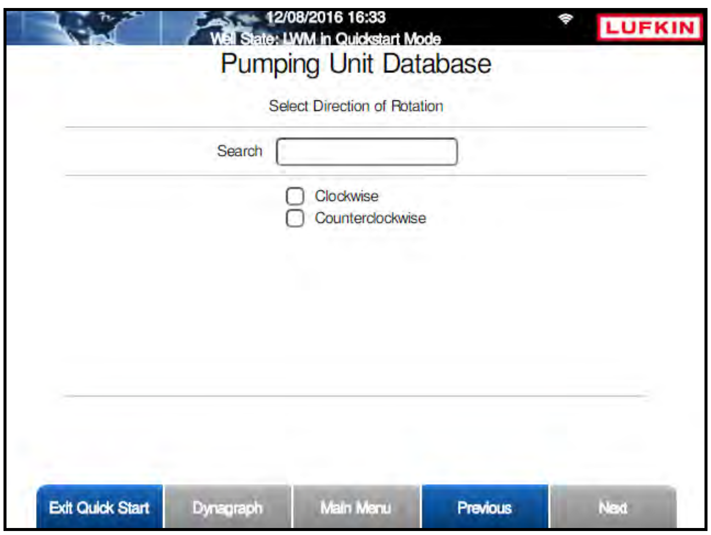


Figure 8-9. Pumping Unit Database – Select Direction of Rotation

Select the direction of rotation using one of the following methods:

- With the **Search** field highlighted, press <**ENTER**>. Use the keypad to type the direction into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
- Use the down arrow key to highlight the box next to **Clockwise** or **Counterclockwise** and then press <**ENTER**>.

Press **Next** to continue.

4. The next screen is used to select the pumping unit's manufacturer code.

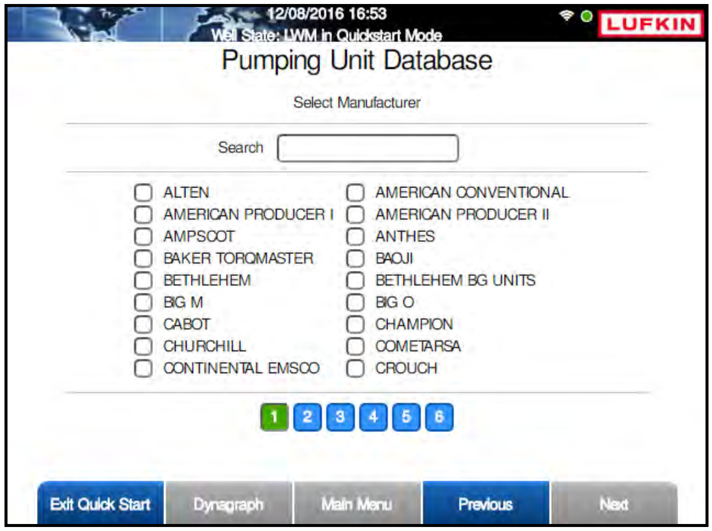


Figure 8-10. Pumping Unit Database – Select Manufacturer Code

Select the manufacturer code using one of the following methods:

- With the **Search** field highlighted, press <**ENTER**>. Use the keypad to type the manufacturer's name into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
- Use the arrow keys to highlight the box next to the manufacturer's name in the list and then press <**ENTER**>. To select a different page of names, use the arrow keys to highlight the page number and then press <**ENTER**>.

Press the **Next** button to continue.

5. The next screen is used to select the pumping unit's ID number.

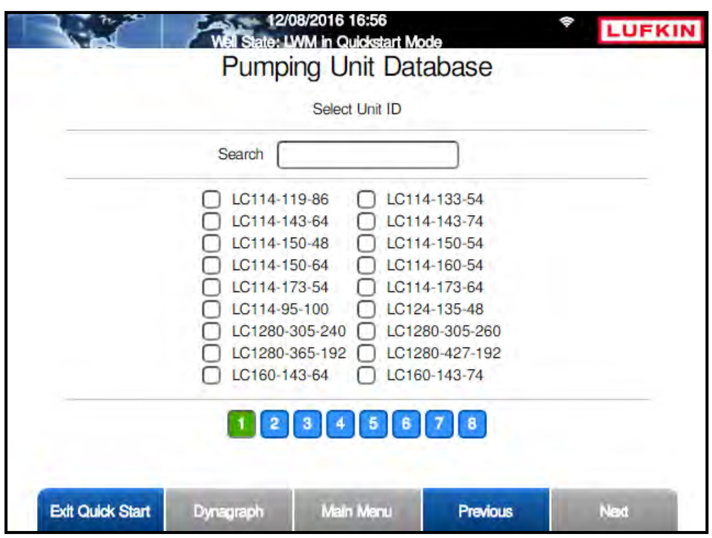


Figure 8-11. Pumping Unit Database – Select Unit ID

Select the unit ID using one of the following methods:

- With the **Search** field highlighted, press <**ENTER**>. Use the keypad to type the unit ID number into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
- Use the arrow keys to highlight the box next to the manufacturer's name in the list and then press <**ENTER**>.

Press the **Next** button to continue.

6. The next screen is used to select the number of crank holes on the pumping unit.

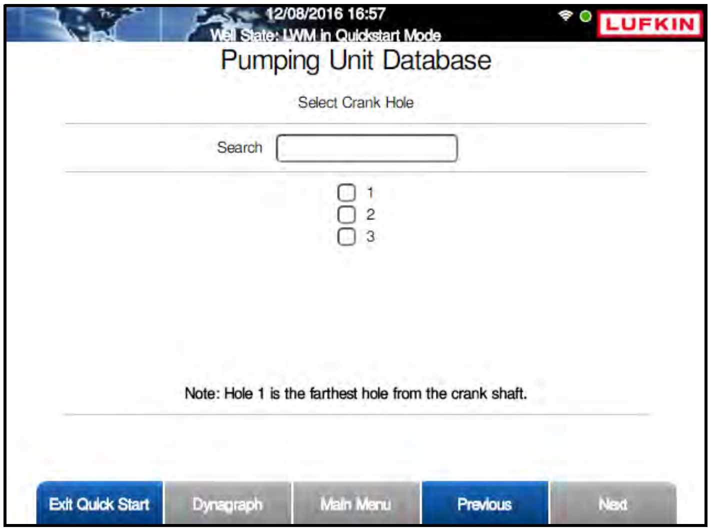


Figure 8-12. Pumping Unit Database – Select Number of Crank Holes

Select the number of crank holes using one of the following methods:

- With the **Search** field highlighted, press <**ENTER**>. Use the keypad to type the number into the **Search** text box. Press the down arrow key to select the search result and then press <**ENTER**>.
- Use the arrow keys to highlight the box next to the correct number in the list and then press <**ENTER**>.

Press the **Next** button to continue.

7. The next screen displays the results of the database search. Figure 8-13 on page 8-11 shows an example.

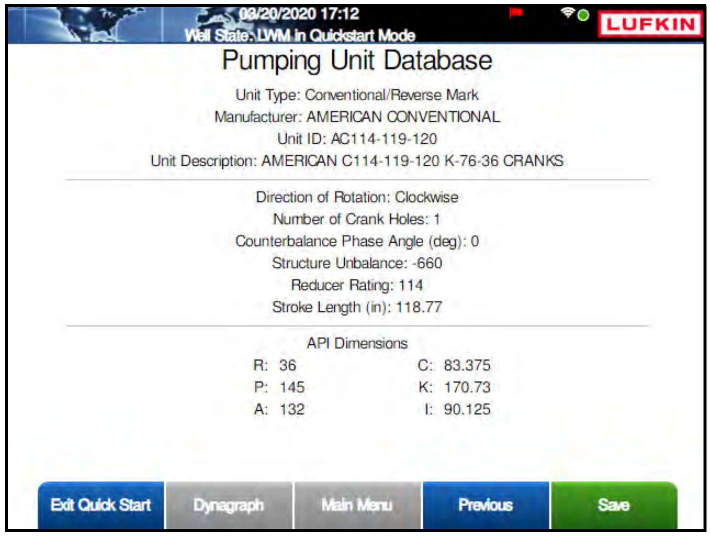


Figure 8-13. Pumping Unit Database – Search Results

Press the **Save** button to save the pumping unit parameters and return to the Pumping Unit Configuration screen.

Press the **Next** button to continue.

Rod Taper Configuration Screen

The Rod Taper Configuration screen is the next screen displayed.

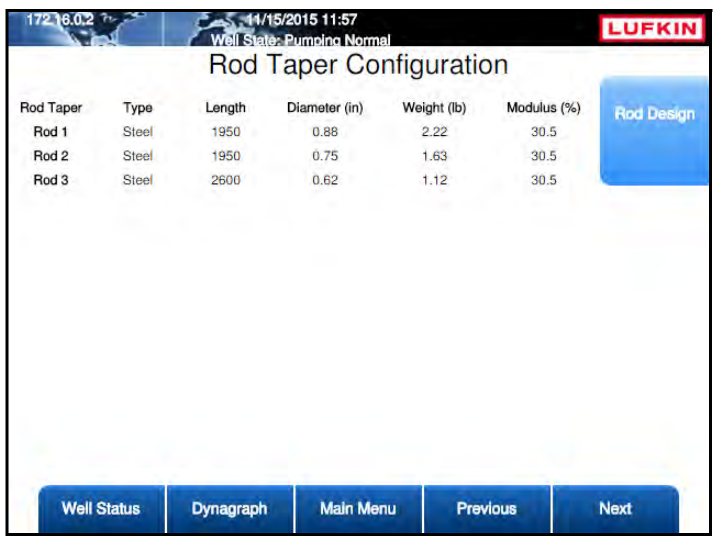


Figure 8-14. Rod Taper Configuration Screen

The controller must have rod string and pump diameter data to calculate the downhole pump card for each stroke. This screen includes default rod data that applies to most pumping configurations.

To make changes to this list, press the **Rod Design** button to display the Rod Design screen shown in Figure 8-15 on page 8-12.

Figure 8-15. Rod Design Screen

This screen allows the operator to change existing rod data, add new rod data, and delete rod data in the rod string list. These procedures are discussed on the following pages.

Change Existing Rod Data

To change existing rod data, perform the following steps:

1. Use the arrow keys to highlight the rod to be changed and then press <**ENTER**>. The rod field will turn green.
2. Use the **Search Rods** field to search the database for rods by manufacturer. Type the desired name in the field and press <**ENTER**>. The **Rod Name** field automatically shows all the available rod options listed for that manufacturer.
3. Select the desired rod name from the **Rod Name** drop-down list and then press <**ENTER**>. The database automatically fills the remaining fields with the default values for that rod name.

Note: If the desired rod name is not listed, select the **CUSTOM** option and manually input the rod data in each field.

4. Select the desired rod diameter (measured in inches) from the **Diameter** drop-down list and then press <**ENTER**>.
5. Type the desired rod length (measured in feet) in the **Length** field and then press <**ENTER**>.
6. **(CUSTOM rods only)** With the **Rod Type** field highlighted, press <**ENTER**>. Use the up or down arrow keys to select **Steel** or **Fiberglass** from the drop-down list and then press <**ENTER**> again.
7. **(CUSTOM rods only)** Type the rod weight (measured in pounds per foot) in the **Weight** field and then press <**ENTER**>.
8. **(CUSTOM rods only)** Type the rod modulus in the **Modulus** field and then press <**ENTER**>.
9. Press the **Save** button to save the changed values.

Press the **ESC** button to return to the Rod Taper Configuration screen.

Add New Rod Data

The Rod Design screen allows the operator to insert new rod data anywhere in the rod string list.

Note: A maximum of 12 rods can be used in this system.

To add new rod data, perform the following steps:

1. Select one of the following options:
   - To insert a new rod at the top of the rod string list, use the arrow keys to highlight the **Rod 1** field and then press the **Insert Before** button.
   - To insert a new rod in the middle of the rod string list, use the arrow keys to select the **Rod 1** or the **Rod 2** field and then press the **Insert After** button.
   - To insert a new rod at the end of the rod string list, use the arrow keys to highlight the **Rod 3** field and then press the **Insert After** button.

   The new rod field appears with the Rod Type field highlighted.
2. Use the **Search Rods** field to search the database for rods by manufacturer. Type the desired name in the field and press <**ENTER**>. The **Rod Name** field automatically shows all the available rod options listed for that manufacturer.
3. Select the desired rod name from the **Rod Name** drop-down list and then press <**ENTER**>. The database automatically fills the remaining fields with the default values for that rod name.

Note: If the desired rod name is not listed, select the **CUSTOM** option and manually input the rod data in each field.

4. Select the desired rod diameter (measured in inches) from the **Diameter** drop-down list and then press <**ENTER**>.
5. Type the desired rod length (measured in feet) in the **Length** field and then press <**ENTER**>.
6. **(CUSTOM rods only)** With the **Rod Type** field highlighted, press <**ENTER**>. Use the up or down arrow keys to select **Steel** or **Fiberglass** from the drop-down list and then press <**ENTER**> again.
7. **(CUSTOM rods only)** Type the rod weight (measured in pounds per foot) in the **Weight** field and then press <**ENTER**>.
8. **(CUSTOM rods only)** Type the rod modulus in the **Modulus** field and then press <**ENTER**>.
9. Press the **Save** button to save the changed values.

Press the **ESC** button to return to the Rod Taper Configuration screen.

Delete Rod Data

To delete rod data, perform the following steps:

1. Use the arrow keys to highlight the rod field to be deleted and then press <**ENTER**>. The rod field will turn green.
2. Press the **Delete Rod** button to delete the rod data.
3. Press the **Save** button to save the change.

Press the **ESC** button to return to the Rod Taper Configuration screen.

Press the **Next** button to continue.

LWT/PIP Parameters 1/3 Screen

The first of three LWT/PIP Parameters screens is displayed next. These screens allow the operator to use Lufkin's patented algorithms that can calculate pump intake pressure (PIP) and make automated fluid volume adjustments for pump slippage, fluid shrinkage, and tubing movement to determine the pump fluid load (LWT).

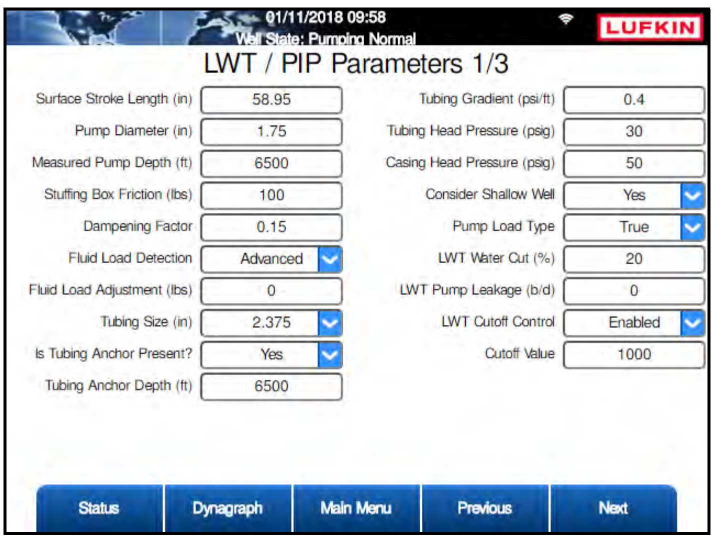


Figure 8-16. LWT/PIP Parameters Screen (1 of 3)

The following values are configured on this screen:

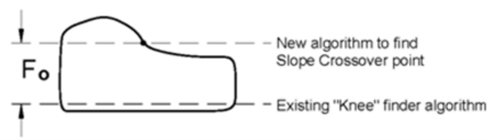
- **Surface Stroke Length (inches)**: Use the keypad to specify the correct surface stroke length in inches. The length needs to be precise to get accurate results, so use a tape measure when in doubt.
- **Pump Diameter (inches)**: Use the keypad to specify the diameter of the pump plunger in inches.
- **Measured Pump Depth (feet)**: Use the keypad to specify the measured pump depth from the surface to the pump intake, in feet.
- **Stuffing Box Friction**: This factor is used to compensate for surface friction due to tight stuffing box seals. Enter in pounds.
- **Dampening Factor**: If the tubing string is not anchored at all, or if the tubing anchor is more than a few hundred feet above the pump intake, select **Yes**.
- **Fluid Load Detection**: Select **Basic** or **Advanced** from the drop-down list.

- If **Basic** is selected, the controller calculates fluid load by subtracting the average downstroke load from the average upstroke load without making any attempt to analyze the pump card shape for friction loads.
- If **Advanced** is selected, the controller uses more advanced techniques of PIP calculation theory for calculating fluid load.

- **Fluid Load Adjustment (lbs)**: The fluid load that the controller calculates by either the Basic or Advanced fluid load detection method can be adjusted by using this field. Use the keypad to define this value.
- **Tubing Size (inches)**: Select the API tubing size (in inches) from the drop-down list.
- **Is Tubing Anchor Present?**: Select **Yes** or **No** from the drop-down list. If the tubing string is not anchored at all, or if the tubing anchor is more than a few hundred feet above the pump intake, select **Yes**.
- **Tubing Anchor Depth (feet)**: (This field is only visible when the **Consider Unanchored Tubing** parameter is set to **Yes**.) The tubing should be secured or "anchored" at the surface as a minimum. Therefore, if no tubing anchor is present, specify a value of 0 for the anchor depth. If an anchor is present up hole from the pump intake, specify the depth of the anchor in feet along the tubing (as opposed to true vertical depth).
- **Tubing Gradient (psi/feet)**: Specify the gradient for the fluid in the tubing in psi/feet.
- **Tubing Head Pressure (psig)**: Specify the gauge pressure at the well head tubing in PSI.
- **Casing Head Pressure (psig)**: Specify the pressure in PSI gauge of the casing at the surface.
- **Consider Shallow Well**: Select **Yes** or **No** from the drop-down list. No generally accepted exact definition of a "shallow well" exists. As a general rule, a shallow well is a well with a pump depth of less than 3,000 feet or a deeper well with a large diameter pump. The primary indicator is the shape of the downhole pump card.

  If the pump card has the general shape as illustrated in the example below, select **Yes**.

  Shallow Well

- **Pump Load Type**: Select **True** or **Effective** from the drop-down list.
- **LWT Water Cut (%)**: Use the keypad to specify the percentage of the produced fluid that is water.
- **LWT Pump Leakage (b/d)**: Use the keypad to specify the amount of leakage around the pump plunger in barrels per day.
- **LWT Cutoff Control**: Select **Enable** or **Disable** from the drop-down list.
- **Cutoff Value (bbls)**: (This parameter is only visible when the **LWT Cutoff Control** parameter is set to **Enable**.) Use the keypad to specify a daily production cutoff value in barrels.

Press the **Save** button to save the new values and then press the **Next** button to display the next screen.

LWT/PIP Parameters 2/3 Screen

This is the second of three LWT/PIP Parameters screens.

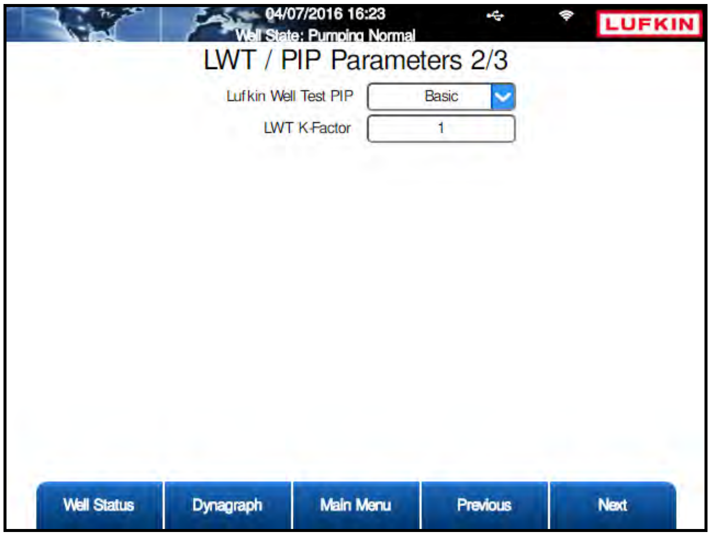


Figure 8-17. LWT/PIP Parameters Screen (2 of 3)

Details of this screen are discussed below.

Lufkin Well Test PIP Configuration

Select the desired Lufkin Well Test PIP configuration. The two drop-down list options are **Basic** or **Advanced**. These options are discussed below:

- When the **Basic** option is selected, the basic calculation for PIP uses only the pump depth and diameter, tubing fluid gradient, and tubing head pressure. No adjustments are made for effects of gas in solution.

  The Basic option uses the LWT K-Factor parameter as a calibration factor to correct for slippage and shrinkage. Use the keypad to define this value.

- When the **Advanced** option is selected, the following parameters are displayed:
  - **Oil Density Degree API**: This is the oil density expressed in degrees API. Use the keypad to define this value.
  - **Water Specific Gravity**: This is the specific gravity of the produced water. Use the keypad to define this value.
  - **Gas Specific Gravity**: This is the specific gravity of the produced gas. Use the keypad to define this value.
  - **Pump Temperature (°F)**: This is the fluid temperature at the pump intake. Use the keypad to define this value.
  - **Bubble Point Pressure (psia)**: This is the pressure at which gas that has been forced into solution by reservoir pressure will start to break out of solution and form gas bubbles. Use the keypad to define this value.
  - **Formation Volume Factor (rb/stb)**: This is the volume of produced fluid will shrink as the ambient pressure decreases and solution gas breaks out of solution. The volume of fluid that passes through the pump barrel reservoir barrel (or rb) may therefore be greater than the volume of fluid production measured at a surface storage unit (stock tank barrel or stb). The shrinkage factor is pump volume divided by surface volume. The formation

volume factor is a theoretical shrinkage factor when the fluid is at bubble point pressure rather than actual surface pressure. Use the keypad to define this value.

- **Solution GOR (scf/stb)**: This is a measure of how much gas is evolved from oil (at or above bubble point) as the oil goes from the reservoir pressure and temperature to separator conditions. The units are volume of gas divided by volume of oil at separator conditions. Use the keypad to define this value.

Figure 8-18 shows the Advanced option enabled. Use the keypad to define these values.

Figure 8-18. LWT/PIP Parameters Screen (2 of 3) – Advanced Option

Press the **Save** button to save the new values.

Press the **Next** button to display the next screen.

LWT/PIP Parameters 3/3 Screen

This is the third LWT/PIP Parameters screen.

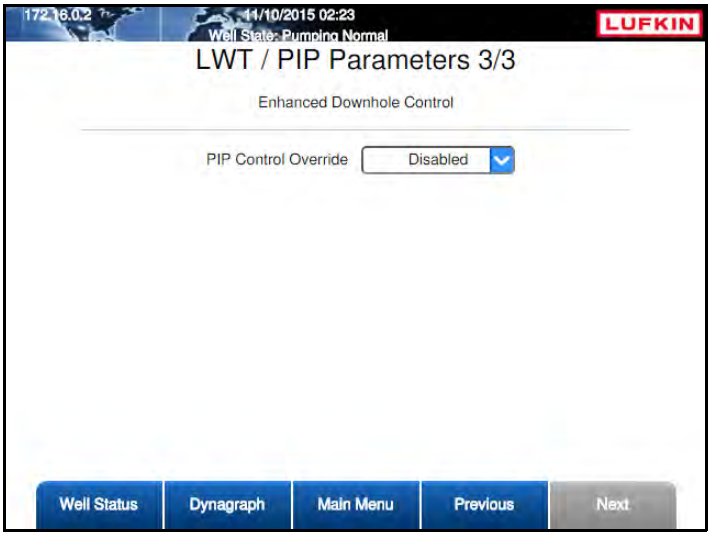


Figure 8-19. LWT/PIP Parameters Screen (3 of 3)

The Lufkin Well Manager 2 is capable of cycling the well based on the calculated PIP. If the calculated PIP falls below the PIP setpoint (described below), the pumping unit will be shut down for a downtime cycle even though the calculated pump fillage is greater than the fillage setpoint.

Select **Enabled** to enable the PIP Control Override feature. The following fields appear when this feature is enabled:

- **PIP Setpoint**: Specify the low limit for calculated PIP. If the calculated PIP falls below the specified number of strokes in the Consecutive Strokes Allowed field (see below), the pumping unit will be stopped for a downtime cycle.

  Use the keypad to define the pump intake pressure setpoint.

- **Consecutive Strokes Allowed**: Specify the number of consecutive pump strokes that the calculated PIP must be below the PIP setpoint before the pumping unit is stopped. Use the keypad to define the number of consecutive strokes allowed before the override is activated.

- **Consider Formation Producing Pressure**: Specify whether you want to use the Consider Formation Pressure query feature. Select **Yes** if the pump is set above "mid-perfs."

Note: When **Yes** is selected, the Formation Depth field appears below it.

- **Formation Depth**: (This field is only visible when the **Consider Formation Producing Pressure** parameter is enabled.) Use the keypad to specify the depth of the topmost perforations in feet.

Figure 8-20 on page 8-19 shows the PIP Control Override feature enabled.

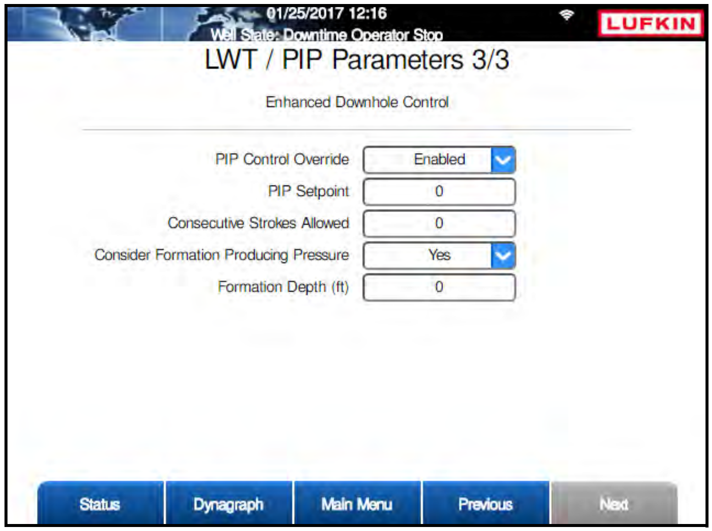


Figure 8-20. LWT/PIP Parameters Screen (3 of 3) – PIP Control Override Enabled

Press the **Save** button to save the parameter changes.

Load/Position Configuration

From the RPC screen, press the **Load/Position** button to display the Load/Position menu screen.

Figure 8-21. Load/Position Menu Screen

The load and position configuration options are discussed on the following pages.

Load/Position Application

Press the **Load/Position Application** button to display the Load/Position Setup screen.

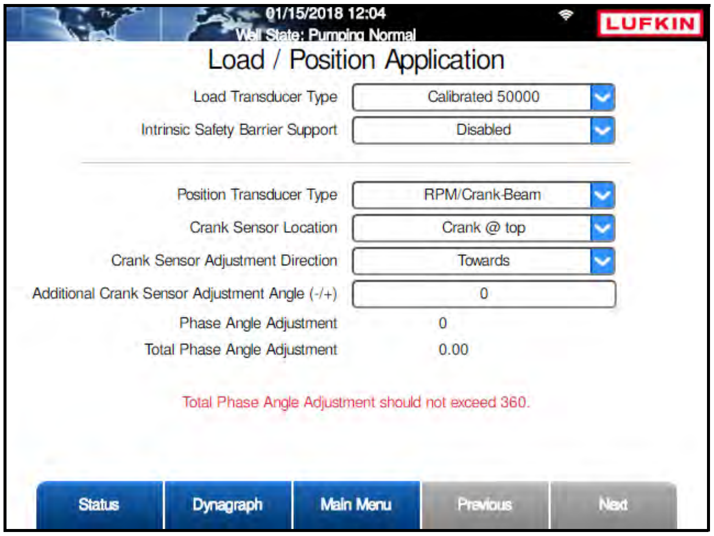


Figure 8-22. Load/Position Setup Screen

The user must specify the types of end devices used for load and position inputs. The parameters on this screen are discussed below.

- **Load Transducer Type**: Select the load transducer type from the drop-down list. Available options are:
  - Calibrated 50,000 (Polished Rod Load Cell)
  - Calibrated 30,000 (Polished Rod Load Cell)
- **Intrinsic Safety Barrier Support**: When an I.S. barrier is used in the pumping system, a voltage drop can occur in the excitation wiring to the load cell. This feature allows the user to define the compensation method for this voltage drop. Select one of the following options from the drop-down list:
  - **Disabled**: Select this option if compensation is not required (e.g. if a barrier is not installed or the barrier type does not introduce a voltage drop).
  - **Analog**: Select this option if the voltage drop will be compensated automatically (e.g. by measuring the drop at Analog Input #2).
  - **Manual**: Select this option if the voltage drop will be compensated with a fixed value.

    With this option selected, the **Load Cell Excitation Volts** field is displayed. Use the keypad to define the expected or measured voltage value at the load cell and then press <**Enter**>.
- **Position Transducer Type**: Select the position transducer type from the drop-down list. Available options are:
  - Analog
  - RPM/Crank-Beam
  - RPM/Crank-Linear

- **Crank Sensor Location**: Select the crank sensor location from the drop-down list. Available options are:
    - Crank at top
    - Crank at bottom
- **Crank Sensor Adjustment Direction**: Select the crank sensor adjustment direction from the drop-down list. Available options are:
    - Towards
    - Against
- **Additional Crank Sensor Adjustment Angle (–/+)**: Using the keypad, define this value.
- **Phase Angle Adjustment:** This field displays status information only.
- **Total Phase Angle Adjustment**: This field displays status information only

Note: The total phase angle adjustment value should not exceed 360.

Press the **Save** button to save the new values.

Calibration

From the Load/Position menu screen, press the **Calibration** button to display the Calibration Menu screen.

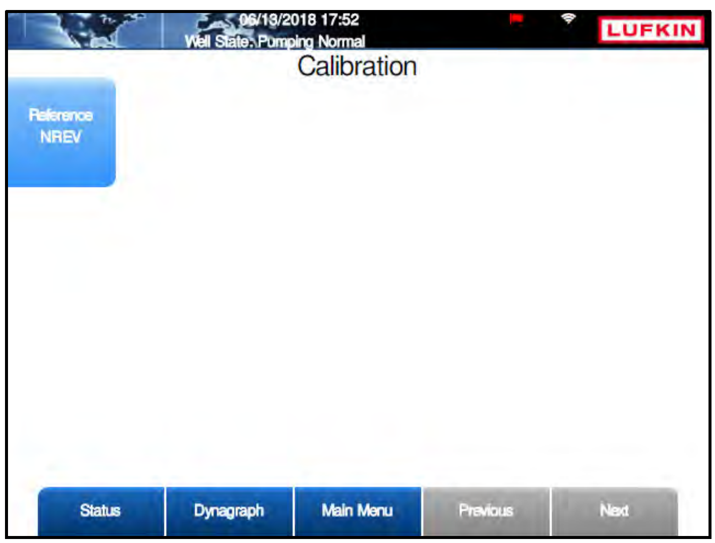


Figure 8-23. Calibration Menu Screen

From the Calibration Menu screen, press the **Reference NREV** button to display the Reference NREV Calibration screen.

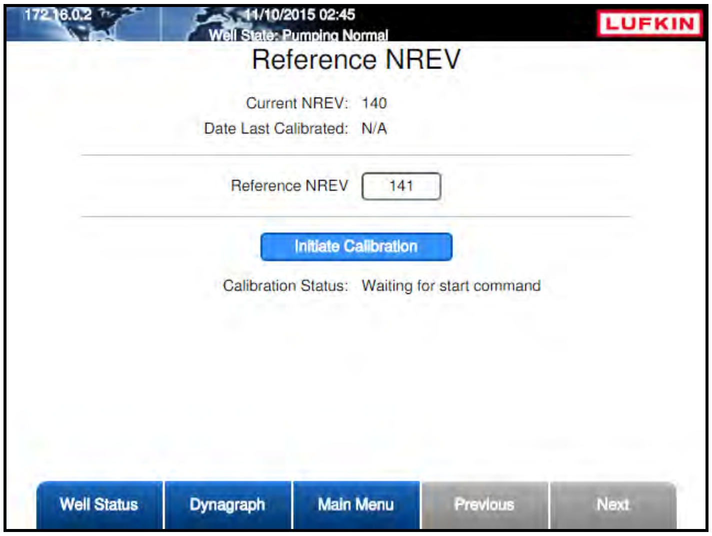


Figure 8-24. Reference Revolution Calibration Screen

In order for some control features to work properly, the controller needs to know the number of motor revolutions required per pump cycle under normal pumping. If the diameter of either drive belt sheave is changed, the pumping speed will change, requiring recalibration of this reference revolution parameter.

The following status information is shown on this screen:

- Current NREV
- Date Last Calibrated
- Reference NREV
- Calibration Status
- Elapsed Time: (This value is displayed during and after the calibration process.)

If reference revolution calibration is needed, use the arrow keys to highlight the **Initiate Calibration** button and then press <**ENTER**> to start the calibration procedure.

WARNING: This command will start the pumping system. All electrical equipment covers MUST be back in place before starting the calibration procedure.

Watch the **Calibration Status** field to check progress of the automatic calibration operation. When the operation is completed, the status field reads **Complete**.

To stop the calibration operation, use the arrow keys to highlight the **Abort** button and then press <**ENTER**> on the keypad.

Press <**ESC**> twice to return to the Load/Position menu screen.

Load Device Configuration

From the Load/Position menu screen, press the **Load Device** button to display the Load Device screen.

Figure 8-25. Load Device Screen

The load device's analog input designation and current load are displayed at the top of the screen.

The following parameters are configured on this screen:

- **Load Transducer Type**: Select the load transducer type from the drop-down list. The available options are:
  - Calibrated 50,000 (Polished Rod Load Cell)
  - Calibrated 30,000 (Polished Rod Load Cell)
- **Input Swing @ 5V Excitation (mV x 100)**: Using the keypad, define the input swing value.
- **Max Weight (lbs)**: Using the keypad, define the maximum allowed weight for the load device.
- **Bipolar/Unipolar**: Select **Bipolar** or **Unipolar** from the drop-down list.
- **Gain Setting**: Select the desired gain setting from the drop-down list.
- **Zero Load Offset (lbs)**: Using the keypad, define the current zero load offset value.
- **Intrinsic Safety Barrier Support**: When an I.S. barrier is used in the pumping system, a voltage drop can occur in the excitation wiring to the load cell. This feature allows the user to define the compensation method for this voltage drop. Select one of the following options from the drop-down list:
  - **Disabled**: Select this option if compensation is not required (e.g. if a barrier is not installed or the barrier type does not introduce a voltage drop).
  - **Analog**: Select this option if the voltage drop will be compensated automatically (e.g. by measuring the drop at Analog Input #2).
  - **Manual**: Select this option if the voltage drop will be compensated with a fixed value.

    With this option selected, the **Load Cell Excitation Volts** field is displayed. Use the keypad to define the expected or measured voltage value at the load cell and then press <**Enter**>.

Press the **Save** button to save the new values and then press **<ESC>** to return to the Load/ Position Setup menu screen.

Position Device Configuration

From the Load/Position menu screen, press the **Position Device** button to display the Position Device screen shown in Figure 8-26.

Figure 8-26. Position Device Screen

This screen is used to specify the position device being used in the system. The position device’s analog input designation and current position reading are displayed at the top of the screen.

Select the position transducer type from the drop-down list. The available options are:

- Analog
- RPM/Crank-Beam
- RPM/Crank-Linear

The following status information is displayed:

- RPM
- Crank Counter
- Crank Period(s)
- NREV

Press the **Save** button to save the new values and then press **<ESC>** to return to the Load/ Position Setup menu screen.

Operational Limits Configuration

From the RPC menu screen, press the **Operational Limits** button to display the Operational Limits screens. These screens and their functions are discussed in the following paragraphs.

Operational Limits 1 Screen

This is the first of three Operational Limits screens. The contents of this screen are discussed on the following pages.

Figure 8-27. Operational Limits 1 Screen

The following VSD parameters are configured on this screen:

- **Control Mode**: Select the desired control mode from the drop-down list. The available VSD options are:
  - **Surface** – The LWM 2.0 RPC controls the well from analysis of surface dynagraph shape using the Pump off setpoint.
  - **Downhole** – The LWM 2.0 RPC controls the well from analysis of the calculated downhole dynagraph using the Pump Fillage setpoint.
  - **DH Pressure** – In this control mode, the controller shuts down the pump when the current downhole intake pressure drops below the defined downhole pressure limit value. The time the system stays in this downtime state is controlled by the Downtime Mode parameter. See “Downtime Mode” for details.

  To change the control mode, use the arrow keys on the keypad to highlight that field and then press <**ENTER**>. Use the up or down arrow keys to change the type and then press <**ENTER**> again.
- **Start Alert Delay (s)**: This parameter provides control of an optional audible or visible start alarm device. The Start Alert output is held ON (low) for the number of seconds programmed in this field. The controller delays starting the pumping unit until the Start Alert Delay time has elapsed. The default value is 10 minutes.
- **Operation Mode**: Select the desired mode of operation from the drop-down list. The available options are:

  - **Normal** – The controller performs all of the enabled safety and control functions. This mode takes full advantage of the LWM 2.0 controller's capabilities.
  - **Host** – The controller ignores load and position input and makes no control decisions. The pump or downtime decision is made by the operator and requires operator intervention to change. Typical use would be when several wells need to be shut down due to a power company request. A global data message can be sent to all LWM 2.0 RPC units on the radio network to place them in the Downtime-Host Mode well state. The LWM 2.0 RPC controls would stop the wells and keep them down until receiving a command to restart.
  - **Timed** – The LWM 2.0 RPC can be programmed to cycle on/off for user set times. Limited control functions by the LWM 2.0 RPC include peak and minimum load checking. Typical use might be to temporarily operate a well while waiting for one of the signal input end devices to be repaired.

- **Minimum Pump Strokes**: When a pumping cycle starts, the controller will not perform any dynagraph analysis for this number of initial strokes. Peak and minimum load protection is provided during Minimum Pump Strokes mode.

  Many pumping systems may need a few strokes to clear gas or trash from the pump at the start of a pump cycle. As a result, this number should be programmed at a fairly low value because the controller has very limited capabilities during Minimum Pump Strokes mode.

  The allowed range is 0 to 999, and the default is 3. Use the keypad to define this value.

- **Start Up Option**: This option allows the controller to automatically restart the pumping unit after the user-defined time delay has passed. See "Power On Delay" below for details.

  To enable this option, select **AutoRestart On** from the drop-down list. To disable this option, select **AutoRestart Off**.

- **Power On Delay(s)**: (This parameter is only visible when the **AutoRestart On** option is selected.) When power is applied to the controller, the initial control state is Downtime Power On Delay. The controller delays starting the pumping unit for the specified number of seconds. This feature allows the operator to stagger the startup of pumping units on a transformer bank or distribution line after a power outage.

  The default value is 10 seconds. If a different value is desired, use the keypad to define the number of seconds for this value.

- **Downtime Mode**: This parameter determines how long the pumping unit stays in a downtime state. The available options are **Manual** and **Pressure**.

Note: For **Surface** and **Downhole** control modes, **Manual** downtime mode is the only available option.

The downtime mode options are described below:

  - **Manual** downtime mode uses a user-defined idle time after a stop for pump off (surface setpoint or downhole pump fillage) or a pumping equipment malfunction. The controller automatically restarts the pumping unit when the specified downtime elapses.

    Select **Manual** downtime mode initially until the well has pumped for a few days to stabilize and the cycle run time stability has been observed.

- **Pressure** downtime mode is selected, the pump restarts when the downhole pressure has built up to a predetermined pressure level.

Select the desired mode from the drop-down list.

Note: If the motor is a gas engine, the engine has to be manually restarted by an operator.

- **Manual Downtime (HH:MM)**: This value defines the initial downtime period used when the controller is in Manual Downtime mode. (See "Downtime Mode" above for description.)

  Program this value short enough to prevent the fluid level in the well bore from reaching the static fluid level, but long enough to allow good pump fillage for more than the minimum pump strokes. (The default value is 30 seconds.)
- **DH Pressure Recovery Target (psi)**: (This value defines the downtime period for the **Pressure** option of Downtime Mode and 2ry Downtime Mode only.) Use the keypad to define this value and then press <**ENTER**>.
- **2ry Downtime Mode**: (This parameter is only visible when the **Secondary Pump Fillage** setpoint is enabled at the bottom of the screen.) Select one of the following downtime modes from the drop-down list:
  - **Manual**: In this mode, the controller stays in a Downtime/Pump-Off state until the **Manual Downtime** period expires. See "Manual Downtime (HH:MM)" above for details.
  - **Pressure**: In this mode, the controller stays in a Downtime/Pump-Off state until the **Downhole (DH) Pressure Recovery Target** pressure is reached.

The bottom half of the screen contains controls for configuring setpoints for malfunctions, pump fillage, and fluid load. Use the arrow keys to select **Enable** or **Disable** from the drop-down list to enable or disable these setpoints and then press <**ENTER**>. Use the keypad to define the Allowed Limit, Consecutive Allowed, and Strokes Allowed values (where applicable) for these setpoints and then press <**ENTER**> to save these values.

- **Malfunction Setpoint**: This parameter sets the number of malfunctions allowed before the controller shuts down the pumping unit. Select **Enabled** or **Disabled** from the drop-down list. The values that apply to this setpoint are described below:
  - **Malfunction Setpoint Consec Allowed**: The controller allows for re-tries for all of the malfunction types of control actions. For example, if the maximum allowed peak load is violated, the controller counts that as a peak load violation and initially shuts down the pumping unit in a downtime state. After the programmed downtime elapses, the controller tries to restart the pumping unit. If the peak load violation is repeated before a normal pump off cycle occurs, the controller counts that as the second consecutive peak load violation and again shuts down the pumping unit in a downtime state. Subsequent violations of the peak load limit increment the consecutive violation counter until the allowed consecutive for peak load is exceeded. The controller at that point shuts down the pumping unit in a malfunction state and operator intervention is required to clear alarms and re-start the unit. This column allows an operator to program the consecutive allowed for malfunction control action.

    Use the keypad to define this value.

- **Malfunction Setpoint Strokes Allowed**: The number of consecutive strokes that the surface malfunction setpoint must be violated before the controller shuts down the pumping unit for one of the consecutive malfunctions allowed.

  The default value is 2 strokes. Use the keypad to define this value.

- **Fluid Load**: (This parameter is only used in **Downhole** and **DH Pressure** control modes.) The controller analyzes the realtime downhole dynagraph and uses this data to calculate fluid load for each pump stroke. If the fluid load drops below this limit, the pumping unit is stopped for a downtime cycle early in the next upstroke.

  The values that apply to this parameter are as follows:

  - The **Allowed Limit** value defines the allowed fluid load limit described above. Use the keypad to define this value.
  - The **Consecutive Allowed** value defines the number of times the fluid load can drop below the limit before the controller shuts down the pumping unit.
  - The **Strokes Allowed** value defines the number of pump strokes allowed in a low fluid load situation before the controller shuts down the pumping unit.

- **DH Press Low Limit**: (This parameter is only used in **DH Pressure** control mode.) When the downhole pressure drops below this limit, the controller will shut down the pumping unit.

  The values that apply to this parameter are as follows:

  - The **Allowed Limit** value defines the allowed pressure limit described above. Use the keypad to define this value.
  - The **Strokes Allowed** value defines the number of pump strokes allowed in a low pressure situation before the controller shuts down the pumping unit.

- **Secondary Pump Fillage**: (This parameter is only used in **Downhole** and **DH Pressure** control modes.) When the current pump fillage drops below this limit, the controller will accumulate the number of times this drop occurs. When the number of occurrences exceeds the defined limit, the controller will stop the pump and then switch to a Downtime/Pump-Off state.

  The time period in which the controller will stay in this state is controlled by the **2ry Downtime Mode** described on the previous page.

  Note: This feature is supported in the **Normal** operation mode only.

  Use the down arrow key to highlight this field and then press <**ENTER**>. In the drop-down list that appears, use the up or down arrow key to select **Enabled** or **Disabled** and then press <**ENTER**> again.

  The values that apply to this parameter are as follows:

- The **Allowed Limit** value defines the allowed fillage limit described above. Use the keypad to define this value.

Note: The **Allowed Limit** value must be set below the deadband range in order to function properly.

- The **Strokes Allowed** value defines the number of pump strokes allowed in a limit violation situation before the controller shuts down the pumping unit.

Press the **Save** button to save the new values and then press the **Next** button to continue.

Operational Limits 2 Screen

The second Operational Limits screen is used to enable or disable violation setpoints for use during pumping operation. It also displays the current operation mode, control mode, load transducer type, position transducer type, and present system values.

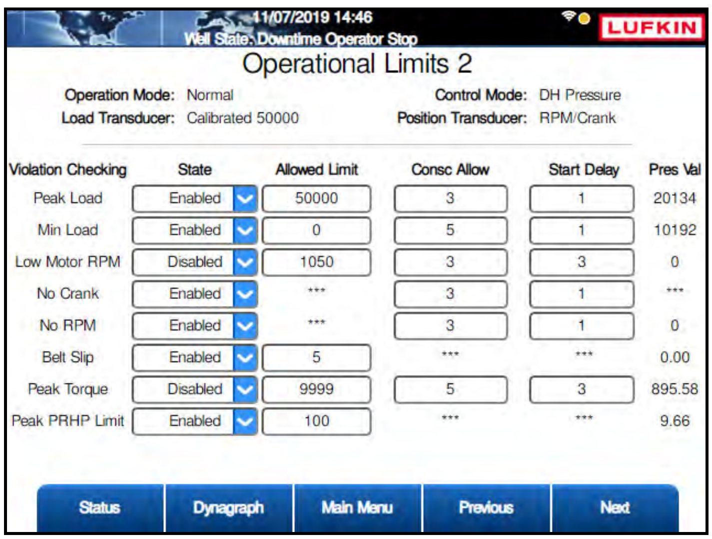


Figure 8-28. Operational Limits 2 Screen

Select **Enabled** or **Disabled** from the drop-down list to enable violation limit parameters. Using the keypad, define the desired values for Allowed Limit, Consecutive Allowed, and Start Delay parameters where applicable.

The available violation limits are:

- **Peak Load**: The maximum allowed value for load input. If the load exceeds this limit, the controller instantly shuts down the pumping unit with no consecutive stroke delay. Units are in pounds. The default value will be the full scale of the programmed load end device.
- **Min Load**: The lowest allowed value for load input. If the load falls below this value, the controller instantly shuts down the pumping unit with no consecutive stroke delay. The default value is zero.

- **Low Motor RPM**: The lowest motor RPM at which the controller will continue to run the pumping unit. This is a time delay setpoint, measured in seconds. It is designed to allow the pumping unit time to accelerate up to operating speed. When the unit starts up, the controller waits a predefined number of seconds before checking for Low Motor RPM violations.
- **No Crank**: Triggers an alarm when a crank switch input is not detected. This setpoint specifies the number of motor revolutions that the controller should wait before it detects the first crank switch input. If a crank switch input is not detected within this number of motor revolutions, the controller declares a No Crank alarm and stops the pumping unit. If the unit is pumping extremely slow and it causes this reference revolution value to be near 300, you may need to program a higher value than the default of 300 revolutions.
- **No RPM**: Triggers an alarm when there is no RPM signal from the pumping unit. This is a time delay setpoint, measured in seconds. It is designed to allow the pumping unit time to accelerate up to operating speed. When the unit starts up, the controller waits a predefined number of seconds before checking for No RPM violations.
- **Belt Slip**: The maximum allowed value for belt slippage. When in the Pumping Normal mode well state, the controller counts the Motor Rev/Stroke for each stroke. At the end of each stroke, the count is compared to the Reference Rev number programmed above. If the current Motor Rev/Stroke count is greater than the Reference Rev by greater than this Belt Slippage percentage, the controller sets an alarm flag to indicate possible belt slippage. No other control action is taken. The default value is 5%.
- **Peak Torque**: The maximum allowed torque value in thousands of inch-pounds. If the controller calculates a torque value greater than this limit at the completion of a stroke, the pumping unit shuts down early in the next upstroke.
- **Peak PRHP Limit**: Specify a value at which the controller will set an alert flag to advise the operator that a paraffin treatment may be required. This value is a high limit.

Press the **Next** button to continue.

Operational Limits 3 Screen

The third Operation Limits screen is displayed next.

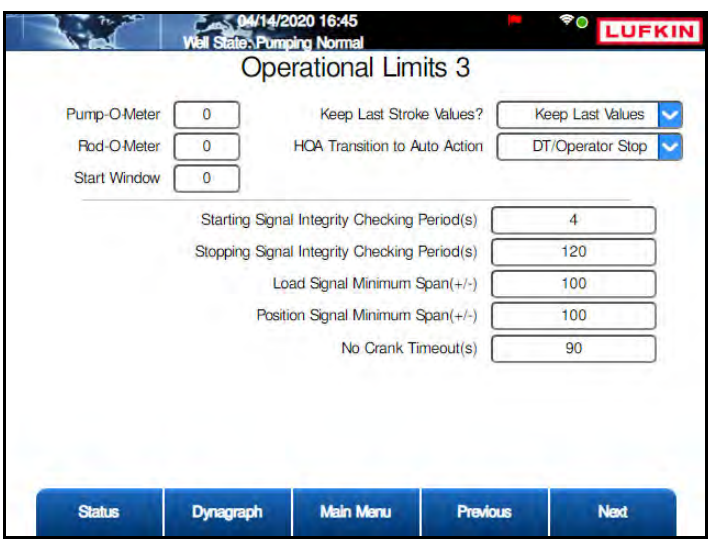


Figure 8-29. Operational Limits 3 Screen

Using the keypad, define the desired values for the following parameters:

- **Pump-O-Meter**: Use this field to clear the counter for rod pump activity. The controller counts and accumulates the number of strokes since the last time pump work was performed. These counts give operators a tool to measure pump life.
- **Rod-O-Meter**: Use this field to clear the counter for rod stroke activity. The controller counts and accumulates the number of strokes since the last time rod string work was performed. These counts give operators a tool to measure rod life.
- **Start Window**: Specify an additional delay time, in seconds, after the well start output is energized before the controller begins checking load and position inputs. This time may be necessary to allow a gas engine prime mover to start and run up to speed or for a clutch to engage. Typically, installations with electric motors do not need an additional delay.
- **Keep Last Stroke Values?**: Use the arrow keys to select one of the following options:
  - Keep Last Values
  - Clear Last Values
- **HOA Transition to Auto Action**: This parameter determines the action the controller takes when the HOA switch is turned to the Auto position. Available options are **DT/Operator Stop** and **Restart**.

  Use the arrow keys to select the desired option and then press <**ENTER**>.
- **Starting Signal Integrity Checking Period(s)**: Use the keypad to define this value.
- **Stopping Signal Integrity Checking Period(s)**: Use the keypad to define this value.
- **Load Signal Minimum Span (+/–)**: Use the keypad to define this value.
- **Position Signal Minimum Span (+/–)**: Use the keypad to define this value.
- **No Crank Timeout(s)**: Use the keypad to define this value.
- **Signal Failure Control**: (Not available in **DH Pressure** control mode.) Select **Enable** or **Disable** from the drop-down list and then press <**ENTER**>.
- **Signal Failure Control Option**: (This field is only visible when the **Signal Failure Control** parameter is set to **Enable**.) When a signal failure is detected in the system, the controller has several control options for handling this situation. These options are described below:
  - **Malfunction** – With this option, the controller treats the signal failure as a malfunction and shuts down the pumping unit. This malfunction state must be cleared by the user before the controller will restart the unit.
  - **Downtime** – With this option, the controller shuts down the pumping unit for a designated period of time when a signal failure is detected.

    Use the arrow keys to highlight the hours and minutes fields and then press <**ENTER**>. Use the keypad to define the desired downtime period and then press <**ENTER**> again.
  - **Run** – With this option, the controller continues to run normally when a signal failure is detected.

  The next two options allow the pumping unit to run for a user-defined percentage of the normal run time period when a signal failure is detected.
  - **Timer 1 - User Define** – This option uses user-defined time limits to control the length of time the pumping unit should run in a signal failure situation.

    Use the arrow keys to highlight the hours and minutes fields and then press <**ENTER**>.

Use the keypad to define the desired on and off periods and then press <**ENTER**> again.

- **Timer 2 - % Run Time – since GOT**: This option sets a minimum and maximum time period the pumping unit can run since the last gauge-off time event.

  Use the arrow keys to highlight the hours and minutes fields for the **Off**, **Minimum Run Period**, and **Maximum Run Period** parameters and then press <**ENTER**>. Use the keypad to define the desired time period for each parameter and then press <**ENTER**> again.

Operational Limits 4 Screen

The Operational Limits 4 screen is displayed next. Use this screen to configure a downhole gauge.

Figure 8-30. Operational Limits 4 Screen

Configure the downhole gauge using the following parameters:

- **DH Gauge Source**: Use the arrow keys to select the downhole gauge source from the drop-down list:
  - **Unavailable**: Select this option if a downhole gauge is not present in the system.
  - **Zenith DH Gauge**: Select this option for Zenith downhole gauges.
  - **AI 8**: Select this option for downhole gauges from other manufacturers.
- **Zenith DH Gauge Model**: (This parameter applies to the **Zenith DH Gauge** Source option only.) Select the desired downhole gauge model from the drop-down list:
  - Model C2
  - Model C5
  - Model C6
- **Intake Pressure Type**: (This parameter applies to the Zenith **Model C5** gauge option only.) Select the desired intake pressure type from the drop-down list. Available options are **Tubing** and **Annulus**.

For Zenith downhole gauge configuration, press or click the **COMM** button to display the Zenith DH Gauge configuration screen shown in Figure 8-31.

For configuration of other downhole gauges by other manufacturers, press the **Analog Input** button to display the Analog Input Configuration screen.

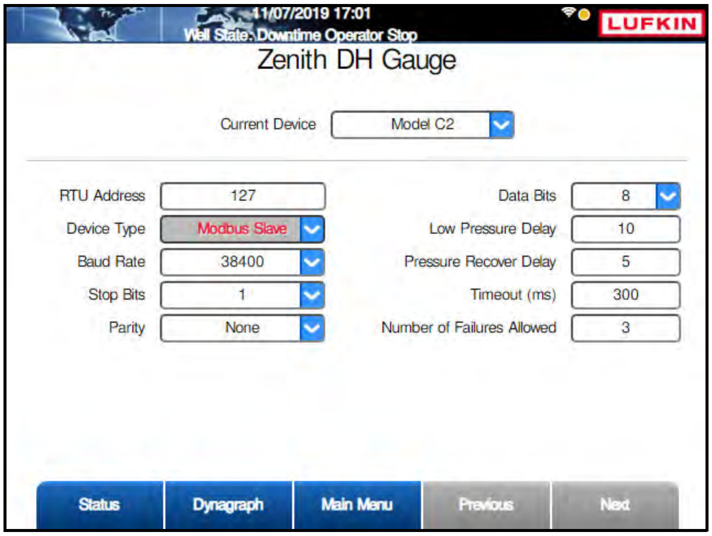


Figure 8-31. Zenith DH Gauge Configuration Screen

The following parameters are configured on this screen:

- **RTU Address**: Each downhole gauge must have a different address number. Address numbers of less than 247 are indicated by the standard Modbus guidelines. The address must match the downhole gauge setting.
- **Device Type**: As of this release, Modbus Slave is the only available option for device type.
- **Baud Rate**: Select from a range of options from 300 to 115,200 baud. The value must match the slave device setting.
- **Stop Bits**: This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Parity**: This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Data Bits:** This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Low Pressure Delay**: (Applies to the **Pressure** mode for Secondary Downtime Mode only.) Use the keypad to define this value and then press <**ENTER**>.
- **Pressure Recover Delay**: (Applies to the **Pressure** mode for Secondary Downtime Mode only.) Use the keypad to define this value and then press <**ENTER**>.
- **Timeout**: Specify the time, in milliseconds, that the controller waits after sending a poll message to check the reply message buffer.
- **Number of Failures Allowed**: Specify the number of times that the controller will continue to try to poll a downhole gauge once that gauge is enabled. If the controller does not receive a valid response after this number of consecutive polling attempts, a communication failure alarm is flagged for the downhole gauge to alert the operator that data from the gauge is not current. Communication failure flags are displayed in red at the top of the screen.

Press the **Save** button to save changes made on this screen.

VSD Configuration

VSD function is only enabled on VSD-equipped controllers.

Gauge-Off Time and Peak Energy Management

From the RPC screen, press the **GOT/PEM** button to display the Gauge-Off Time and Peak Energy Management screen shown in Figure 8-32.

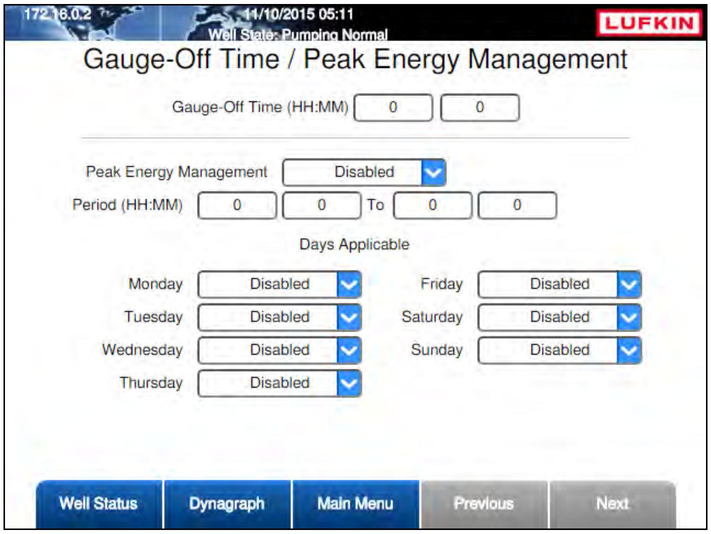


Figure 8-32. Gauge-Off Time and Peak Energy Management Screen

Gauge-Off Time

Gauge-Off Time is the time of day that the controller updates all of the 60-day historical data buffers. This feature enables the operator to specify the time of day that the controller updates all of the 60-day historical data buffers. Time is specified using the 24-hour clock format of HH:MM:SS.

To configure gauge-off time, perform the following steps:

1. With the **HH** (hours) field highlighted, use the number keys to define the hours value.
2. Press the right arrow key to highlight the **MM** (minutes) field. Use the number keys to define the minutes value.
3. Press the **Save** button to save the values in the system.

Peak Energy Management

The Peak Energy Management feature enables the controller to shut down the pump during peak times, go into a Downtime Peak Energy Management state, and suspend all normal operation. The operator can program the period of day and which days this function is to take effect. Normal operation resumes at the end of the programmed period.

To configure peak energy management, perform the following steps:

1. Use the arrow keys to highlight the **Peak Energy Management Enabled/Disabled** field.

2. Press <**ENTER**> to display the drop-down list. Press the down arrow key to select the **Enable** option and then press <**ENTER**> again.
3. Use the down and left arrow keys to highlight the **Period (HH:MM)** fields. Using the number keys, define the hours and minutes values for the start and stop times.
4. Use the left and down arrows to highlight the **Monday** drop-down list. Press <**ENTER**> to display the drop-down list. Press the up or down arrow keys to select the **Enable** or **Disable** option and then press <**ENTER**> again.
5. Repeat step 4 for each day.
6. Press the **Save** button to save the values in the system.

Press the **Main Menu** button to return to the Main Menu screen.

RPC Miscellaneous I/O

From the Setup screen, press the **RPC MISC I/O** button to display the RPC Miscellaneous I/O screen shown in Figure 8-33.

Figure 8-33. RPC Miscellaneous I/O Screen

Use this screen to enable or disable the miscellaneous digital input/output channels for optional features such as an HOA switch or ESD switch. These features use a signal relay that is wired to discrete inputs or outputs on the Mark VIe controller terminal strip.

Note: Each input or output must be assigned using the Digital Input/Output Configuration screen. See “Digital Configuration” on page 8-47 for details.

These optional features are described below:

- **Motor Control**: This channel is enabled by default and cannot be disabled. Motor control uses **DO1** as the default output point.
- **Fault**: Fault sensing devices use **DO2** as the default output point. Select **Enabled** to enable this channel.
- **Start Alert**: The optional Start Alert relay may be wired to a siren or light beacon to warn personnel that the unit is about to start. If this device is installed, enable this channel. Start alert devices use **DO3** as the default output point.
- **Error**: Enable this feature if an external error lamp is used with the controller. When enabled, this lamp will flash when an error is detected in the controller. This feature uses **DO4** as the default input/output point.
- **HOA**: An extra contact block on the unit Hand-Off-Auto (LWM) switch can be wired to discrete inputs on the LWM 2.0 controller to give an operator at the host computer a definitive indication of the position of that HOA (HOL) switch. The contacts must be wired so that one discrete input (**DI6**) is connected to the signal common when the switch is in the Auto position. A second discrete input (**DI5**) is connected to the signal common when the switch is in the Hand position. When the switch is in the Off position, neither of the programmed discrete inputs is connected to the signal common.

  When this channel is enabled, the well states “Pumping/HOA in Hand” and “Downtime/HOA Off” are activated.
- **ESD**: For systems equipped with an ESD (Emergency Shutdown) switch, enable this channel. The default digital input/output point for ESD is **DI7**.

Use the up or down arrow keys to highlight the desired field and then press <**ENTER**>. Use the up or down arrow keys to select **Enabled** or **Disabled** and then press <**ENTER**> again.

Advanced RPC Applications

From the Setup menu screen, press or click the **Advanced RPC Applications** button to display the Advanced RPC Applications menu screen shown in Figure 8-34.

Figure 8-34. Advanced RPC Applications Menu Screen

These applications are discussed in the following pages.

Pump Tag Mitigation

Note: This feature is only available in Normal operation mode and the Downhole control mode with the controller in a "Pumping Normal" well state. Refer to the section titled "Operational Limits 1 Screen" on page 8-25 for details on operation and control modes.

From the Advanced RPC Applications menu screen, press the **Pump Tag Mitigation (PTM)** button to display the Pump Tag Mitigation (PTM) screen shown in Figure 8-35 below.

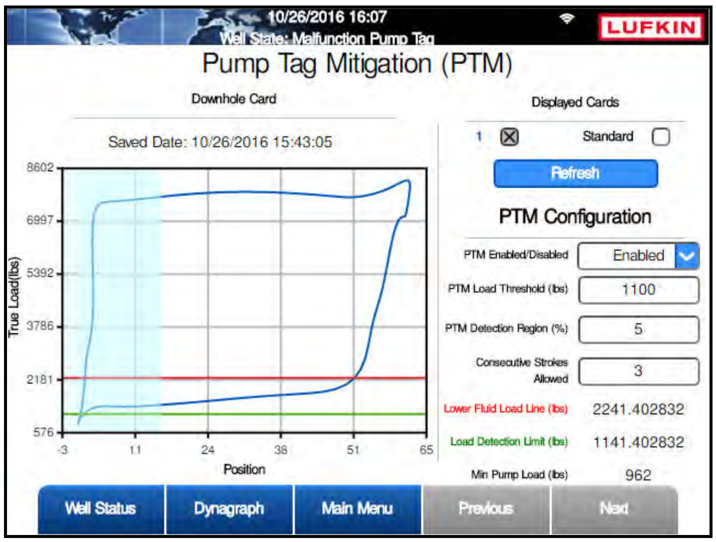


Figure 8-35. Pump Tag Mitigation (PTM) Screen

Pump tagging (also known as pump tapping) is defined as the mechanical contact that can occur between the pump plunger and the lower end of the pump barrel. This is a common condition that is sometimes intentionally set by operators on shallow and mid-depth applications as a way to ensure complete stroke efficiency in downhole conditions.

In deep well pumping, such conditions must be avoided as the total weight of the rod string (several tons) will usually overcome the mechanical integrity limits of the pump and its landing array. This causes catastrophic damage and generates deferred production and well intervention costs.

The Pump Tag Mitigation (PTM) feature allows the LWM 2.0 controller to recognize the pump tag condition by analyzing runtime metrics data contained in the downhole card. Once the condition is detected, the controller will shut down the pumping unit to prevent damage to the pump and the rod string.

The standard LWM 2.0 RPC generates a downhole card at the end of stroke after a complete pumping cycle. When the PTM feature is enabled, the controller analyzes the downhole card in the specified Pump Tag Mitigation Detection Region. When the pump load in this region drops below the defined Pump Tag Mitigation Detection Load setpoint, the controller shuts down the pumping unit after the Consecutive Strokes Allowed setpoint has been violated.

After the pumping unit has been shut down or slowed to low speed, the controller then goes into a Malfunction Pump Tag well state, requiring the user to restart.

Status Information

This screen displays relevant status information related to the pump tag mitigation feature. This information is discussed below.

- **Displayed Cards**: There are two options available for displayed cards:
  - **Most Recent** – When a pump tag condition is detected, a timestamped copy of the downhole card showing the most recent pump tag occurrence is saved and displayed on this screen.
  - **Standard** – A downhole card can be saved as a reference for troubleshooting purposes. To view this standard card, use the arrow keys to highlight the **Standard** check box and then press <**ENTER**>.

  Press the **Refresh** button to clear the saved card and load the most recent saved downhole card.
- **Lower Fluid Load Line**: The controller automatically detects this load value from the downhole card and displays the value in green on the saved dynagraph card.
- **Load Detection Limit**: This value is calculated as follows:

  Lower Fluid Load Line – PTM Load Threshold

  This calculated value is displayed in red on the saved dynagraph card. When the pump load within the PTM Detection Region drops below the PTM Detection Limit value, the controller issues a Shutdown or Run Low Speed command after the Consecutive Strokes Allowed setpoint has been violated.
- **Minimum Pump Load**: This value is determined by the controller as the minimum load in pounds.

PTM Configuration

The following parameters are used in configuring PTM:

- **PTM Enabled/Disabled**: Select **Enabled** or **Disabled** to enable or disable the Pump Tag Mitigation function.
- **PTM Load Threshold (lbs)**: This is a user-defined parameter to calculate the pump tag mitigation detection load.
- **PTM Detection Region (%)**: This is the pump position region from the bottom of stroke expressed as percentage of the total gross stroke length. This is a user-defined variable.
- **Consecutive Strokes Allowed** – This user-defined variable defines the number of consecutive strokes that detected pump tag is allowed before the controller shuts down the pumping unit.

Pattern Matching

From the Advanced RPC Applications menu screen, press or click the **Pattern Matching** button to display the Pattern Matching screen shown in Figure 8-36.

Figure 8-36. Pattern Matching Screen

Pattern matching allows the user to analyze patterns in saved downhole cards for troubleshooting purposes. To start the analysis, perform the following steps:

1. Use the arrow keys to select the check box for the desired card to display and then press <**ENTER**>.
2. Use the arrow keys to highlight the **Analyze DHC** button and then press <**ENTER**>.

   The controller then compares the stored card against a database of stored cards and displays the results on the screen.

There are two methods for viewing the patterns:

- To display all the patterns, use the arrow keys to highlight the **Show Patterns** button and then press <**ENTER**>. All five patterns will be displayed on top of the card being analyzed.
- To display individual patterns, use the arrow keys to highlight the desired pattern and then press <**ENTER**>.

To clear patterns from the screen, use the arrow keys to highlight the **Clear Patterns** button and then press <**ENTER**>.

Speed Sensor

Note: This feature is used for Rotaflex pumping systems only.

From the Advanced RPC Applications menu screen, press or click the **Speed Sensor** button to display the Speed Sensor screen shown in Figure 8-37.

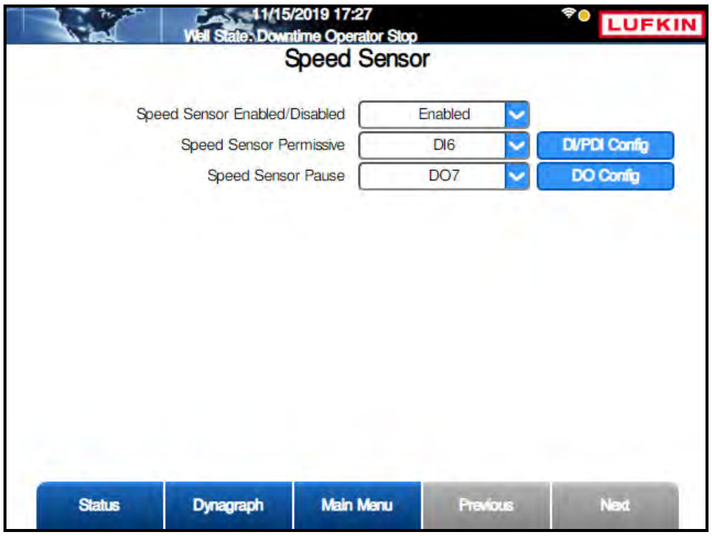


Figure 8-37. Speed Sensor Configuration Screen

Rotaflex linear pumping unit systems use an automatic braking system that engages in the event the pumping unit goes into a free fall. This braking system uses a speed sensor that monitors the pumping unit's speed and engage the brake when the sensor's speed setpoint is exceeded.

Configure these speed sensors using the following parameters:

- **Speed Sensor Enabled/Disabled**: To enable the speed sensor, select **Enabled** from the drop-down list.
- **Speed Sensor Permissive**: This parameter directs the speed sensor to send data to the controller. Select the desired digital or pseudo digital input from the drop-down list and then press the **Save** button.

  To configure the selected input, press the **DI/PDI Config** button to display the configuration screen for the selected input.

Note: If a digital input is selected, the Digital Input/Output Configuration screen will be displayed. If a pseudo digital input is selected, the Pseudo Digital Input Configuration screen will be displayed. Refer to “Digital Configuration” on page 8-47 and “Pseudo Digital Input Configuration” on page 8-51 for details on configuring these inputs.

After configuring the selected input, press the <**ESC**> button to return to the Speed Sensor configuration screen.

- **Speed Sensor Pause**: This parameter directs the speed sensor to temporarily stop sending speed data to the controller. Select the desired digital output from the drop-down list and then press the **Save** button.

  To configure the selected digital output, press the **DO Config** button to display the Digital Output Configuration screen. Refer to “Digital Configuration” on page 8-47 for details on configuring digital outputs.

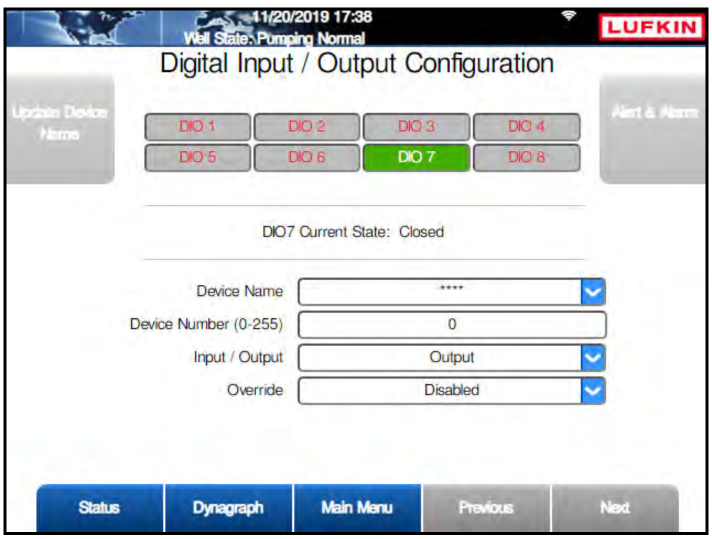


Figure 8-38. Speed Sensor Digital Output Configuration

After configuring the selected output, press the <**ESC**> button to return to the Speed Sensor configuration screen.

General I/O Programming

From the Setup menu screen, press the **General I/O** button to display the General Input/Output Configuration menu screen shown below.

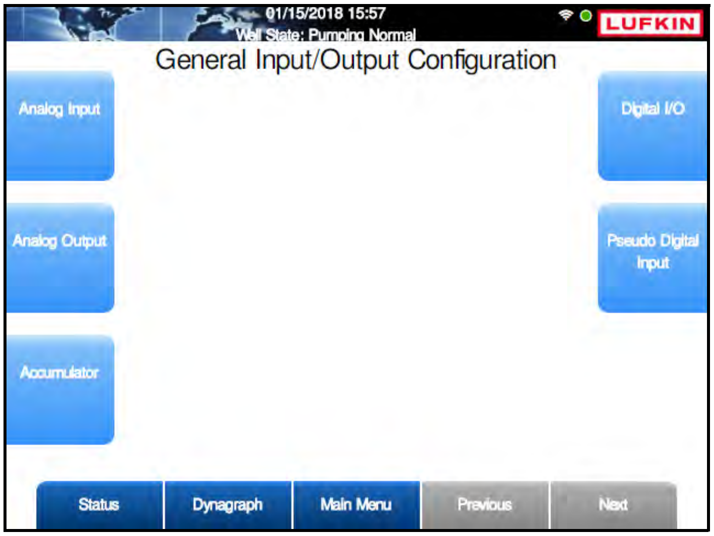


Figure 8-39. General I/O Menu Screen

The input and output options available on this screen are discussed on the following pages.

This screen enables the operator to configure and troubleshoot analog and digital inputs and outputs. Press the appropriate button to access the desired configuration screen.

These screens are discussed on the following pages.

Analog Input Configuration

From the General Input/Output Configuration menu screen, press the **Analog Input** button to display the Analog Input Configuration screen shown in Figure 8-40.

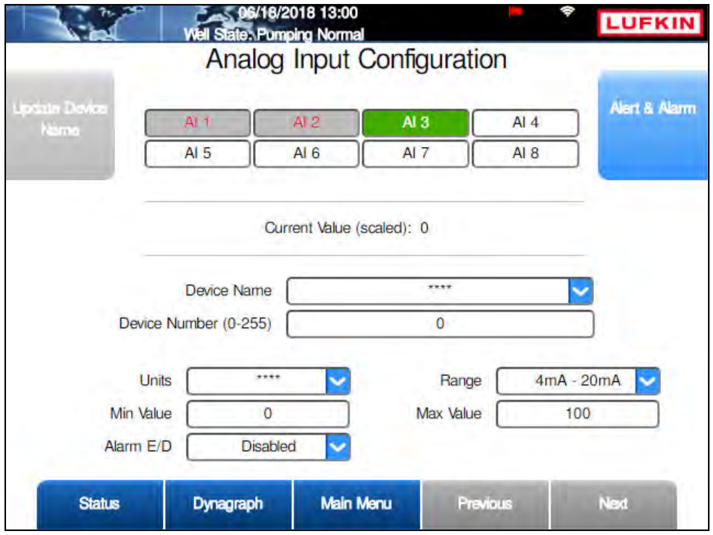


Figure 8-40. Analog Input Configuration Screen

This screen is used to configure all configurable analog inputs in the system. The top of the screen lists all available analog input points. Unavailable analog input points are grayed out.

Use the arrow keys to highlight the analog input point to be configured. Status information and available parameters are then displayed as shown above.

The **Current Value** field indicates the present scaled value of the highlighted input.

Each point is configurable using the fields at the bottom of the screen. Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Available parameters are as follows:

- **Device Name**: Select one of the preprogrammed device names from the drop-down list or create a custom device name. Available options are:
  - Casing Pressure
  - Tubing Pressure
  - Flowline Pressure
  - Upstream Pressure
  - Delta Pressure
  - Tank Level
  - Temperature
  - Casing Temperature
  - Tubing Temperature
  - Flowline Temperature
  - Custom Name (1 – 5)

Select the **Custom Name** option to create up to five custom device names. Press or click the **Update Device Name** button, type the desired name, and then press or click **Update**.

- **Device Number (0-255)**: Use the keypad to type a device number in the text field and then press or click the Save button.
- **Units**: Select the desired engineering units of measurement from the drop-down list and then press <**ENTER**>.
- **Range:** Use the up or down arrow keys to select the expected input range of the transducer being used for the highlighted analog input point.
- **Min Value**: This parameter defines the value in engineering units for the minimum output level from the transducer. This value will typically be zero, but if the transducer has a known offset, the controller is able to compensate if the correct value is entered in this field.
- **Max Value**: This parameter defines the value in engineering units for the maximum output from the transducer.
- **Alarm E/D**: Use the up or down arrow keys to select **Enabled** or **Disabled** and then press <**ENTER**>.

Press or click the **Alert & Alarm** button to display the alert and alarm configuration options for the available analog input points. These options are described below:

- **Alarm Option**: Use the keypad to select what action the controller takes when an alarm condition is detected:
  - **Disabled**: No action is taken.
  - **Alarm Only**: An alarm is activated, but the system continues running.
  - **Motor Stop (downtime)**: The motor is stopped and the controller stays in a downtime state until the alarm is cleared.
  - **Malfunction**: A malfunction is logged and the controller responds to this malfunction based on its current malfunction setpoint configuration. See “Operational Limits 1 Screen” on page 8-25 for details on the malfunction setpoint.
  - **DO Ctrl**: With this option, a command is sent to an assigned digital output port. For example, a high pressure alarm could trigger a command to open a valve to relieve the pressure.

Note: When selecting this option for an analog input point, that point must have an assigned name (preprogrammed or custom) selected in the **Device Name** parameter. See “Device Name” on the previous page for details.

- **DO Ctrl Port**: (This parameter is only visible when the **DO Ctrl** alarm option is selected.) This parameter allows the user to configure a digital output port to be triggered when an alarm condition is present.
- **Alert Setpoint**: Use the keypad to specify the high and low alert setpoints in engineering units and then press <**ENTER**>.

- **Alarm Setpoint**: Use the keypad to specify the high and low alarm setpoints in engineering units and then press <**ENTER**>.
- **Alarm Delay(s)**: Use the keypad to specify the high and low setpoints for delay time before the alarm is declared. Press <**ENTER**> to save this value.
- **Alarm Hold(s)**: Use the keypad to specify the high and low values for alarm hold time. Press <**ENTER**> to save this value.

Press or click the **Save** button to save all changes.

Press or click the **General** button to display the device general parameters.

Press <**ESC**> to return to the General Input/Output Configuration menu screen.

Analog Output Configuration

From the General Input/Output Configuration menu screen, press the **Analog Output** button to display the Analog Output Configuration screen shown in Figure 8-41.

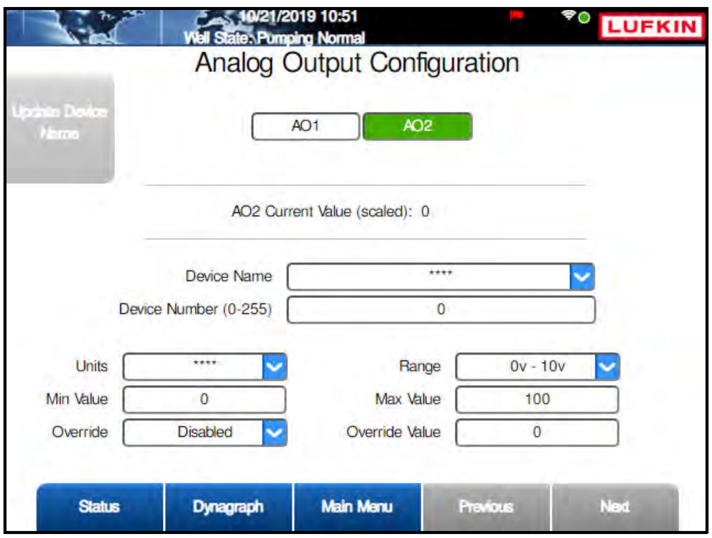


Figure 8-41. Analog Output Configuration Screen

This screen is used to configure the analog outputs in the system. The top of the screen lists the available analog output points.

Use the arrow keys to highlight the analog output point to be configured. Status information and available parameters are then displayed as shown above.

The Current Reading field indicates the present raw value of the highlighted output.

Each point is configurable using the fields at the bottom of the screen. Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Available parameters are as follows:

- **Device Name**: Select one of the preprogrammed device names from the drop-down list or create a custom device name. Available options are:
  - Casing Pressure
  - Tubing Pressure

    - Flowline Pressure
    - Upstream Pressure
    - Delta Pressure
    - Tank Level
    - Custom Name (1 – 5)

  Select the **Custom Name** option to create up to five custom device names. Press or click the **Update Device Name** button, type the desired name, and then press or click **Update**.

- **Device Number (0-255)**: Use the keypad to type a device number in the text field and then press or click the Save button.
- **Units**: Select the desired engineering units of measurement from the drop-down list.
- **Range**: Specify the expected output range from the process transducer. Use the up or down arrow keys to select the desired range from the drop-down list and then press <**ENTER**>.
- **Min Value**: Enter the engineering units for the minimum output level from the transducer/transmitter. This value will typically be zero, but if the transducer has a known offset, the controller is able to compensate if the correct value is entered in this field.
- **Max Value**: Enter the full scale engineering value for the maximum output from the transducer.
- **Override**: Use the up and down arrow keys to select **Enabled** or **Disabled** from the drop-down list and then press <**ENTER**>.
- **Override Value**: Use the keypad to specify the value to transmit through the analog output if the override feature is enabled. When override is enabled, the application has no control over the analog output.

Press or click the **Save** button to save all changes.

Press <**ESC**> to return to the General Input/Output Configuration menu screen.

Digital Configuration

From the General Input/Output Configuration menu screen, press the **Digital I/O** button to display the Digital Configuration screen.

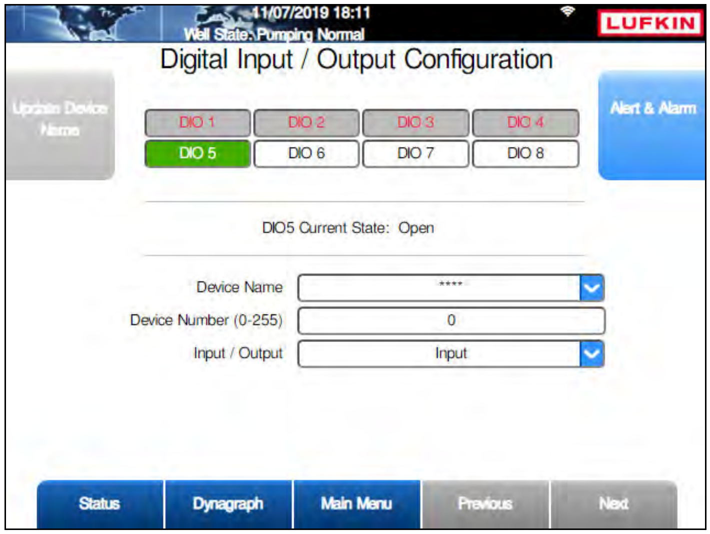


Figure 8-42. Digital Input/Output Configuration Screen

This screen is used to configure digital inputs and outputs in the system. The top of the screen lists all digital input/output points.

Note: Points that are grayed out are factory-configured and are not configurable.

Use the arrow keys to highlight the digital input/output point to be configured. Status information and available parameters are then displayed as shown above.

The **Current State** field indicates the present raw value of the highlighted point.

Each available point is configurable using the fields at the bottom of the screen. Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Available parameters are as follows:

- **Device Name**: Select one of the preprogrammed device names from the drop-down list or create a custom device name. Available options are:
  - DBR
  - Vibration Switch
  - Pressure Switch
  - Pump Switch
  - Environmental Pot
  - Facility Shutdown

- PLC
- Run Status
- Output
- Stuffing Box Leak Detector
- Kill Switch
- Flowline Pressure
- Tank Level
- Casing Pressure
- Tubing Pressure
- Custom Name (1 – 5)

  Select the **Custom Name** option to create up to five custom device names. Press or click the **Update Device Name** button, type the desired name, and then press or click **Update**.

- **Device Number (0-255)**: Use the keypad to type a device number in the text field and then press or click the Save button.
- **Input/Output**: Use the up or down arrow keys to select **Input** or **Output** for the highlighted point.

Press or click the **Save** button to save all changes.

Press or click the **Alert & Alarm** button to display the alert and alarm configuration options described below:

- **Alarm Option**: Use the keypad to select what action the controller takes when an alarm condition is detected:
  - **Disabled**: No action is taken.
  - **Alarm Only**: An alarm is activated, but the system continues running.
  - **Motor Stop (downtime)**: The motor is stopped and the controller stays in a downtime state until the alarm is cleared.
  - **Malfunction**: A malfunction is logged and the controller responds to this malfunction based on its current malfunction setpoint configuration. See “Operational Limits 1 Screen” on page 8-25 for details on the malfunction setpoint.
  - **DO Ctrl**: With this option, a command is sent to an assigned digital output port. For example, a high pressure alarm could trigger a command to open a valve to relieve the pressure.

Note: When selecting this option for a digital input point, that point must have an assigned name (preprogrammed or custom) selected in the **Device Name** parameter. See “Device Name” on the previous page for details.

- **DO Ctrl Port**: (This parameter is only visible when the **DO Ctrl** alarm option is selected.) This parameter allows the user to configure a digital output port to be triggered when an alarm condition is present.
- **Alarm Type**: (This parameter is available for input points only.) Use the up or down arrow keys to select the desired alarm type for the highlighted point. The options are **Open** or **Closed**.
- **State Change Delay**: (This parameter is available for input points only.) Use the keypad to specify the number of seconds that a digital state change must be observed before the controller acknowledges the change.

Press or click the **Save** button to save all changes.

Press or click the **General** button to display the device general parameters again.

Press <**ESC**> to return to the General Input/Output Configuration menu screen.

Accumulator Configuration

From the General Input/Output Configuration menu screen, press the **Accumulator** button to display the Accumulator Configuration screen shown in Figure 8-43.

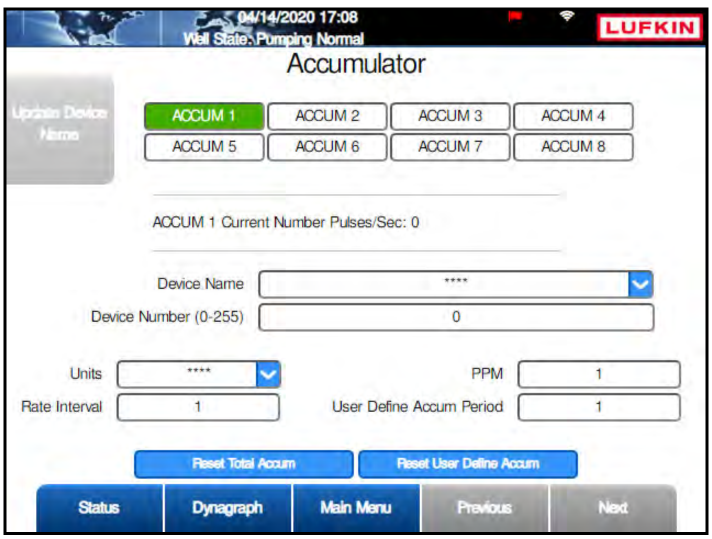


Figure 8-43. Accumulator Configuration Screen

This screen is used to configure all accumulator input points in the system. These input points are displayed at top of the screen.

Use the arrow keys to highlight the accumulator input point to be configured and then press <**ENTER**>. Status information and available parameters are then displayed as shown above.

The **Current Number Pulses/Sec** status field indicates the present value of the highlighted input.

Each point is configurable using the fields at the bottom of the screen. Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Available parameters are as follows:

- **Device Name**: Select one of the five custom name fields. Press or click the **Update Device Name** button, type the desired name, and then press or click **Update**.

- **Device Number (0-255)**: Use the keypad to type a device number in the text field and then press or click the Save button.
- **Units**: The controller offers approximately 29 options for the unit of measurement to be associated with each auxiliary input. The units selected will be displayed on the Accumulator Status screen. (See “Accumulator Status” on page 9-23.) It is logically related to the PPM field below, but the unit selected does not impact the actual scaling of the accumulator input.
- **PPM**: Pulses per unit of measure (PPM) is an integer that programs the controller to scale this given number of pulses counted at the defined accumulator input point as a single unit. The range is 1 to 999,999.
- **Rate Interval**: This is a user-defined sampling period, measured in minutes. The range is 0 to 1440 minutes. As an example, if a value of 8 is programmed, a 24-hour rate will be calculated based on the number of pulses accumulated during the most recent eight-minute period. The formula for this example of a rate interval of 8 minutes is as follows:

  $$\text{Rate} = \frac{\text{\# of pulses for last 8 minutes}}{\text{PPM}} \times \frac{\text{1440 minutes}}{\text{8 minutes}}$$

  Using the keypad, define this value and then press <**ENTER**>.
- **User Defined Accum Period**: The controller will accumulate a total for this user-defined number of days. The range is 1 to 365 days. At the end of the user-defined period, the accumulated value for that period is saved in a “Previous User-Defined Accumulator” register in the memory map and then the accumulator is cleared to start the accumulation for the next user-defined period. In addition to the User-Defined Period, the controller also maintains a 60-day record of the totals accumulated for the each of the previous sixty 24-hour days specified by Gauge Off Time.

  Use the keypad to define this value.
- **Reset Total Accum**: This button clears the total accumulation value for the highlighted point.
- **Reset User Define Accum**: This button clears the value for the user-defined accumulation period.

Press or click the **Save** button to save all changes.

Press <**ESC**> to return to the General I/O menu screen.

Pseudo Digital Input Configuration

From the General Input/Output Configuration menu screen, press the **Pseudo Digital Input** button to display the Pseudo Digital Input Configuration screen shown in Figure 8-44.

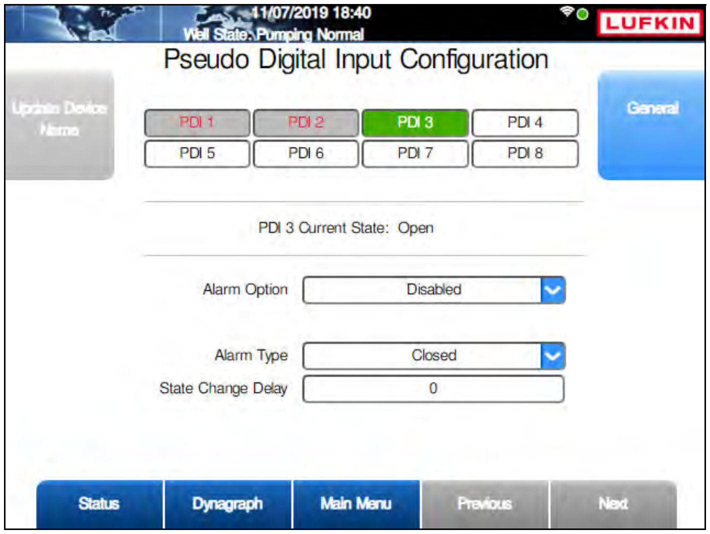


Figure 8-44. Pseudo Digital Input Configuration Screen

Pseudo digital inputs are analog inputs that can be configured to operate like digital inputs. They use the same physical terminal as the analog input channel.

This screen is used to configure pseudo digital inputs in the system. The top of the screen lists all pseudo digital input points.

Note: Points that are grayed out are factory-configured and are not configurable.

Use the arrow keys to highlight the pseudo digital input to be configured and then press <**ENTER**>. Status information and available parameters are then displayed as shown above.

The **Current State** field indicates the present raw value of the highlighted input.

Each available input is configurable using the fields at the bottom of the screen. Available parameters are as follows:

- **Device Name**: Select one of the preprogrammed device names from the drop-down list or create a custom device name. Available options are:
  - DBR
  - Vibration Switch
  - Pressure Switch
  - Pump Switch
  - Environmental Pot

    - Facility Shutdown
    - PLC
    - Run Status
    - Output
    - Stuffing Box Leak Detector
    - Kill Switch
    - Flowline Pressure
    - Tank Level
    - Casing Pressure
    - Tubing Pressure
    - Custom Name (1 – 5)

  Select the **Custom Name** option to create up to five custom device names. Press or click the **Update Device Name** button, type the desired name, and then press or click **Update**.

- **Device Number (0-255)**: Use the keypad to type a device number in the text field and then press or click the **Save** button.

Press or click the **Alert & Alarm** button to display the alert and alarm configuration options available for the selected pseudo digital input:

- **Alarm Option**: Use the keypad to select what action the controller takes when an alarm condition is detected:
    - **Disabled**: No action is taken.
    - **Alarm Only**: An alarm is activated, but the system continues running.
    - **Motor Stop (downtime)**: The motor is stopped and the controller stays in a downtime state until the alarm is cleared.
    - **Malfunction**: A malfunction is logged and the controller responds to this malfunction based on its current malfunction setpoint configuration. See “Operational Limits 1 Screen” on page 8-25 for details on the malfunction setpoint.
    - **DO Ctrl**: With this option, a command is sent to an assigned digital output port. For example, a high pressure alarm could trigger a command to open a valve to relieve the pressure.

> **Note**: The **DO Ctrl** option requires the pseudo digital input to have an assigned name (preprogrammed or custom) selected in the **Device Name** parameter field. See “Device Name” on the previous page for details.

- **DO Ctrl Port**: (This parameter is only visible when the **DO Ctrl** alarm option is selected.) This parameter allows the user to configure a digital output port to be triggered when an alarm condition is present.

- **Alarm Type**: (This parameter is available for input points only.) Use the up or down arrow keys to select the desired alarm type for the highlighted point. The options are **Open** or **Closed**.
- **State Change Delay**: Specify the number of seconds that a digital state change must be observed before the controller acknowledges the change. Use the arrow keys to highlight this field and then press <**ENTER**>. Use the keypad to define this value and then press <**ENTER**> again.

Press or click the **Save** button to save all changes.

Press <**ESC**> to return to the General Input/Output Configuration menu screen.

Pulse Configuration

From the General Input/Output Configuration menu screen, press the **Pulse** button to display the Accumulator Configuration screen shown in Figure 8-43.

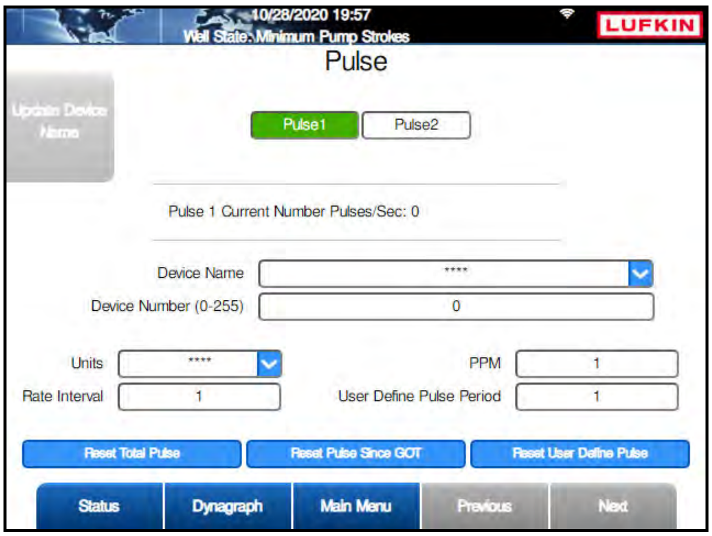


Figure 8-45. Accumulator Configuration Screen

This screen is used to configure all pulse input points in the system. These input points are displayed at top of the screen.

Use the arrow keys to highlight the pulse input point to be configured and then press <**ENTER**>. Status information and available parameters are then displayed as shown above.

The **Current Number Pulses/Sec** status field indicates the present value of the highlighted input.

Each point is configurable using the fields at the bottom of the screen. Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Available parameters are as follows:

- **Device Name**: Select one of the five custom name fields from the drop-down list. Press or click the **Update Device Name** button, type the desired name, and then press or click **Update**.
- **Device Number (0-255)**: Use the keypad to type a device number in the text field and then press or click the Save button.

- **Units**: The controller offers approximately 29 options for the unit of measurement to be associated with each auxiliary input. The units selected will be displayed on the Pulse Status screen. (See “Accumulator Status” on page 9-23.) It is logically related to the PPM field below, but the unit selected does not impact the actual scaling of the pulse input.
- **PPM**: Pulses per unit of measure (PPM) is an integer that programs the controller to scale this given number of pulses counted at the defined pulse input point as a single unit. The range is 1 to 999,999.
- **Rate Interval**: This is a user-defined sampling period, measured in minutes. The range is 0 to 1440 minutes. As an example, if a value of 8 is programmed, a 24-hour rate will be calculated based on the number of pulses accumulated during the most recent eight-minute period. The formula for this example of a rate interval of 8 minutes is as follows:

$$\text{Rate} = \frac{\text{\# of pulses for last 8 minutes}}{\text{PPM}} \times \frac{\text{1440 minutes}}{\text{8 minutes}}$$

  Using the keypad, define this value and then press <**ENTER**>.
- **User Defined Pulse Period**: The controller will accumulate a total for this user-defined number of days. The range is 1 to 365 days. At the end of the user-defined period, the accumulated value for that period is saved in a “Previous User-Defined Pulse” register in the memory map and then the pulse is cleared to start the accumulation for the next user-defined period. In addition to the User-Defined Period, the controller also maintains a 60-day record of the totals accumulated for the each of the previous sixty 24-hour days specified by Gauge Off Time.

  Use the keypad to define this value.
- **Reset Total Pulse**: This button clears the total pulse value for the highlighted point.
- **Reset User Define Pulse**: This button clears the value for the user-defined pulse accumulation period.

Press or click the **Save** button to save all changes.

Press <**ESC**> to return to the General I/O menu screen.

Communication Setup

From the Setup screen, press the **COMM** button to display the COMM menu screen shown in Figure 8-46.

Figure 8-46. COMM Menu Screen

These options are discussed on the following pages.

Radio Port Configuration

Press the **Radio** button to display the Radio Port Configuration menu screen shown in Figure 8-47 on page 8-55.

Figure 8-47. Radio Port Configuration Screen

The options on this screen are described on the following pages.

Serial Port Configuration

From the Radio Port Configuration menu screen, press or click the **Serial** button to display the Serial Port Configuration shown in Figure 8-48.

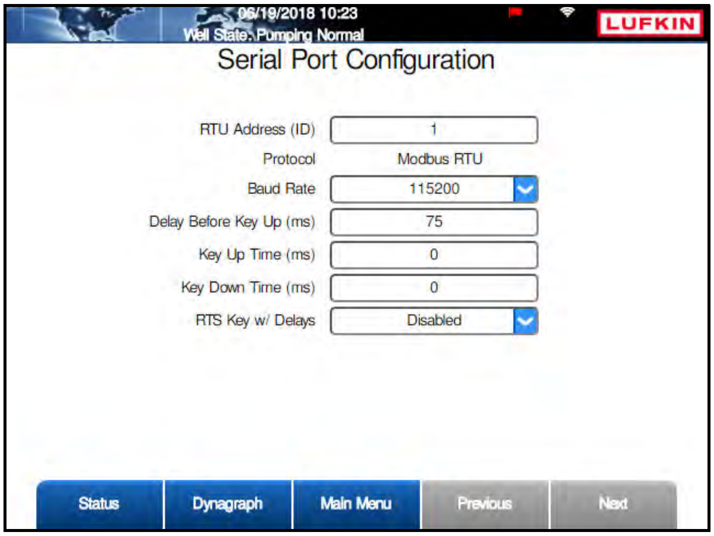


Figure 8-48. Serial Port Configuration Screen

- **RTU Address (ID)**: Specify a unique identifier number for the controller that must be coordinated with the address entry in the host computer SCADA software. The controller uses standard RTU Modbus protocol for address settings of 247 and below. The Extended Lufkin Automation Modbus (ELAM) protocol is used for addresses of 248 through 2295. ELAM protocol allows for much larger blocks of data to be transmitted, and it also allows standard Modbus messages to be combined together.

  Use the keypad to define this value and then press <**ENTER**>.

- **Protocol**: This field displays the communication protocol used by the serial port.
- **Baud Rate**: The controller supports a range of data transmission rates from 300 to 115,200 baud. The baud rate of the front panel DB-9 RS-232 laptop port can be set at a different value from that of the radio port.

  Use the down arrow key to highlight this field and then press <**ENTER**> to display the drop-down list. Use the down arrow key to highlight the desired baud rate and then press <**ENTER**> again.

- **Delay before Key Up**: The time delay, in milliseconds, from the time that the controller recognizes an incoming message addressed to it before the RTS line is raised to key the radio to send a reply.

  Use the keypad to define this value and then press <**ENTER**>.

- **Key Up Time (ms)**: Once the RTS line is raised, the controller will delay this amount of time before actually starting to send data.

  Use the keypad to define this value and then press <**ENTER**>.

- **Key Down Time (ms)**: At the end of the message string, the RTS is held high for this amount of time.

  Use the keypad to define this value and then press <**ENTER**>.

- **RTS Key w/Delays**: Select this option if an RTS key with delays is used for the serial port.

  Use the arrow keys to select **Disabled** or **Enabled** and then press <**ENTER**>.

Press the **Save** button to save the changes.

Press <**ESC**> to return to the COMM menu screen.

Ethernet Port Configuration

From the Radio Port Configuration menu screen, press or click the **Ethernet** button to display the Ethernet Port Configuration screen shown in Figure 8-49.

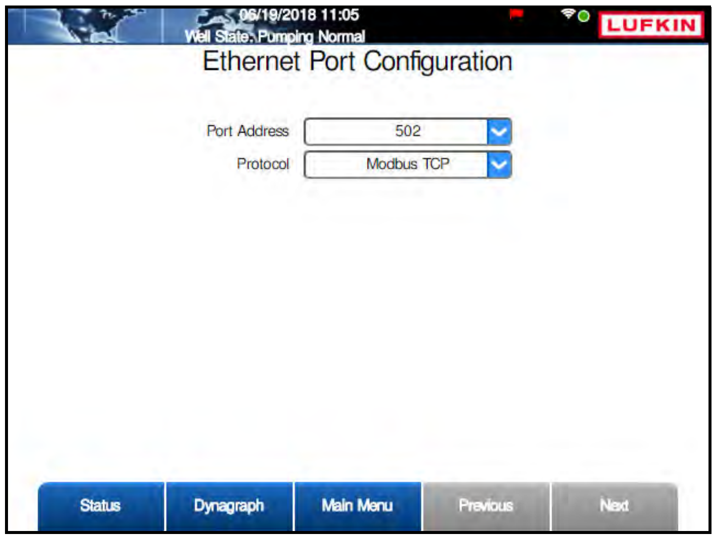


Figure 8-49. Ethernet Port Configuration Screen

Select the desired port address from the **Port Address** drop-down list and then press or click the **Save** button.

Select the desired protocol from the **Protocol** drop-down list and then press or click the **Save** button.

Network Configuration

From the COMM menu screen, press the **Network** button to display the Network Configuration screen shown in Figure 8-50.

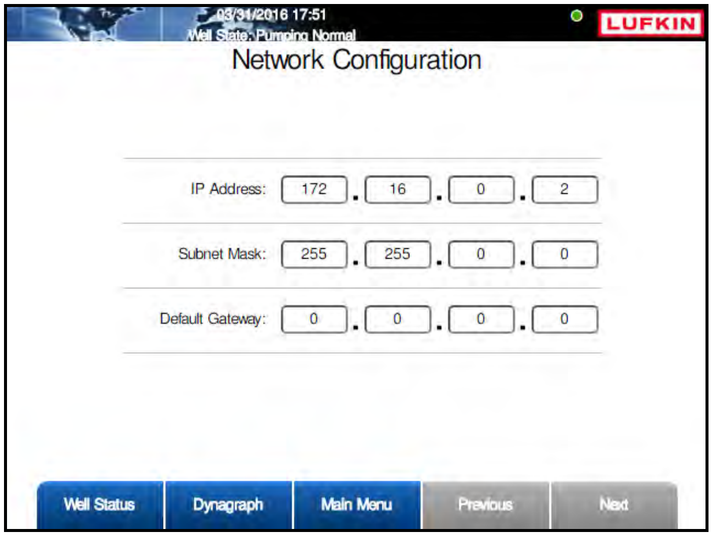


Figure 8-50. Network Configuration Screen

This screen allows the operator to change the network settings for the controller.

Use the arrow keys to highlight the desired field and then press <**ENTER**>. Use the number keys to define the value and then press <**ENTER**> again.

Press the **Save** button to save the new values.

Modbus Master Configuration

Press the **Modbus Master** button to display the Modbus Master menu screen shown in Figure 8-51.

Figure 8-51. Modbus Master Menu Screen

The LWM 2.0 controller can read and store data from other Modbus RTUs on location. This data is stored in the controller's Modbus register map and can be read on the local LCD and/or with host SCADA software. This feature allows a single on-location radio in the controller to read data from and write data to any of up to 10 Modbus-protocol RTUs at the wellsite.

Slave RTUs must be compatible with the Modbus RTU protocol and have an RS-485 communication port available. A two-wire or four-wire RS-485 data cable network must be installed to connect the controller master with each slave device.

The configuration functions are discussed on the following pages.

Polling

From the Modbus Master menu screen, press the **Polling** button to display the Modbus Master Polling screen shown in Figure 8-52.

Figure 8-52. Modbus Master Polling Screen

Type the desired polling rate in the field provided and then press the **Save** button.

Configuration

Press the **Config** button to display the Modbus Master Configure screen. The available slave devices are listed on this screen.

Figure 8-53. Modbus Master Configure Screen

With the **Current Device** field highlighted, press <**ENTER**> to display the drop-down list. Use the arrow keys to select the slave device to be configured and then press <**ENTER**.>.

The **Status** field is used to enable or disable the polling of the slave device. Polling must be enabled to activate the polling function. If a slave device is to be offline for service, disable it to prevent nuisance communication failure alarms.

Use the arrow keys to highlight this field and then press <**ENTER**> to display the drop-down list. Press the down arrow key to highlight **Enable** or **Disable** and then press <**ENTER**> again.

The following parameters are configured on this screen:

- **RTU Address**: Each slave device must have a different address number. Address numbers of less than 247 are indicated by the standard Modbus guidelines. The address must match the slave device setting.
- **Device Type**: As of this release, Modbus Slave is the only available option for device type.
- **Baud Rate**: Select from a range of options from 300 to 115,200 baud. The value must match the slave device setting.
- **Stop Bits**: This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Parity**: This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Timeout**: Specify the time, in milliseconds, that the controller waits after sending a poll message to check the reply message buffer.
- **Data Bits:** This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Delay before Key Up**: Specify the time, in milliseconds, that the processor needs to pause before raising the RTS line when the controller is ready to poll a slave device.
- **Key Up Time**: Specify the time, in milliseconds, that are to be added before data is actually transmitted once the RTS line is raised.
- **Key Down Time**: Specify the time, in milliseconds, that the RTS line is held high at the end of the outgoing message string.
- **Number of Failures Allowed**: Specify the number of times that the controller will continue to try to poll a slave device once that device is enabled. If the controller does not receive a valid response after this number of consecutive polling attempts, a communication failure alarm is flagged for the slave device to alert the operator that data from the slave is not current. Communication failure flags can be checked using the local LCD display. For more information, see the description about the Status field.

Read

Press the **Read** button to display the Modbus Master Read screen shown in Figure 8-54 below.

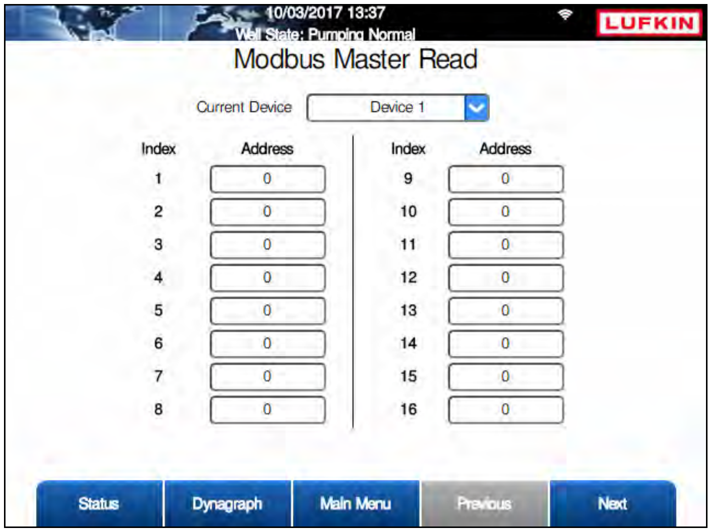


Figure 8-54. Modbus Master Read Screen

After the type of slave device used is specified as an RTU, and the slave device communication parameters to be used for it are specified, the operators need to configure register addresses to register indices. The Modbus Master function is capable of reading data from a maximum 125 register addresses per Modbus slave device. These addresses are associated to register indices in groups of 16 to a screen. This configuration is performed using the Modbus Master Config screen shown in Figure 8-53 on page 8-60.

The numbers in the Index column are the numbers assigned in the LWM’s buffer of values. The values in the Address column must be programmed with the register numbers in the slave device that contains the data to be read. Perform this operation separately for each Modbus slave device on the data network.

When assigning register numbers, keep in mind the generic Modbus organization guidelines. This type of organization minimizes the number of data transmissions required to read all of the desired data, and it reduces data access time.

- Group together all registers read with a given function code
- Read contiguous groups of registers where possible
- Arrange the **Register Address** column with the smaller register numbers at the top of each group

The procedure for assigning register numbers is as follows:

1. On the Modbus Master Read screen, select the desired slave device from the **Current Device** drop-down list.
2. Use the keypad to type the register address in the **Address** field next to the desired index number.
3. Press the **Save** button to save the address.

4. Repeat these steps for each register address.

Note: Every slave device that is to be polled by the controller must have an index number assigned to it.

Write

Press the **Write** button to display the Write Utility screen shown in Figure 8-55.

Figure 8-55. Modbus Master Write Screen

The Modbus Master Write function can write register values to one or multiple registers of a Modbus slave device. Register values can be assigned to a maximum of 25 register addresses. After the addresses are configured, specify the Modbus slave device that is to receive these values and then write them to it.

The procedure for assigning register numbers is as follows:

1. On the Modbus Master Read screen, select the desired slave device from the **Current Device** drop-down list.
2. Use the keypad to type the register address in the **Address** field next to the desired index number.
3. Press the **Save** button to save the address.
4. Repeat these steps for each register address.

Press the **Next** button to display the next communication setup screen.

VSD Communication

VSD functions are available on VSD-equipped controllers only.

Zenith Downhole Gauge

From the COMM menu screen, press the **Zenith DH Gauge** button to display the Zenith DH Gauge screen shown in Figure 8-56.

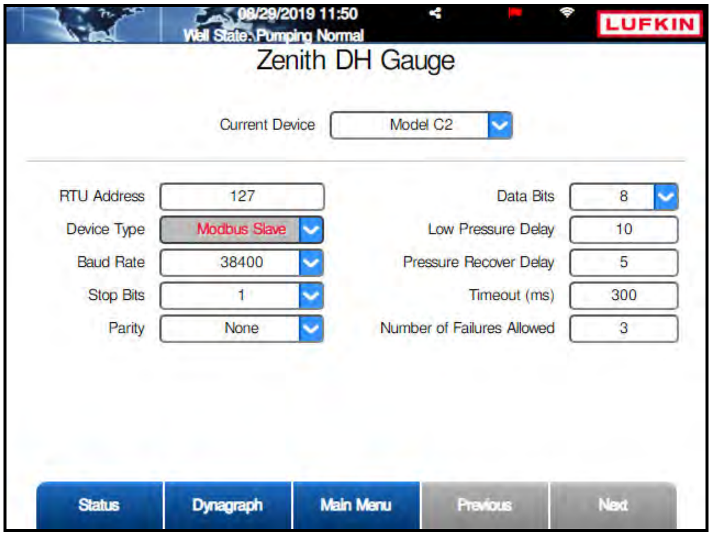


Figure 8-56. Zenith Downhole Gauge Configuration Screen

The following parameters are configured on this screen:

- **RTU Address**: Each downhole gauge must have a different address number. Address numbers of less than 247 are indicated by the standard Modbus guidelines. The address must match the downhole gauge setting.
- **Device Type**: As of this release, Modbus Slave is the only available option for device type.
- **Baud Rate**: Select from a range of options from 300 to 115,200 baud. The value must match the slave device setting.
- **Stop Bits**: This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Parity**: This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Data Bits:** This is one of three fields (Stop Bits, Parity, and Data Bits) that define the data format to be used by the controller. These settings must be the same as the slave device.
- **Low Pressure Delay**: (Applies to the **Pressure** mode for Secondary Downtime Mode only.) Use the keypad to define this value and then press <**ENTER**>.
- **Pressure Recover Delay**: (Applies to the **Pressure** mode for Secondary Downtime Mode only.) Use the keypad to define this value and then press <**ENTER**>.
- **Timeout**: Specify the time, in milliseconds, that the controller waits after sending a poll message to check the reply message buffer.
- **Number of Failures Allowed**: Specify the number of times that the controller will continue to try to poll a downhole gauge once that gauge is enabled. If the controller does not receive a valid response after this number of consecutive polling attempts, a communication failure alarm is flagged for the downhole gauge to alert the operator that data from the gauge is not current. Communication failure flags are displayed in red at the top of the screen.

Press the **Save** button to save the changes.

Function Block Variable Configuration

Press the **FB Variable** button to display the FB Variable screen shown in Figure 8-57.

Figure 8-57. Function Block Variable Screen

Use this screen to configure function block programming parameters.

- **Function Block E/D**: Press <**ENTER**> to display the drop-down list. Use the up or down arrow keys to select **Enabled** or **Disabled** and then press <**ENTER**> again.
- **Function Block Downtime**: There are two options available:
  - **Standard DT** – Select this option to use the standard system downtime parameter. (See “Operational Limits Configuration” on page 8-25 for details on the standard system downtime parameter.)
  - **Func Blk DT** – Select this option to use the Function Block Downtime parameter shown on this screen.
- **Manual DT (HH:MM)**: Use the keypad to define the downtime period in hours and minutes and then press <**ENTER**>.

Press the **Save** button to save the changes.

The function block variable buttons are discussed in the following pages.

Function Block Variable Command

From the FB Variable screen, press or click the **FB Variable Command** button to display the FB Variable Command screen shown in Figure 8-58.

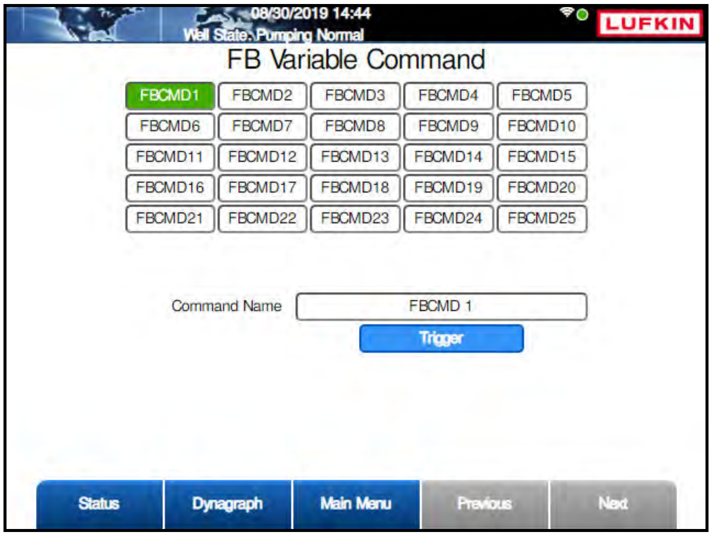


Figure 8-58. Function Block Variable Command Screen

This screen is used to assign names for up to 25 existing function block variable commands. The operator can also trigger these commands from this screen.

To assign a name to a function block variable command, perform the following steps:

1. Select the button for the function block alarm variable to be named.
2. In the **Alarm Name** field, type the desired alarm variable name and then press or click the **Save** button.
3. Repeat these steps as needed.

To trigger a command, use the arrow keys to highlight the **Trigger** button and then press <**ENTER**>. The results from the triggered command can be viewed on the RPC Event Log screen. See “RPC Event Log” on page 11-11 for details on this screen.

Function Block Variable Alarm

From the FB Variable screen, press or click the **FB Variable Alarm** button to display the FB Variable Alarm screen shown in Figure 8-58.

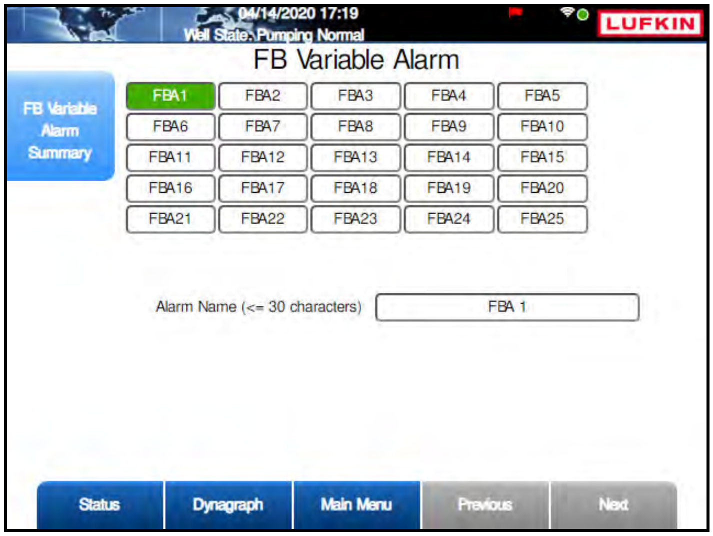


Figure 8-59. Function Block Variable Alarm Screen

This screen is used to assign names to function block variable alarms. Perform the following steps:

1. Select the button for the function block alarm to be named.
2. In the **Alarm Name** field, type the desired alarm variable name and then press or click the **Save** button.
3. Repeat these steps as needed.

Press the **FB Variable Alarm Summary** button to view a summary of function block variable alarm data.

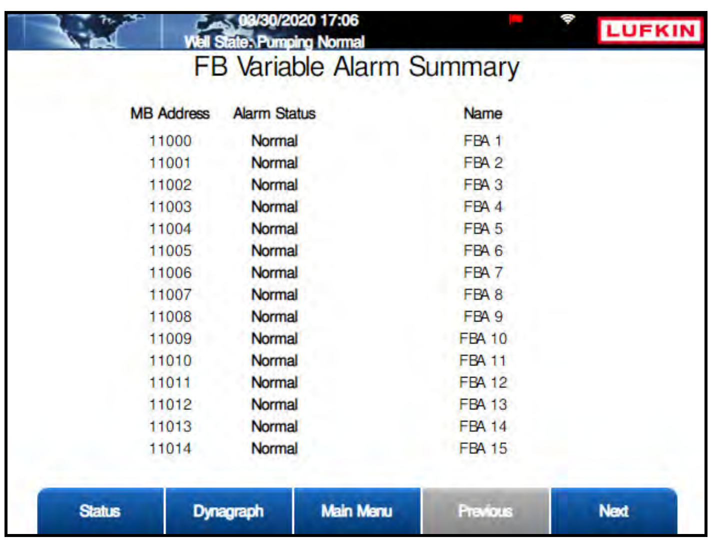


Figure 8-60. Function Block Variable Alarm Summary Screen

Use the **Next** and **Previous** buttons to navigate through the variable list. When finished, press the **FB Variable Alarm** button to return to the FB Variable Alarm screen.

Press the **<ESC>** button to return to the FB Variable screen.

Function Block Variable Status

From the FB Variable screen, press the **FB Variable Status** button to display the FB Variable Status screen shown in Figure 8-61.

Figure 8-61. Function Block Variable Status Screen

This screen is used for assigning names for up to 75 existing function block status variables. These variables are grouped into three categories:

- **REAL**: The first 25 variables (FBS1-FBS25) use a real number system and allow values with decimal points.
- **SIGNED**: The next 25 variables (FBS26-FBS50) use a signed number system, which allows positive and negative values.
- **UNSIGNED**: The next 25 variables (FBS51-FBS75) use an unsigned number system, which allows positive values only.

Perform the following steps to assign status variable names:

1. Select the button for the function block status variable to be named.
2. In the **Variable Name** field, type the desired alarm variable name and then press or click the **Save** button.
3. Repeat these steps as needed. Use the **Next** and **Previous** buttons to navigate through the variable list.

Press the **FB Variable Status Summary** button to view a summary of function block variable status data.

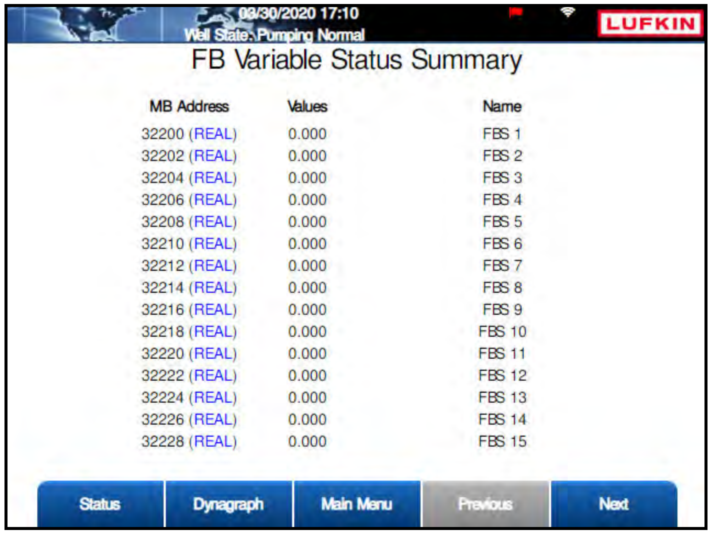


Figure 8-62. Function Block Variable Status Summary Screen

Press the **FB Variable Status** button to return to the FB Variable Status screen.

Press the **<ESC>** button to return to the FB Variable screen.

Function Block Variable Configuration

From the FB Variable screen, press the **FB Variable Config** button to display the FB Variable Config screen shown in Figure 8-63.

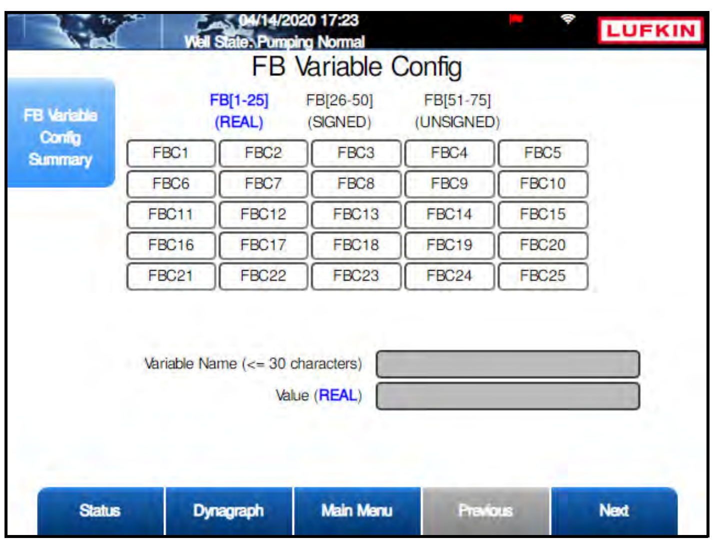


Figure 8-63. Function Block Variable Configuration Screen

This screen is used for assigning names and values to existing function block variables. This screen is used for assigning names and values for up to 75 existing function block variables.These variables are grouped into three categories:

- **REAL**: The first 25 variables (FBS1-FBS25) use a real number system and allow values with decimal points.

- **SIGNED**: The next 25 variables (FBS26-FBS50) use a signed number system, which allows positive and negative values.
- **UNSIGNED**: The next 25 variables (FBS51-FBS75) use an unsigned number system, which allows positive values only.

Perform the following steps:

1. Select the button for the function block variable to be configured.
2. In the **Variable Name** field, type the desired alarm variable name and then press or click the **Save** button.
3. In the **Value (REAL)** field, type the desired value and then press or click the **Save** button.
4. Repeat these steps as needed. Use the **Next** and **Previous** buttons to navigate through the variable list.

Press the **FB Variable Config Summary** button to view a summary of function block variable configuration data.

Figure 8-64. Function Block Variable Config Summary Screen

Press the **FB Variable Config** button to return to the FB Variable Config screen.

Press the **<ESC>** button to return to the FB Variable screen.

AGA Configuration

From the second Setup menu screen, press the **AGA Configuration** button to display the AGA Configuration screen shown in Figure 8-65.

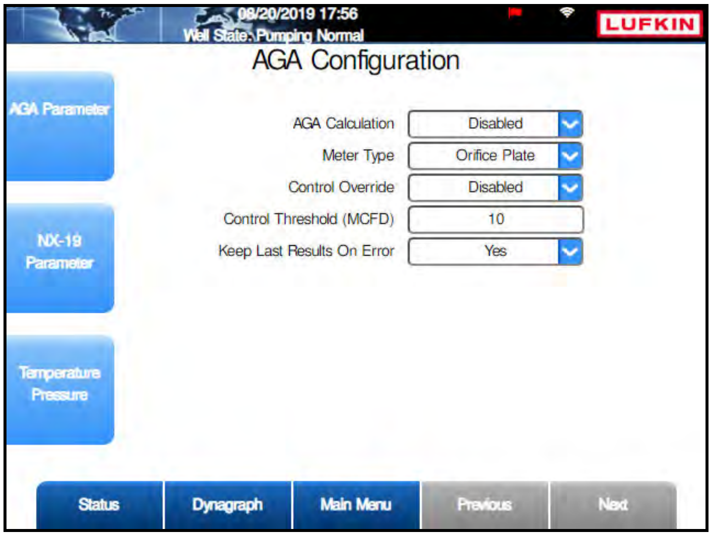


Figure 8-65. AGA Configuration Screen

The following parameters are configured on this page:

- **AGA Calculation**: To enable this feature, select **Enabled** from the drop-down list and then press <**ENTER**>.
- **Meter Type**: Select **Orifice Plate** or **Turbine Meter** from the drop-down list and then press <**ENTER**>.
- **Control Override**: To enable this feature, select **Enabled** from the drop-down list and then press <**ENTER**>.
- **Control Threshold (MCFD)**: Use the keypad to define this value and then press <**ENTER**>.
- **Keep Last Results On Error**: Select **Yes** to keep the last results when an error occurs. Select **No** to erase the last results.

Press the **Save** button to save the new values.

AGA Parameter

From the AGA Configuration screen, press the **AGA Parameter** button to display the AGA Design Parameters screen shown in Figure 8-66.

Figure 8-66. AGA Design Parameters Screen

The following parameters are configured on this screen:

- **Tap Type**: Select **Flange** or **PIpe** from the drop-down list and then press <**ENTER**>.
- **Tap Location**: Select **Upstream** or **Downstream** from the drop-down list and then press <**ENTER**>.
- **Orifice Material**: Select the appropriate orifice material from the drop-down list and then press <**ENTER**>. Available options are:
  - Stainless Steel
  - Monel
  - Carbon Steel
- **Orifice Diameter**: Use the keypad to define the orifice diameter and then press <**ENTER**>.
- **Pipe Material**: Select the appropriate orifice material from the drop-down list and then press <**ENTER**>. Available options are:
  - Stainless Steel
  - Monel
  - Carbon Steel
- **Pipe Diameter (in)**: Use the keypad to define the pipe diameter and then press <**ENTER**>.
- **Measurement Temp (F)**: Use the keypad to define the measurement temperature and then press <**ENTER**>.
- **Viscosity (cP)**: Use the keypad to define the viscosity and then press <**ENTER**>.
- **Isentropic Exponent**: Use the keypad to define this value and then press <**ENTER**>.
- **Calibration Factor**: Use the keypad to define this value and then press <**ENTER**>.

- **Compressible Fluid**: Select **Yes** or **No** from the drop-down list and then press <**ENTER**>.

Press the **Save** button to save the new values.

NX-19 Parameter

From the AGA Configuration screen, press the **NX-19 Parameters** button to display the NX-19 Design Parameters screen shown in Figure 8-67.

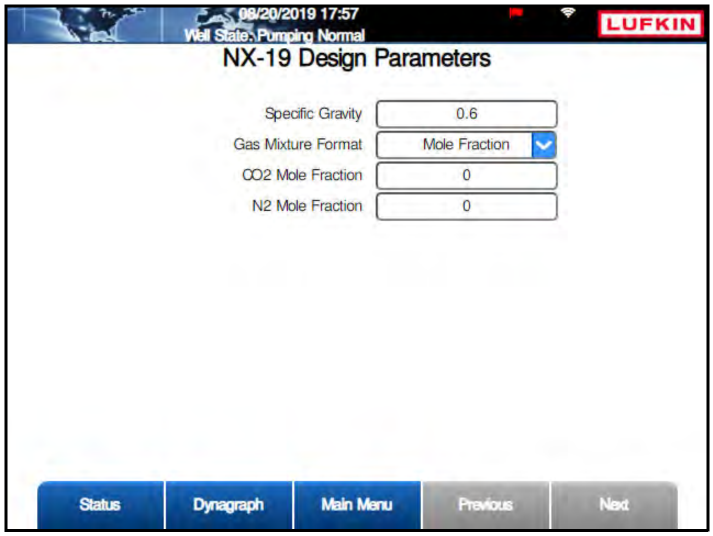


Figure 8-67. NX-19 Design Parameters Screen

The following parameters are configured on this screen:

- **Specific Gravity**: Use the keypad to define this value and then press <**ENTER**>.
- **Gas Mixture Format**: Select **Mole Fraction** or **Mole Percent** from the drop-down list and then press <**ENTER**>.
- **CO2 Mole Fraction**: Use the keypad to define this value and then press <**ENTER**>.
- **N2 Mole Fraction**: Use the keypad to define this value and then press <**ENTER**>.

Press the **Save** button to save the new values.

Temperature/Pressure

From the AGA Configuration screen, press the **Temperature Pressure** button display the Temperature/Pressure Configuration screen shown in Figure 8-68.

Use the keypad to define the following base conditions parameters:

- **Base Pressure**: Use the keypad to define this value and then press <**ENTER**>.
- **Base Temperature**: Use the keypad to define this value and then press <**ENTER**>.
- **Adj Pressure**: Use the keypad to define this value and then press <**ENTER**>.

The flowing conditions parameters are configured as follows:

- **Differential Pressure**: Select an analog input from the drop-down list and then press <**ENTER**>. To configure this input, press the **AI Config** button to display the Analog Input Configuration screen. See “Analog Input Configuration” on page 8-43 for details.
- **Zero Cutoff**: Use the keypad to define this value and then press <**ENTER**>.

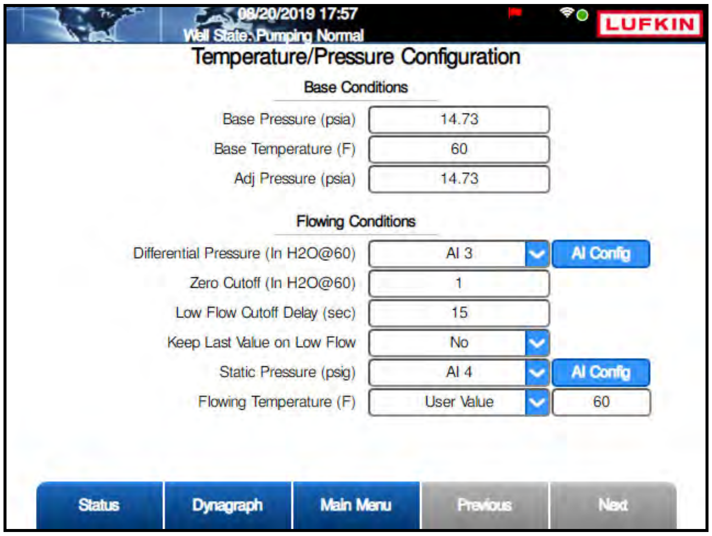


Figure 8-68. Temperature/Pressure Configuration Screen

- **Low Flow Cutoff Delay**: Use the keypad to define this value and then press <**ENTER**>.
- **Keep Last Value on Low Flow**: Select **Yes** to keep the last value in a low flow condition. Select **No** to erase the last value in a low flow condition.
- **Static Pressure**: Select an analog input from the drop-down list and then press <**ENTER**>. To configure this input, press the **AI Config** button to display the Analog Input Configuration screen. See “Analog Input Configuration” on page 8-43 for details.
- **Flowing Temperature**: This parameter is defined using data from an analog input or a user-defined value:
  - **AI 3-8**: Select an analog input from the drop-down list and then press <**ENTER**>. To configure this input, press the **AI Config** button to display the Analog Input Configuration screen. See “Analog Input Configuration” on page 8-43 for details.
  - **User Value**: This option uses a user-defined value for the flowing temperature. Use the keypad to define this value in the text field.

Press the **Save** button to save the new values.

Section 9: Status Screens

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Section Overview

The LWM 2.0 controller has several well status screens that display information about current values for measured process variables, alarms and alerts, and reminders on about how control parameters are configured. This section discusses these screens and the available data.

Main Status Data Screens

There are four main status data screens available. These are discussed in the following paragraphs.

Well Status

Press the **Status** button to display the Well Status screen shown in Figure 9-1.

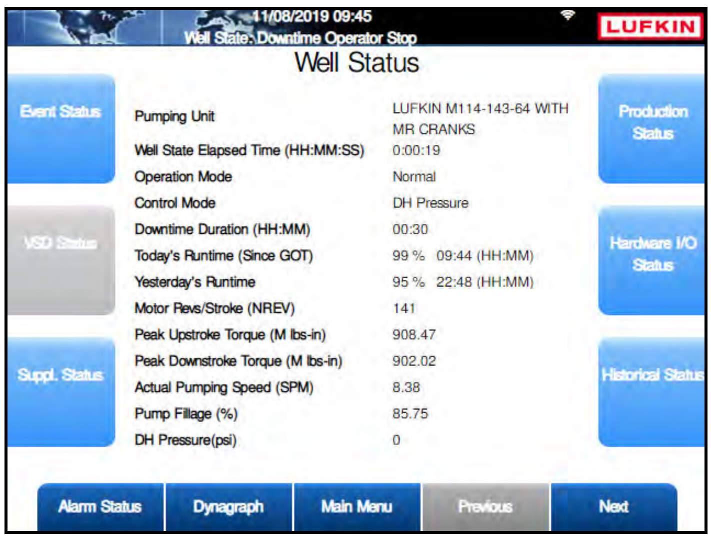

Figure 9-1. Well Status Screen

This is the first of five main well status screens available. Current pumping unit, well state, control and operation modes, and runtime status information are displayed on this screen.

Each main well status screen contains menu buttons that provide access to additional data screens. These screens are discussed later in this section.

The information displayed on this first screen is discussed below:

- **Pumping Unit**: This field displays the pumping unit currently used in the system.
- **Well State Elapsed Time**: States how long (HH:MM:SS format) the LWM 2.0 controller has been in the current well state.
- **Operation Mode**: This field displays the operation mode currently being used by the controller. The LWM 2.0 controller has three available operation modes:

  See “Operational Limits Configuration” on page 10-25 for more information on operation modes.

- **Control Mode**: The control mode field shows which control algorithm is currently being used for well control decisions. In some cases, the controller automatically changes the control method. See “Operational Limits Configuration” on page 10-25 for more information on control modes.
- **Downtime Duration**: This field indicates the amount of time (displayed in HH:SS format) the pumping unit has been in downtime mode.
- **Today’s Runtime**: This field shows the amount of time the pumping unit has been operating on the current date.
- **Yesterday’s Runtime**: This field indicates the amount of time the pumping unit was in operation on the previous date.
- **Motor Revs/Stroke (NREV)**: This field displays the number of motor revolutions required for each pump stroke.
- **Actual Pumping Speed**: States the actual pumping speed in strokes per minute as measured by the controller using the position input data. Slight variations may be shown from one stroke to the next.
- **Pump Fillage**: When operating in Downhole or VSD Downhole control mode, the controller calculates a dynagraph pump card each stroke. This card is analyzed to determine gross pump stroke and net pump stroke.

  Net pump stroke is the part of the downhole pump stroke that is actually lifting fluid for a given stroke. Net stroke as a percentage of gross stroke is referred to as pump fillage. Fillage is the control parameter for pump off detection in the Downhole control mode.

  When the calculated pump fillage falls below the setpoint for fillage, the controller counts that stroke value as a pumped off stroke. When the number of consecutive pumped off strokes equals the programmed number of pump off strokes allowed, the controller stops the pumping unit for the programmed downtime.
- **DH Pressure (psi)**: (Applies to the **DH Pressure** control mode only.) Displays the current downhole pressure reading from an installed downhole gauge.

Press the **Alarm Status** button to display the Alarm Status screen shown in Figure 9-2.

Figure 9-2. Alarm Status Screen

This screen displays a list of active system alarms.

Press the **Status** button to return to the Well Status screen.

Press **Next** to display the next screen.

Violation Status

The Violation Status screen shown in Figure 9-3 is the second status screen displayed. This screen shows all violation occurrences for system setpoints such as weight and fluid loads, motor RPM, and malfunction setpoints. Each setpoint's current state (**E** for Enabled or **D** for Disabled), parameter value, and present value are also displayed.

Figure 9-3. Violation Status Screen

The following violation data is displayed in column format:

- **Violation**: This column shows the name of the violation setpoint.
- **State**: This column shows the current state of the violation setpoint. **E** indicates that the function is enabled, and **D** indicates that the function is disabled.

  Each parameter can be enabled or disabled independently using the Operational Limits screens. For more information about these screens, see "Operational Limits Configuration" on page 10-25.
- **Consc Allow**: This column displays the number of programmed retries (consecutive allowed) for that function. For more information about this parameter, see "Operational Limits Configuration" on page 10-25.
- **Consc/Cum**: This column displays a historical record of consecutive retries and the cumulative number the malfunction has occurred with no consecutive criteria.
- **Pres Val**: This column displays the present value of the variable associated with the malfunction control. Typically, the controller updates present values at the bottom of stroke when in a pumping well state.

The following setpoint violations are shown:

- **Peak Load**: The maximum allowed value for load input. If the load exceeds this limit, the controller instantly shuts down the pumping unit with no consecutive stroke delay. Units are in pounds. The default value will be the full scale of the programmed load end device.

- **Min Load**: The lowest allowed value for load input. If the load falls below this value, the controller instantly shuts down the pumping unit with no consecutive stroke delay. The default value is zero.
- **No RPM**: This is a time delay setpoint, measured in seconds. It is designed to allow the pumping unit time to accelerate up to operating speed. When the unit starts up, the controller waits a predefined number of seconds before checking for No RPM violations.
- **No Crank**: This setpoint specifies the number of motor revolutions that the controller should wait before it detects the first crank switch input. If a crank switch input is not detected within this number of motor revolutions, the controller declares a No Crank alarm and stops the pumping unit. If the unit is pumping extremely slow and it causes this reference revolution value to be near 300, you may need to program a higher value than the default of 300 revolutions.
- **Low Motor RPM**: Like the No RPM setpoint, this is also a time delay setpoint, measured in seconds. It is designed to allow the pumping unit time to accelerate up to operating speed. When the unit starts up, the controller waits a predefined number of seconds before checking for Low Motor RPM violations.
- **Peak Torque**: The maximum allowed torque value in thousands of inch-pounds. If the controller calculates a torque value greater than this limit at the completion of a stroke, the pumping unit shuts down early in the next upstroke.
- **Malf Setpoint**: States the number of consecutive strokes that the surface malfunction setpoint has been violated. This feature shuts down the well if surface load on the upstroke falls below the malfunction setpoint for the programmed number of consecutive strokes.
- **Low Fluid Load**: The controller analyzes the realtime downhole dynagraph and uses this data to calculate fluid load for each pump stroke. If the fluid load drops below this low limit, the pumping unit is stopped for a downtime cycle early in the next upstroke.

Alarm and control setpoints are displayed at the bottom of the screen. The state of each setpoint is displayed as **E** (enabled) or **D** (disabled).

When an alarm setpoint is active, the system will sound an audible alarm when a setpoint violation occurs. The following alarm setpoints are displayed:

- **Belt Slippage**: When in the Pumping Normal mode well state, the controller counts the Motor Rev/Stroke for each stroke. At the end of each stroke, the count is compared to the Reference Rev number programmed above. If the current Motor Rev/Stroke count is greater than the Reference Rev by greater than this Belt Slippage percentage, the controller sets an alarm flag to indicate possible belt slippage. No other control action is taken. The default value is 5%.
- **Peak PRHP**: This is the value at which the controller will set an alert flag to advise the operator that a paraffin treatment may be required. This value is a high limit.

Control setpoints determine pump downtime based on the control mode currently being used. When the controller is in Surface control mode, the Pump Off setpoint is displayed. When the controller is in Downhole control mode, the Pump Fillage setpoint is displayed.

All the setpoints displayed on this screen are configured on the Operational Limits Configuration screen and on the dynagraph screens. See “Operational Limits Configuration” on page 10-25 for details on configuring these setpoints.

Press **Next** to display the next screen.

Downhole Gauge Status

The DH (Downhole) Gauge Status screen is the third status screen displayed. This screen shows realtime and average data for the installed downhole gauge.

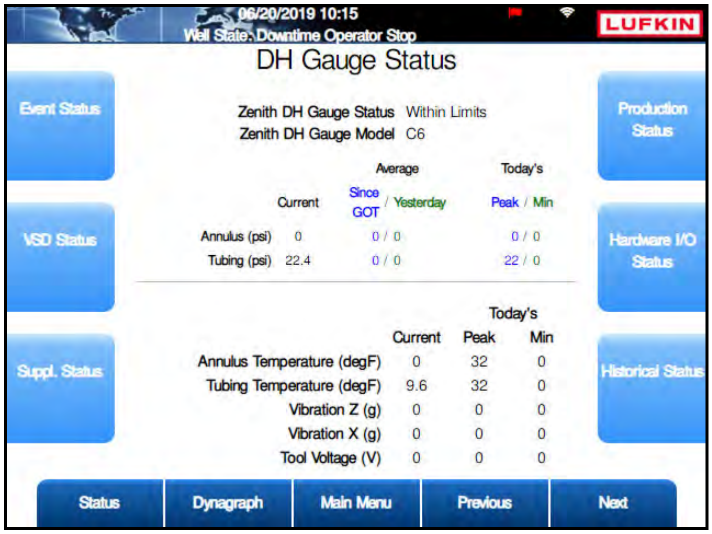

Figure 9-4. Downhole Gauge Status Screen

The available downhole gauge data varies depending on the model installed.

- **Annulus Pressure (psi)**: Available for all models
- **Tubing Pressure (psi)**: Available for Model C6 only
- **Annulus Temperature (degF)**: Available for Models C2 and C6 only
- **Tubing Temperature (degF)**: Available for Models C5 and C6 only
- **Vibration Z (g)**: Available for all models
- **Vibration X (g)**: Available for all models
- **Tool Current (A)**: Available for Model C2 only
- **Tool Voltage (V)**: Available for all models

Press **Next** to display the next screen.

Stroke Status

The Stroke Status screen shown in Figure 9-5 is the fourth status screen displayed. This screen shows pump stroke status data including power values, stroke counters, and average stroke speed.

Figure 9-5. Stroke Status Screen

The data fields are described below.

Power Values

The recorded horsepower of the polished rod and the pumping unit are displayed at the top of the screen. Values displayed are:

- **Current Polished Rod Power**: This value shows the current horsepower of the polished rod during pumping operation.
- **Peak Polished Rod Power**: This value displays the peak horsepower recorded for the polished rod since the pumping system was started.
- **Last Stroke Pump Power**: This value displays the horsepower recorded during the pumping unit's last stroke.
- **Average Downstroke Motor Power**: This value shows the average downstroke horsepower of the pumping unit motor.

Stroke Counters

The stroke counters display the following data:

- **Today's Total Strokes**: This value indicates the total recorded pump strokes for the current day.
- **Yesterday's Total Strokes**: This value shows the total recorded pump strokes for the previous day.
- **Rod-O-Meter**: This resettable accumulating value displays the current pump cycles of the rod string.
- **Pump-O-Meter**: This resettable accumulating value displays the current pump cycles of the pumping unit.

Stroke Speed Data

The system records the speed of the pump strokes and averages this data for each day of operation. Values displayed on this screen are:

- **Today's Average Stroke Speed**: This is the average speed calculated for the current day's pump strokes.
- **Yesterday's Average Stroke Speed**: This is the average speed calculated for the previous day's pump strokes.

Press **Next** to display the next screen.

Control Override Status

The Control Override Status screen shown in Figure 9-6 is the fourth status screen displayed. This screen provides status information on all control override functions that are active in the system.

Figure 9-6. Control Override Status Screen

The control settings shown on this screen are:

- **PIP (Pump Intake Pressure) Control**: When the PIP control setting is enabled, the controller shuts down the pumping unit if the calculated PIP value falls below the PIP setpoint. See "LWT/PIP Parameters 3/3 Screen" on page 10-18 for more information on this setpoint.
- **Function Block**: This field indicates whether the Function Block Downtime feature is enabled or disabled. See "Pump Tag Mitigation" on page 10-53 for more information on this feature.
- **HOA**: This field indicates whether the HOA switch override feature is enabled or disabled. See "RPC Miscellaneous I/O" on page 10-51 for details on enabling this feature.
- **Production Cutoff**: This field indicates whether the Production Cutoff feature is enabled or disabled. When this feature is enabled, the pumping unit shuts down for the day when a programmed daily production volume is reached and remains shut down until next GOT, at which time normal operation resumes.
- **Peak Energy Management**: This field indicates whether the Peak Energy Management feature is enabled or disabled. See "Gauge-Off Time and Peak Energy Management" on page 10-50 for details on enabling this feature.

- **ESD (Emergency Shutdown):** This field indicates whether the Emergency Shutdown feature is enabled or disabled. See “RPC Miscellaneous I/O” on page 10-51 for details on enabling this feature.

Event Data

Event data displays the recorded date and time that significant events relating directly to the RPC control processes occurred, including startups/shutdowns and alarms.

From any of the main status menu screens, press the **Event Status** button to display the Event Status menu screen shown in Figure 9-7.

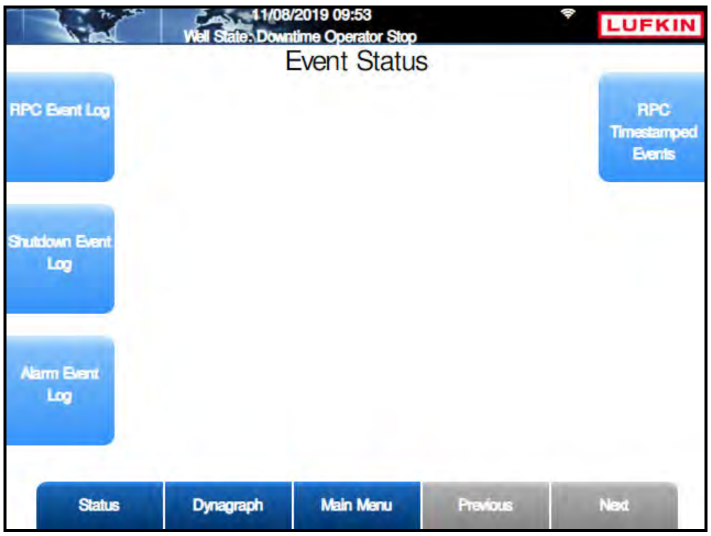

Figure 9-7. Event Status Menu Screen

The event status screens are discussed in the following pages.

RPC Event Log

Press the **RPC Event Log** button to display the RPC Event Log screen shown in Figure 9-8.

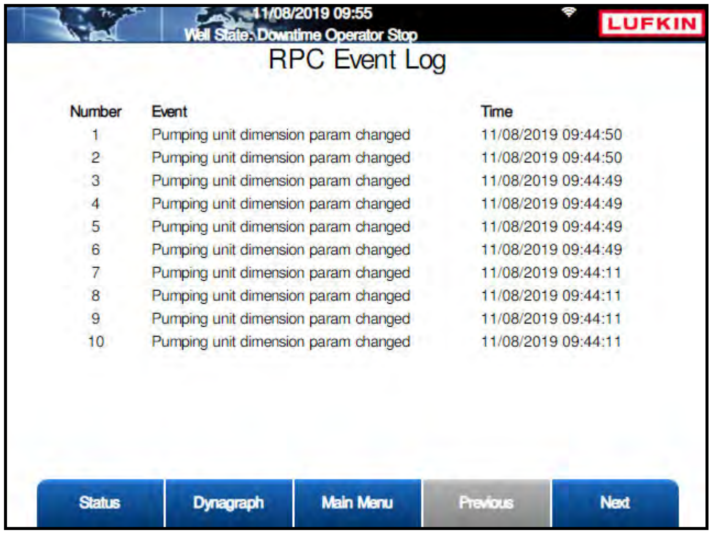

Figure 9-8. System Event Log Screen

The event log feature displays a record of the last 57 significant RPC events. All events are recorded with a date/time stamp. This log can be useful for checking when programming changes were made, power outages occurred, etc.

Press the **Next** or **Previous** buttons to navigate between the system event log pages.

Press <**ESC**> to return to the Event Status menu screen.

Shutdown Event Log

Press the **Shutdown Event Log** button to display the Shutdown Event Log screen shown in Figure 9-9.

This screen displays the last 20 times that the controller stopped and started the pumping unit with a date/time stamp for each. The reason for the stop or shutdown decision is included.

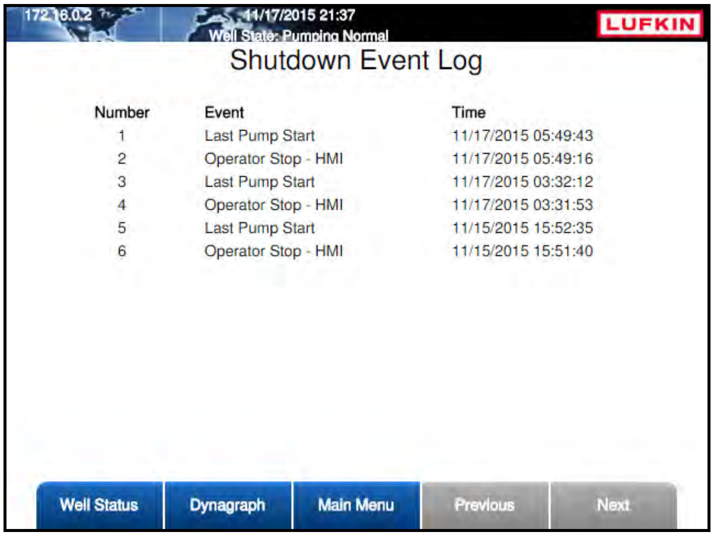

Figure 9-9. Shutdown Event Log

Press the **Next** or **Previous** buttons to navigate between the shutdown event log pages.

Press <**ESC**> to return to the Event Status menu screen.

Alarm Event Log

Press the **Alarm Event Log** button to display the Alarm Log screen shown in Figure 9-10.

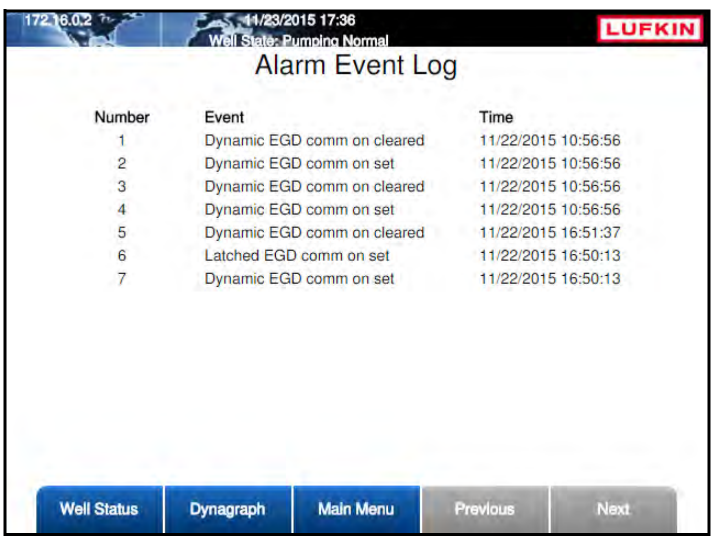

Figure 9-10. Alarm Log Screen

This screen displays data for alarms that have been triggered in the system. This log screen can display a maximum of 100 recorded alarm logs with date and time stamps and descriptions of each alarm.

Press the **Next** or **Previous** buttons to navigate between the alarm log pages.

Press <**ESC**> to return to the Event Status menu screen.

RPC Timestamped Events

Press the **RPC Timestamped Events** button to display the RPC Event Log screen shown in Figure 9-11 on page 9-13.

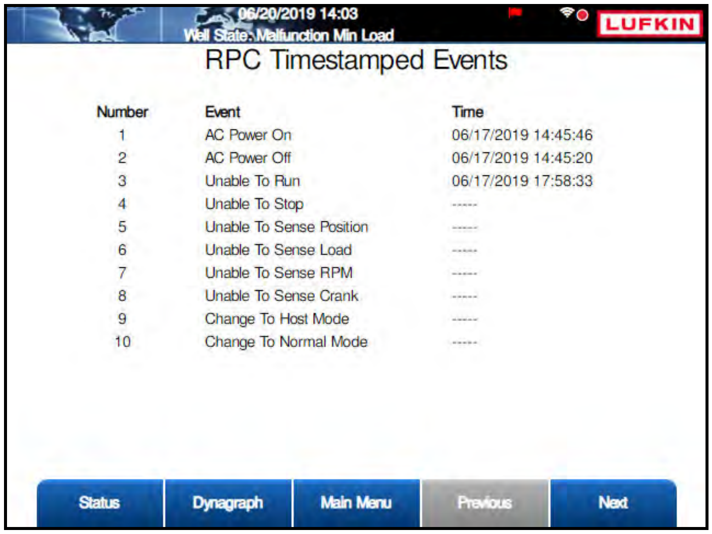

Figure 9-11. RPC Event Log Screen

This log screen is one of three screens that display a list of 23 significant RPC events and a date/time stamp for the last time each event occurred.

Press **Next** or **Previous** buttons to navigate between the RPC event pages.

Press <**ESC**> to return to the Event Status menu screen.

VSD Status

VSD status screens are not used on this controller.

Supplemental Status

The supplemental status screens display status data for gearbox torque, function blocks, and Modbus Master devices.

Press the **Supplemental Status** button to display the Supplemental Status Menu screen shown in Figure 9-12.

Figure 9-12. Supplemental Status Menu Screen

The supplemental status screens are discussed on the following pages.

Gearbox Torque

From the Supplemental Status menu screen, press the **Gearbox Torque** button to display the Gearbox Net Torque screen shown in Figure 9-13.

This screen shows the pumping unit's gearbox net torque values and counterbalance effect (CBE). These values are displayed in real time both numerically and graphically.

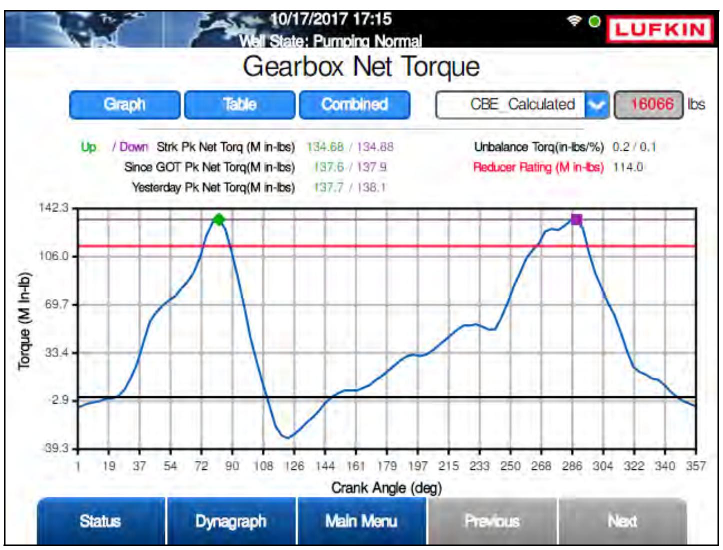

Figure 9-13. Gearbox Net Torque Screen – Graph Format

There are three options for displaying counterbalance effect on the graph:

- **CBAL_Calculated**: This option displays the counterbalance value calculated by the controller.
- **CBE_Entered (lbs)**: This option allows the operator to set a specific counterbalance effect value in the text box.

- **CBM_Entered (M in-lbs)**: This option allows the operator to set a specific counterbalance moment value in the text box.

Select the desired option from the drop-down list and then press the **Save** button.

The following peak net torque data is displayed numerically:

- Upstroke
- Downstroke
- Since GOT (Gauge-Off Time)
- Yesterday

Unbalance torque and reducer rating is also displayed as realtime data.

This data can be displayed in three formats:

- **Graph**: Select this option to display the data graphically as shown in Figure 9-13 above. This is the default display option.
- **Table**: Select this option to display the data in table format.
- **Combined**: Select this option to display the data in a combination of graph and table format.

Press the appropriate button for the desired display option.

Press the **Previous** or **Next** buttons to navigate between pages of data when viewed in Table or Combined format.

Press the <**ESC**> button to return to the Supplemental Status menu screen or press the **Main Menu** button to return to the Main Menu screen.

Function Block Variable Summary

From the Supplemental Status menu screen, press the **FB Variable Summary** button to display the FB Variable Summary menu screen shown in Figure 9-14.

Figure 9-14. Function Block Variable Summary Menu Screen

The function block variable summary screens are discussed in the following pages.

Function Block Variable Alarm Summary

From the FB Variable Summary menu screen, press the **FB Variable Alarm Summary** button to view a summary of function block variable alarm data. See Figure 9-15.

Use the **Next** and **Previous** buttons to navigate through the list.

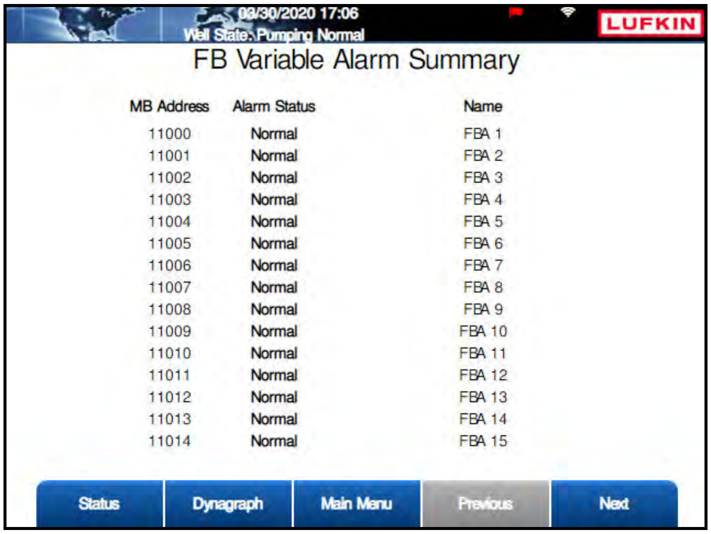

Figure 9-15. Function Block Variable Alarm Summary Screen

Press the **<ESC>** button to return to the FB Variable Summary menu screen.

Function Block Variable Status Summary

From the FB Variable Summary menu screen, press the **FB Variable Status Summary** button to view a summary of function block variable status data.

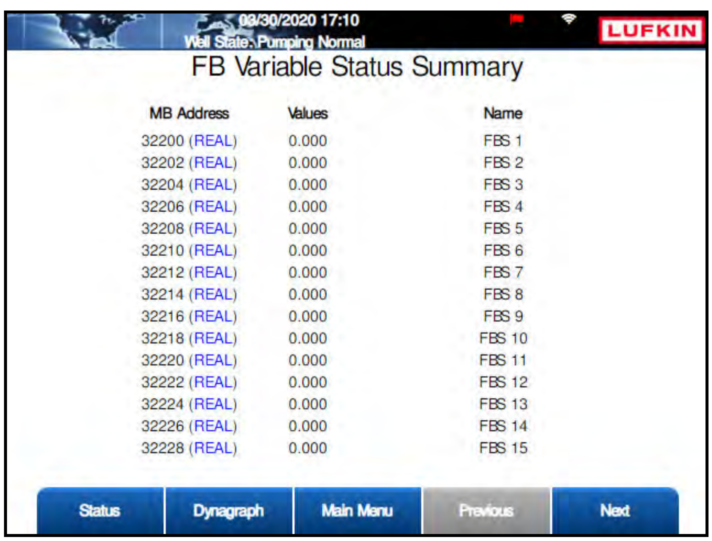

Figure 9-16. Function Block Variable Status Summary Screen

Use the **Next** and **Previous** buttons to navigate through the list.

Press the **<ESC>** button to return to the FB Variable Summary menu screen.

Function Block Variable Configuration Summary

From the FB Variable Summary menu screen, press the **FB Variable Config Summary** button to view a summary of function block variable configuration data.

Figure 9-17. Function Block Variable Config Summary Screen

Use the **Next** and **Previous** buttons to navigate through the list.

AGA Status

From the Supplemental Status menu screen, press the **AGA Status** button to display the AGA Status screen shown in Figure 9-18.

Figure 9-18. AGA Status Screen

This is the first of two screens that display status information related to the AGA Calculation feature. To clear the Total Production counter, press the **Reset Total Production** button.

Press the **Next** button to display the AGA Diagnostic screen shown in Figure 9-19.

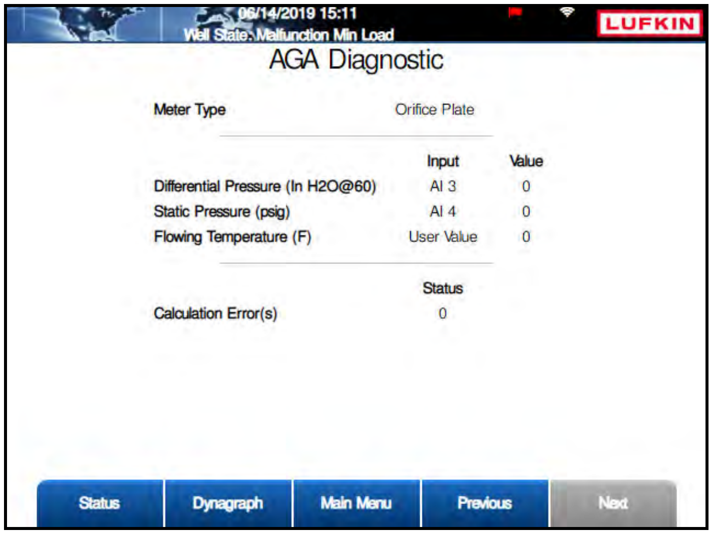

Figure 9-19. AGA Diagnostic Screen

This screen displays AGA diagnostic status data.

Modbus Master

Press the **Modbus Master** button to display the Modbus Master Status screen shown below.

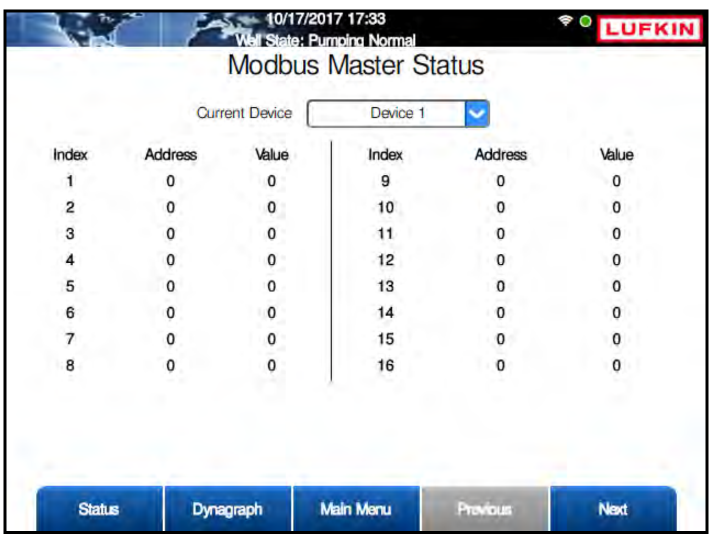

Figure 9-20. Modbus Master Status Screen

Status information for all connected Modbus Master devices are shown on this screen.

Select the desired device from the **Current Device** drop-down menu and then press **<Enter>** to display its status.

Press the **Previous** or **Next** buttons to navigate between pages of data.

Press <**ESC**> to return to the Supplemental Status menu screen.

Production Status

Press the **Production Status** button to display the first of two screens showing production status data. The first screen shown in Figure 9-21 displays inferred production status data. Total fluid, oil, and water amounts are shown along with last stroke data.

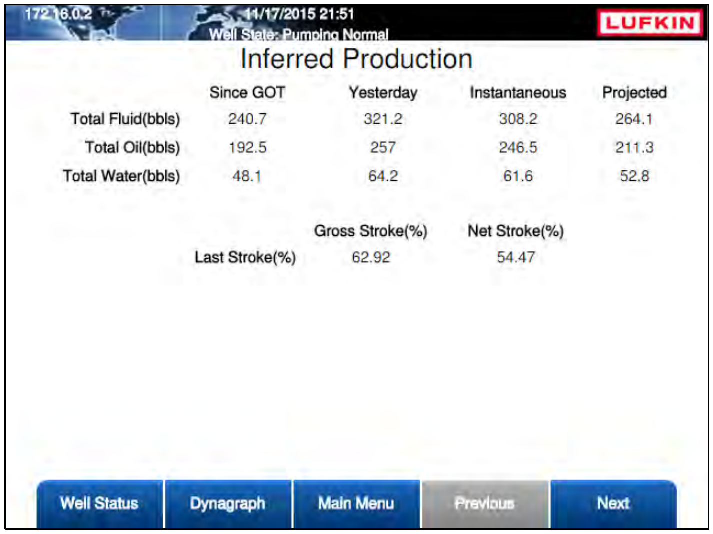

Figure 9-21. Inferred Production Status Screen

Press the **Next** button to display the next screen.

The next screen displays pump intake pressure (PIP) status data. Figure 9-22 shows an example of this screen.

Figure 9-22. Pump Intake Pressure Status Screen

Hardware Input/Output Status

Press the **Hardware I/O Status** button to display the Hardware Input/Output Status menu screen shown in Figure 9-23.

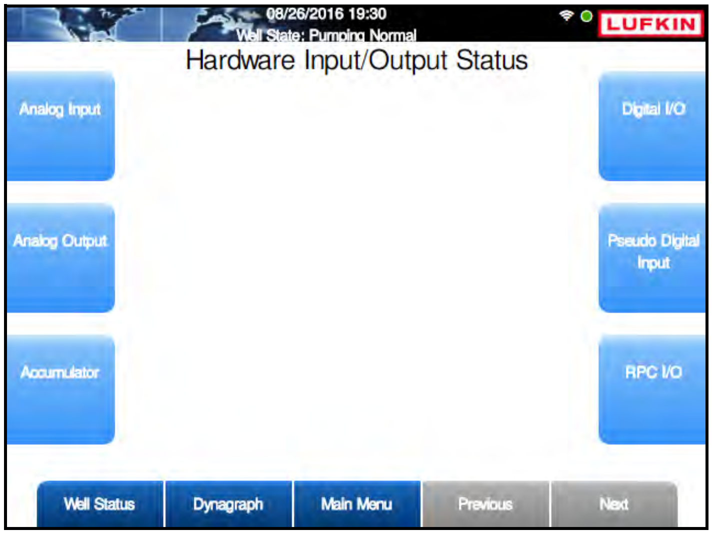

Figure 9-23. Hardware Input/Output Status Menu Screen

These screens are discussed in the following pages.

Analog Input Status

Press the **Analog Input** button to display the Analog Input Status screen shown in Figure 9-24.

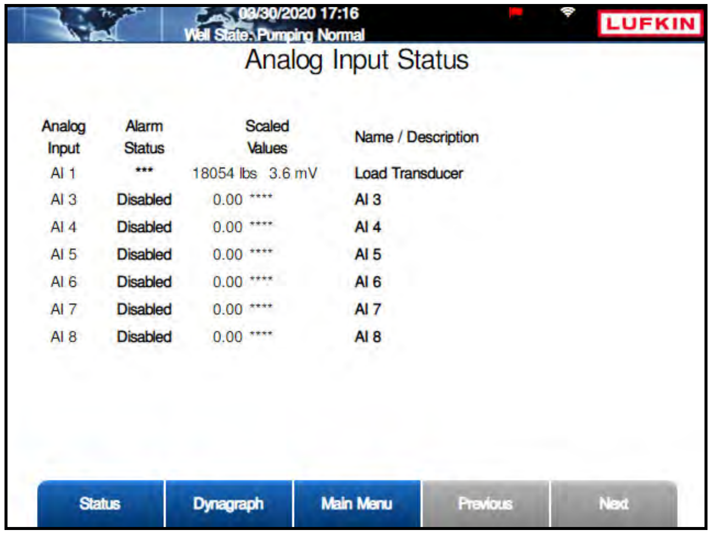

Figure 9-24. Analog Input Status Screen

This screen displays status information for all analog inputs in the system. These inputs are configured using the Analog Input Configuration screen. For information about this screen, see “Analog Input Configuration” on page 10-59.

Information about each data field is provided below:

- **Analog Input**: States the analog input channel number.
- **Alarm Status**: States whether an alarm is enabled or disabled for the channel.
- **Scaled Value**s: States the present value of the analog input in engineering units.
- **Name/Description**: States either the programmed virtual analog input number or the function description.

Press <**ESC**> to return to the Hardware Status screen.

Analog Output Status

Press the **Analog Output** button to display the Analog Output Status screen shown in Figure 9-25.

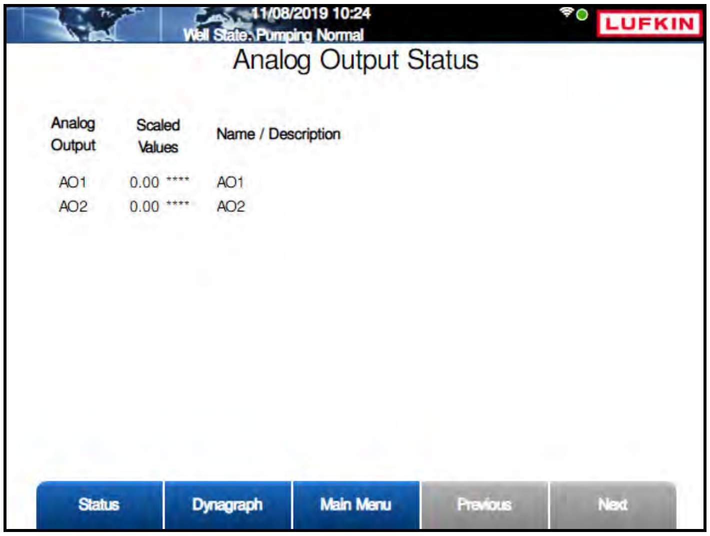

Figure 9-25. Analog Output Status Screen

This screen displays status information for all analog outputs in the system. These outputs are configured using the Analog Output Configuration screen. For information about this screen, see “Analog Input Configuration” on page 10-59.

Information about each data field is provided below:

- **Analog Output**: States the location of the output channel on the controller module. (See “Controller Module” on page 2-19 for more information.)
- **Scaled Values**: States the present value of the analog output in engineering units.
- **Name/Description**: States either the programmed virtual analog output number or the function description.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

Accumulator Status

Press the **Accumulator** button to display the first of two Accumulator Status screens.

Figure 9-26. Accumulator Status Screen

This screen shows the status of the two accumulator inputs. The data fields are described below:

- **ACCUM:** States the location of the accumulator input channel on the controller module. (See “Mark* VIe Controller Module” on page 1-16 for more information.)
- **Unit**: States the unit of measurement to be associated with each accumulator input.
- **Current Rate**: States the current recorded pulse rate for each input.
- **Total Since Reset**: States the total accumulation value since the last reset was performed.
- **Total Since GOT**: States the total accumulation value since the controller last updated the 60-day historical data buffers.
- **User Define Period**: States the user-defined number of days for the total accumulation value.
- **Name/Description**: Displays the programmed accumulator input name.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

Digital Input/Output Status

Press the **Digital I/O** button to display the Digital Input/Output Status screen shown in Figure 9-27.

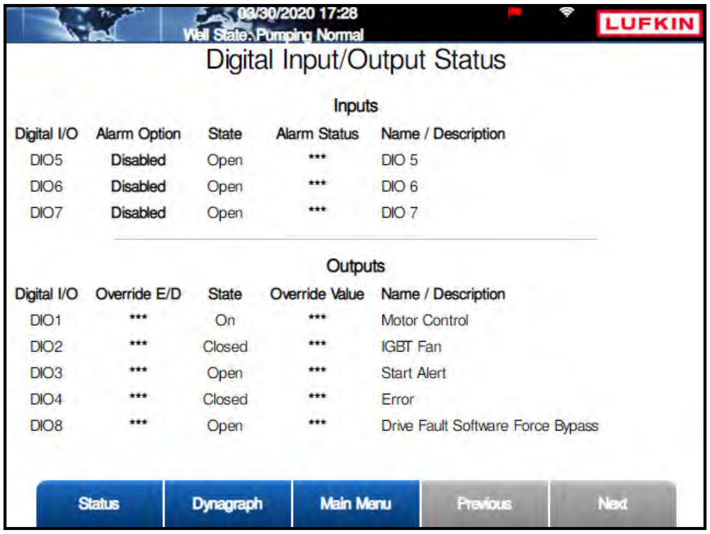

Figure 9-27. Digital Input/Output Status Screen

This screen shows status information for all digital inputs and outputs in the system. This information is grouped into input and output sections.

The input status information lists the following fields:

- **Digital I/O**: States the programmed virtual digital input number.
- **Alarm Option**: Indicates whether the alarm state is enabled or disabled for that channel.
- **State**: Indicates an open or closed state.
- **Alarm Status**: Indicates the current alarm status for that channel.
- **Name/Description**: States the location of the digital input point on the controller module.

The output status information lists the following fields:

- **Digital I/O**: States the programmed virtual digital output number.
- **Override E/D**: Indicates whether the override function is enabled or disabled for that point.
- **State**: Indicates an open or closed state.
- **Override Value**: Indicates the current override status for that point.
- **Name/Description**: States the location of the digital output point on the controller module.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

Pseudo Digital Input Status

Press the **Pseudo Digital Input** button to display the Pseudo Digital Input Status screen shown in Figure 9-28.

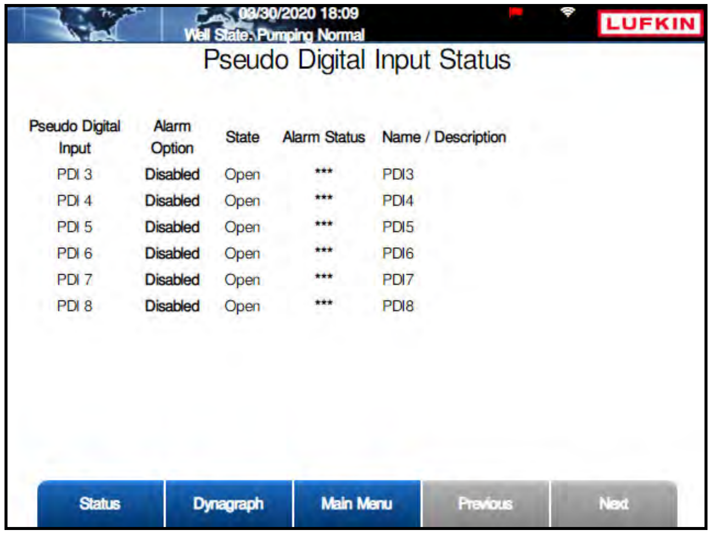

Figure 9-28. Pseudo Digital Input Status Screen

This screen displays status information for the pseudo digital inputs. The following information is provided:

- **Pseudo Digital Input**: States the programmed pseudo digital input number.
- **Alarm Option**: Indicates whether the alarm state is enabled or disabled for that input point.
- **State**: Indicates an open or closed state.
- **Alarm Status**: Indicates the current alarm status for that input point.
- **Name/Description**: States the location of the pseudo digital (analog) input point on the controller module.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

RPC I/O Status

Press the **RPC I/O** button to display the RPC Input/Output Status screen shown in Figure 9-29.

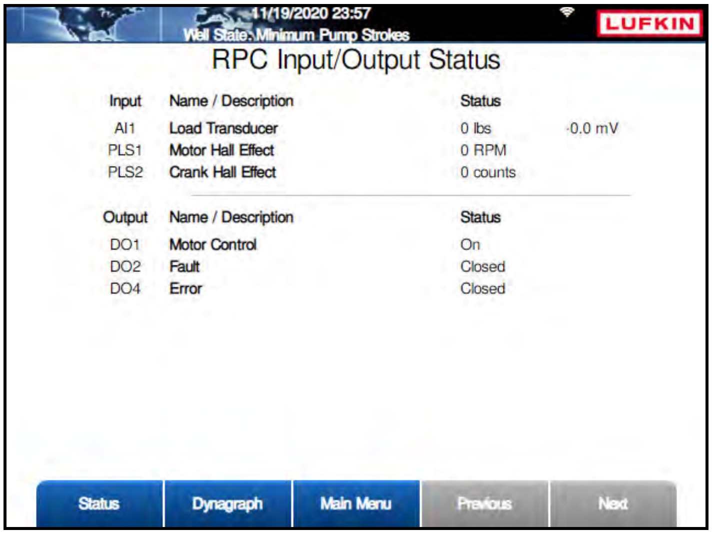

Figure 9-29. RPC Input/Output Status Screen

Realtime status information for all connected RPC inputs and outputs are displayed on this screen.

Historical Status

Press the **Historical Status** button to display the Historical Status menu screen. This screen provides access to historical data values for process variables such as RPC production and performance, calculated flow rates and production volumes, and input/output data.

Figure 9-30. Historical Data Menu Screen

Refer to the section titled "Historical Status Data" on page 11-1 for details on these data screens.

Section 10: Dynagraph Screens

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Section Overview

The LWM 2.0 controller displays a live real-time dynagraph trace and stores historical dynagraph cards. Control parameters related to the dynagraph shape analysis are programmed on the dynagraph screens. This section discusses the various dynagraph screens that are available.

Dynagraph Screen

Press the **Dynagraph** button (**F2**) to display the Dynagraph screen shown in Figure 10-1. This screen shows a real-time dynagraph of the load and position data recorded during pumping operation. Three dynagraph display options are provided:

- **Surface**: This button displays the Surface card. This card and its functions are described below.
- **Downhole**: This button displays the Downhole card. See “Downhole Card” on page 10-8 for details on this card and its functions.
- **Both**: This button displays a combined view of the surface and downhole cards. See “Both Cards” on page 10-9 for more details.

Use the arrow keys to highlight the desired display option and then press <**ENTER**>.

This screen also provides a full-screen view of the dynagraph. Press the **Toggle View** button to switch between the standard view and the full-screen view.

These dynagraph cards and their features are discussed in the following paragraphs.

Surface Card

The Surface Card shown in Figure 10-1 is displayed by default. This card shows a real-time dynagraph of the surface load and position data recorded during pumping operation.

Figure 10-1. Dynagraph Screen – Surface Card

Current status data, display options, and applicable setpoints are also displayed on this screen.

Status Data

The following status data is displayed on this screen:

- **Elapsed Time**: This field displays the amount of time (measured in hours, minutes, and seconds) the pumping unit has been running.
- **SPM:** This field displays the current strokes per minute at which the pumping unit is operating.
- **Min/Peak Load**: This field displays the current recorded minimum and peak load of the pumping cycle. These values are updated at the end of each stroke and are the minimum and maximum values of the polished rod load in the stroke just completed.
- **PO Setpoint Csc**: This field displays the consecutive number of times the POC setpoint has been violated.

Display Options

The Surface Card has several options for displaying load and setpoint data. These are described on the following pages.

- **Permissible Load**: Select this check box to display the defined permissible load values as shown in Figure 10-2. See “Surface Card Setpoints” on page 10-6 for details on configuring these parameters.

  Press the down arrow to highlight the **Permissible Load** check box and then press <**ENTER**> to select this option. The Permissible Load title flashes red while the data is calculated and then the setpoint values are graphically displayed in red on the card.

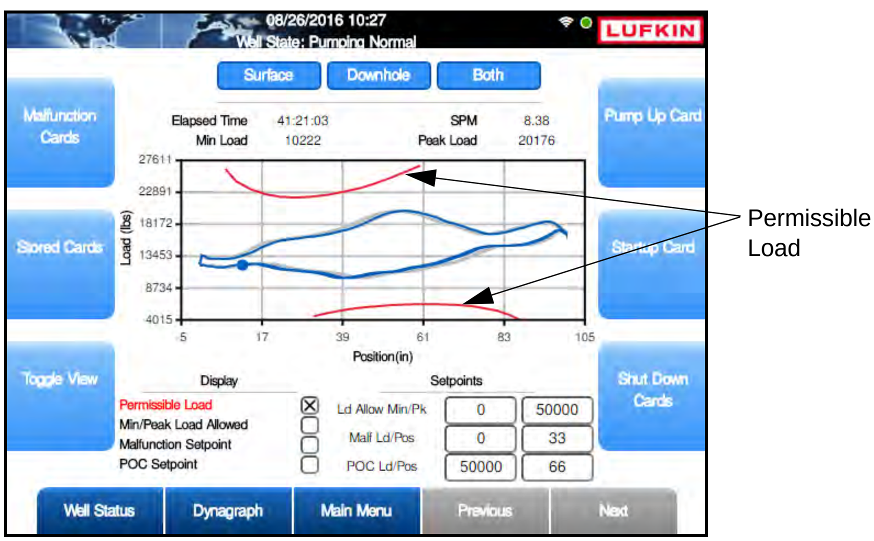

Figure 10-2. Surface Card with Permissible Load Display

  To hide these values, clear the **Permissible Load** check box using the same method described above.

- **Min/Peak Load Allowed**: Select this check box to display the minimum and the maximum allowed values for load input. Figure 10-3 shows an example of the Min/Peak Allowed display option. See “Surface Card Setpoints” on page 10-6 for details on configuring these parameters.

  Press the down arrow to highlight the **Min/Peak Load Allowed** check box and then press <**ENTER**> to select this option. The Minimum and Peak Load Allowed setpoint values are displayed as horizontal colored lines at the top and bottom of the card.

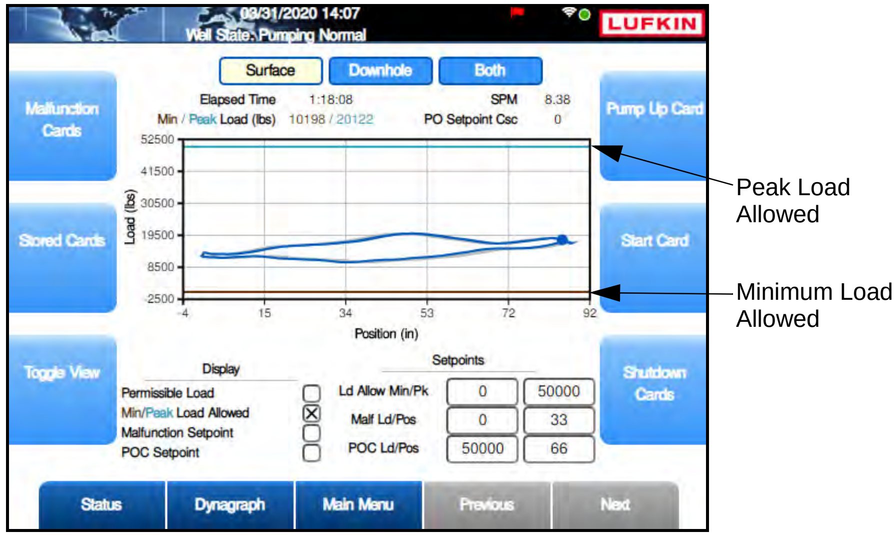

Figure 10-3. Surface Card with Min/Peak Allowed Display

To hide these values, clear the **Min/Peak Load Allowed** check box using the same method described above.

- **Malfunction Setpoint**: Select this check box to display the Malfunction Setpoint value on the dynagraph as shown in Figure 10-4. See “Surface Card Setpoints” on page 10-6 for details on configuring the parameters for this setpoint.

  Press the down arrow to highlight the **Malfunction Setpoint** check box and then press <**ENTER**> to select this option. The Malfunction Setpoint title turns purple when active and its value is displayed as a purple square on the card.

Figure 10-4. Surface Card with Malfunction Setpoint Display

To hide this setpoint, clear the **Malfunction Setpoint** check box using the same method described above.

- **POC Setpoint**: Select this check box to display the POC Setpoint value on the dynagraph as shown in Figure 10-5. See “Surface Card Setpoints” on page 10-6 for details on configuring the parameters for this setpoint.

Press the down arrow to highlight the **POC Setpoint** check box and then press <**ENTER**> to select this option. The POC Setpoint title turns green while active and its value is displayed as a green diamond on the card.

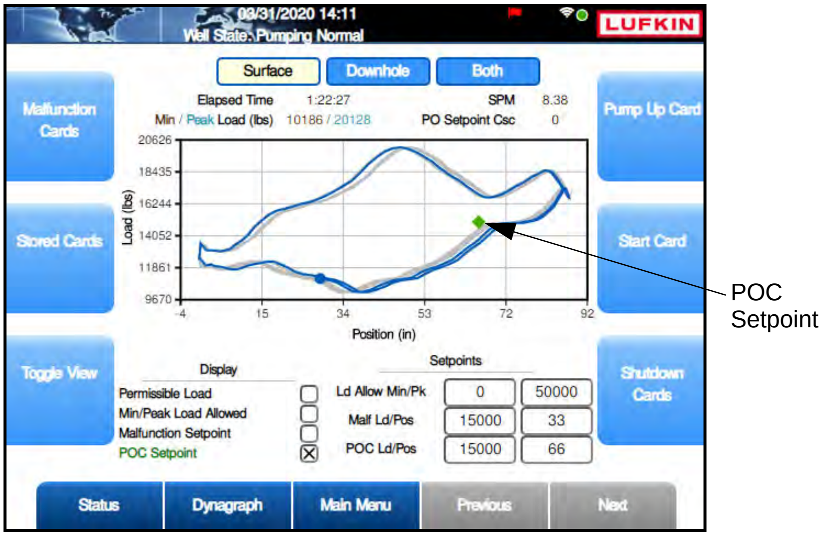

Figure 10-5. Surface Card with POC Setpoint Display

To hide this setpoint, clear the **POC Setpoint** check box using the same method described above.

Surface Card Setpoints

The configurable surface card setpoints are as follows:

- **Permissible Load:** This setpoint represents the minimum and peak load allowed for the pumping unit's gearbox. These values are graphically displayed in red on the card.
- **Ld Allow Min/Pk**: These setpoints set the minimum and peak load allowed for the polished rod during operation. If the rod load exceeds the peak load setpoint or drops below the minimum load setpoint, the controller instantly shuts down the pumping unit with no consecutive stroke delay.

  The setpoint parameters are as follows:

  - **Allowed Minimum Load**: The left parameter field sets the minimum load allowed during operation. If the load drops below this limit, the controller instantly shuts down the pumping unit with no consecutive stroke delay.
  - **Allowed Peak Load**: The right parameter field sets the maximum load allowed during operation. If the load exceeds this limit, the controller instantly shuts down the pumping unit with no consecutive stroke delay.

  To change these parameters, do the following:

  a. Use the arrow keys to highlight the desired parameter field and then press <**ENTER**>.

  b. Use the keypad to define the parameter value and then press <**ENTER**> again.

These values are displayed as colored horizontal lines at the top and bottom of the card.

Note: The controller automatically scales the dynagraph screen to show both Allowed Peak and Allowed Min Load. If the programmed values are far above or below the actual working peak and minimum loads, the dynagraph trace on the screen will be fairly small. To obtain a larger dynagraph trace, configure the Allowed Peak and Allowed Min Load values to within 15 percent or 25 percent above/below the working loads.

- **Malf Ld/Pos**: These setpoints are used to check for rod parts or other pump malfunctions that cause no fluid load to be picked up by the pump. If the load falls below the Malfunction load setpoint in the upstroke, the controller counts that as a violation of the setpoint. The number of consecutive Malfunction Strokes Allowed can be configured on the Operational Limits 1 screen. (See “Operational Limits 1 Screen” on page 8-25 for details on this screen.)

  The configurable parameters are:

  - **Load** – The left parameter field sets the minimum load weight allowed during operation.
  - **Position (inches)** – The right parameter field sets the minimum distance the rod must move during operation.

  To change these parameters, do the following:

  a. Use the arrow keys to highlight the desired parameter field and then press <**ENTER**>.

  b. Use the keypad to define the parameter value and then press <**ENTER**> again.

  The malfunction setpoint is displayed as a purple square on the dynagraph. (See Figure 10-4 on page 10-5.)

- **POC (Pump Off Control) Setpoint**: This setpoint is the pump off **“**limit**”** for the Surface control mode. When the load goes above the POC setpoint in the downstroke, the controller counts that as a pump off stroke. The consecutive number of pump off strokes allowed is specified with the RPC Control Parameter programming screen.

  The parameters for this setpoint are:

  - **Load (lbs)** – the maximum load weight allowed during operation
  - **Position (inches)** – the maximum distance the rod can move during operation

  To change these parameters, do the following:

  a. Use the arrow keys to highlight the desired parameter field and then press <**ENTER**>.

  b. Use the keypad to define the parameter value and then press <**ENTER**> again.

  The POC setpoint is displayed as a green diamond on the dynagraph. (See Figure 10-5 on page 10-6.)

Downhole Card

The Downhole card displays a realtime live trace of the well's downhole activity. Figure 10-6 shows an example of this card.

Figure 10-6. Downhole Card

Status Data

The following status data is displayed on this screen:

- **Elapsed Time**: This field displays the amount of time (measured in hours, minutes, and seconds) the pumping unit has been running.
- **SPM:** This field displays the current strokes per minute at which the pumping unit is operating.
- **Pump Fillage:** The Pump Fillage value is updated at the end of each stroke after the Minimum Pump Strokes. It is the calculated percent pump fillage represented by the downhole pump card. When this value falls below the Pump Fillage-Set % value, that stroke is counted as a pump off stroke. You can specify the consecutive number of pump off strokes allowed using the RPC Control Parameter programming screen.
- **Fluid Load:** This value is the difference between the average upstroke load and the average downstroke load of the downhole pump card as calculated by the LWM 2.0 controller. This value is the input for the Fluid Load control function. If this calculated fluid load falls below the set low fluid load limit, the LWM 2.0 controller stops the pumping unit.
- **Buoyant Force:** This value is the upward force on the rod string caused by the displaced fluid in the tubing. It is calculated by multiplying the cross sectional area of the bottom rod taper times the pressure at the bottom of the rods.
- **Net Stroke:** The LWM 2.0 controller uses an algorithm to find the point that the pump plunger in the downstroke contacts fluid in the pump. Net stroke length is used to calculate the percent pump fillage for pump off control in the Downhole control mode. This value is also used in the inferred production calculations.
- **Gross Stroke:** This value is the maximum possible pump plunger stroke length calculated by the LWM 2.0 controller.
- **Min Pump Load:** This value is the lowest value for load in the displayed downhole card.
- **Peak Pump Load:** This value is the highest value for load in the displayed downhole card.

- **DH Pressure (psi)**: (Displayed in **VSD DH Pressure** control mode only.) This value is the current recorded downhole pressure.

Downhole Card Setpoints

The configurable downhole card parameters are as follows:

- **Pump Fillage**: This value is the pump off shutdown level for the Downhole Control mode.
- **2ry Pump Fillage**: This value is the secondary pump off shutdown level for the Downhole Control mode.
- **Fluid Load**: This value is the Low limit for the fluid load control function. See “Current Fluid Load” on the previous page.
- **Fill Base**: This value is the full range load percentage of the downhole card at which the controller, in the downstroke, starts to look for the slope change indicating plunger contact with fluid in the pump barrel. The adjustable fill base allows the controller to find accurate net stroke with a variety of unusual pump conditions. If net stroke calculation results do not appear to be reasonable, adjust the fill base up or down for more logical results. Zero percentage is the minimum load value for the downhole card. The default value of 45 will work for most wells.
- **PTM Region & Ld Detection Lmt**: Select this parameter when the Pump Tag Mitigation feature is active. Refer to “Pump Tag Mitigation” on page 8-37 for more information.

To change these parameters, do the following:

1. Use the arrow keys to highlight the desired parameter and then press <**ENTER**>.
2. Use the keypad to define the parameter value and then press <**ENTER**> again.

All setpoints except **Fluid Load** can be displayed graphically on the downhole card. To display these setpoints, use the arrow keys to highlight the check box next to the desired setpoint and then press <**ENTER**>.

Both Cards

The Both display option shows a split-screen realtime live trace of both surface and downhole activity. This screen displays status information only and is not configurable.

Figure 10-7. Both Cards Displayed

Historical Dynagraph Cards

The Lufkin Well Manager 2.0 also stores historical dynagraph cards. These cards can be accessed by pressing the menu buttons displayed on the main dynagraph screen.

Each option provides saved dynagraph screens for surface, downhole, and a split-screen view of both surface and downhole cards. The time and date of the saved card and relevant status information are displayed on each saved screen.

These screens are discussed in the following paragraphs.

Malfunction Cards

From any of the dynagraph screens, press the **Malfunction** button to access the Malfunction Card screen shown in Figure 10-8.

This screen shows a copy of both the surface and downhole dynagraph cards as they appeared at the time of the malfunction. Figure 10-8 shows an example of this screen.

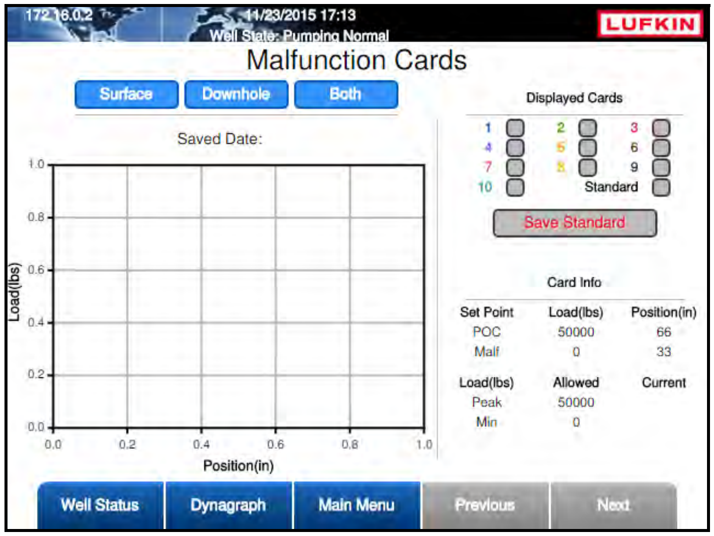

Figure 10-8. Malfunction Card Screen

When a malfunction occurs, the controller takes the data obtained during the malfunction and stores it in the malfunction card buffer. A timestamped copy of the dynagraph card is displayed along with the cause of the malfunction and relevant status data. The last ten malfunctions are stored.

No card is stored after a NO RPM or a NO Crank malfunction occurred because, due to the nature of these malfunctions, any card data that is available cannot be guaranteed to be accurate. These malfunctions are stored in the buffer with a malfunction time and cause.

There are three options for viewing the stored malfunction cards:

- **Surface**: This button displays the stored surface cards.
- **Downhole**: This button displays the stored downhole cards.
- **Both**: This button displays a combined view of the stored surface and downhole cards.

Use the arrow keys to highlight the desired display option and then press <**ENTER**>.

The stored malfunction cards can be displayed one at a time or overlaid on top of one another. Use the arrow keys to highlight the check box for the desired stored card or cards to display and then press <**ENTER**>.

Press the **Save Standard** button to save the card displayed as the standard card.

Note: Only one card can be saved as a standard card.

To view the standard card, use the arrow keys to highlight the **Standard** check box and then press <**ENTER**>.

Press <**ESC**> to return to the main Dynagraph screen.

Stored Cards

From any of the dynagraph screens, press the **Stored Cards** button to access the Stored Cards screen. Figure 10-9 shows an example of a stored surface card.

Figure 10-9. Stored Cards Screen

This screen displays the most-recent five strokes. If the controller is in a pumping state, the buffer is updated at the bottom of each stroke by replacing the oldest card with the latest completed stroke. If the controller is in a downtime or malfunction condition, the stored cards will be duplicates of the Group 1 shutdown cards.

There are three options for viewing the stored cards:

- **Surface**: This button displays the stored surface cards. The Surface card view is displayed by default as shown in Figure 10-9 above.
- **Downhole**: This button displays the stored downhole cards.
- **Both**: This button displays a combined view of the stored surface and downhole cards.

Use the arrow keys to highlight the desired display option and then press <**ENTER**>.

The stored cards can be displayed one at a time or overlaid on top of one another. Use the arrow keys to highlight the check box for the desired stored card or cards to display and then press <**ENTER**>.

Press the **Save Standard** button to save the card displayed as the standard card.

Note: Only one card can be saved as a standard card.

To view the standard card, use the arrow keys to highlight the **Standard** check box and then press <**ENTER**>.

The stored downhole card screen provides the option of analyzing the stored card for troubleshooting purposes. (See Figure 10-10 below.) To start the analysis, use the arrow keys to highlight the **Analyze DHC** button and then press <**ENTER**>. The controller then compares the stored card against a database of stored cards and displays the results on the screen.

Figure 10-10. Stored Cards Screen – Downhole Card

Press <**ESC**> to return to the Dynagraph menu screen.

Pump Up Cards

From any of the dynagraph screens, press the **Pump Up Card** button to access the Pump Up Card screen. Figure 10-11 shows an example of a stored pump up card.

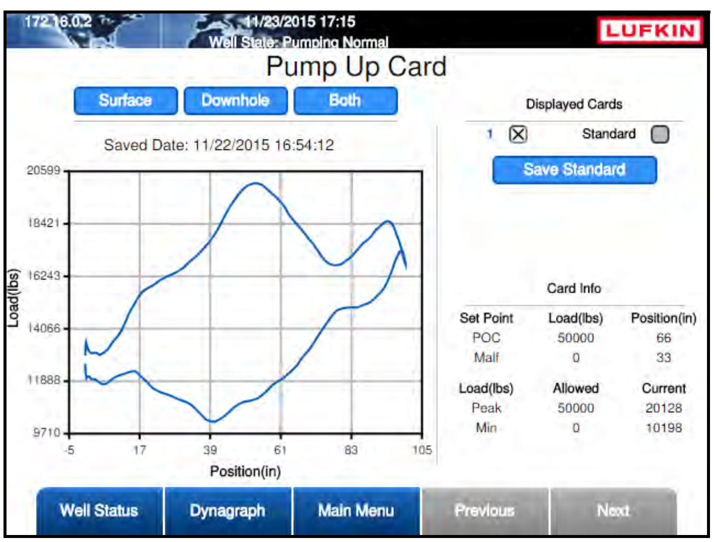

Figure 10-11. Pump Up Card Screen

The Pump Up card is a single card saved at the last transition from Minimum Pump Strokes to Pumping. This card is updated each time the controller goes through a stop/start cycle.

There are three options for viewing the pump up cards:

- **Surface**: This button displays the stored surface card.
- **Downhole**: This button displays the stored downhole card.
- **Both**: This button displays a combined view of the stored surface and downhole cards.

Use the arrow keys to highlight the desired display option and then press <**ENTER**>.

The saved pump up card can be displayed by itself or overlaid on top of a saved standard pump up card described below. Use the arrow keys to highlight the check box for the pump up card to display and then press <**ENTER**>.

Press the **Save Standard** button to save the card displayed as the standard card.

Note: Only one card can be saved as a standard card.

To view the standard card, use the arrow keys to highlight the **Standard** check box and then press <**ENTER**>.

Press <**ESC**> to return to the Dynagraph menu screen.

Start Cards

From any of the dynagraph screens, press the **Start Card** button to access the Start Card screen. Figure 10-12 shows an example of a typical start card.

Figure 10-12. Startup Card

This is a single dynagraph card saved by the controller as early in the pumping cycle as possible. This dynagraph represents the start of minimum pump strokes as opposed to the Pump Up card that is saved at the end of Minimum Pump Strokes.

There are three options for viewing the startup cards:

- **Surface**: This button displays the stored surface startup card.
- **Downhole**: This button displays the stored downhole startup card.
- **Both**: This button displays a combined view of the stored surface and downhole startup cards.

Use the arrow keys to highlight the desired display option and then press <**ENTER**>.

The saved start card can be displayed by itself or overlaid on top of a saved standard start card described below. Use the arrow keys to highlight the check box for the start card to display and then press <**ENTER**>.

Press the **Save Standard** button to save the card displayed as the standard start card.

Note: Only one card can be saved as a standard start card.

To view the standard start card, use the arrow keys to highlight the **Standard** check box and then press <**ENTER**>.

Press <**ESC**> to return to the Dynagraph menu screen.

Shutdown Cards

From any of the dynagraph screens, press the **Shutdown Cards** button to access the Shutdown Cards screens. Figure 10-13 shows an example of a typical shutdown card screen.

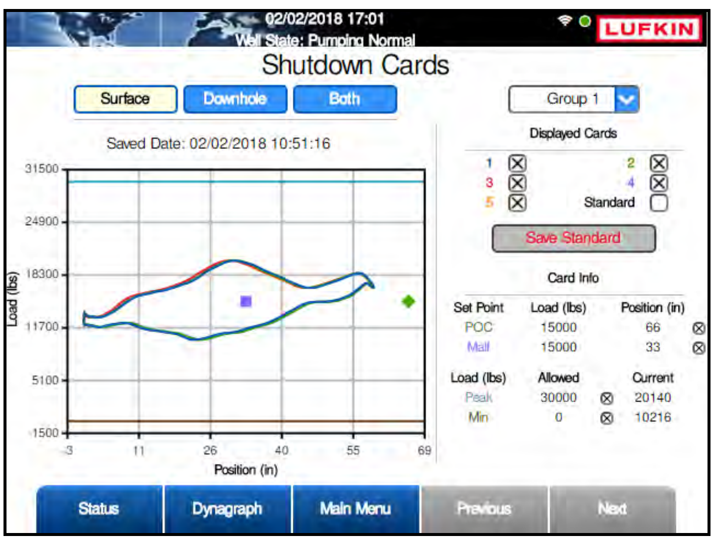

Figure 10-13. Shut Down Card

This option displays the last five strokes leading up to the last two shutdown events. Shutdown cards are saved when the pump is shut down for any reason, including operator action using the keypad. Shutdown cards may therefore not always indicate a “pumped off” condition.

There are three options for viewing the shutdown cards:

- **Surface**: This button displays the surface shutdown card.
- **Downhole**: This button displays the downhole shutdown card.
- **Both**: This button displays a combined view of the surface and downhole shutdown cards.

Use the arrow keys to highlight the desired display option and then press <**ENTER**>.

Two groups of saved cards are available for viewing:

- **Group 1** represents the most recent shutdown.
- **Group 2** represents the shutdown prior to the most recent.

Use the arrow keys to highlight the desired group button and then press <**ENTER**>.

The shutdown cards can be displayed one at a time or overlaid on top of one another. Use the arrow keys to highlight the check box for the desired shutdown card or cards to display and then press <**ENTER**>.

Press the **Save Standard** button to save the card displayed as the standard card.

Note: Only one card can be saved as a standard card.

To view the standard card, use the arrow keys to highlight the **Standard** check box and then press <**ENTER**>.

Press <**ESC**> to return to the Dynagraph menu screen.

Section 11: Historical Status Data

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Section Overview

The LWM 2.0 controller maintains historical status data in various formats to provide useful information about RPC production and performance. This section discusses the different types of available historical data.

Historical Data Description

The LWM 2.0 controller saves into onboard memory historical data values for process variables, such as RPC production and performance, calculated flow rates and production volumes, VSD performance, and alarm and event logs. Historical data can be retrieved and displayed for activity from the previous 24-hour period in one-minute intervals, or the daily average for the previous 60 days.

To access this historical data, press the **Well Status** button to display the Well Status screen shown in Figure 11-1.

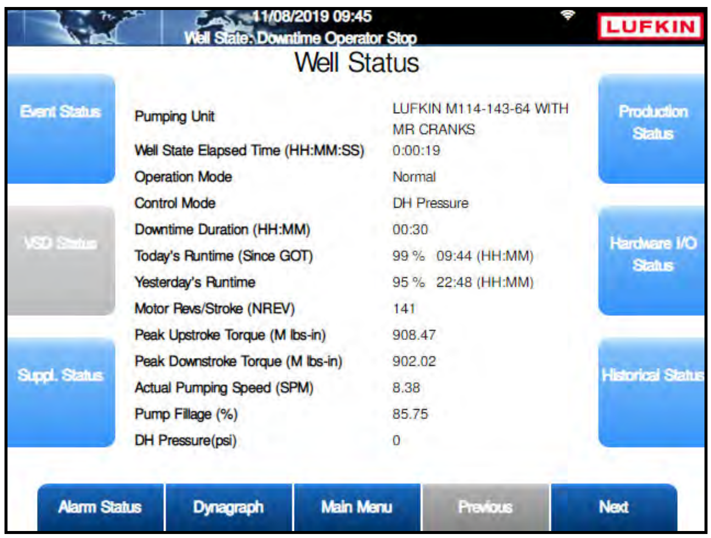

Figure 11-1. Well Status Screen

From this screen, press the **Historical Status** button to display the Historical Status menu screen shown in Figure 11-2 on page 11-4.

Figure 11-2. Historical Status Menu Screen

This screen displays historical data values for process variables such as RPC production and performance, calculated flow rates and production volumes, and input/output data.

This data is discussed on the following pages.

RPC Data

From the Historical Status menu screen, press the **RPC** button to display the Historical RPC Status menu screen shown in Figure 11-3.

Figure 11-3. Historical RPC Status Menu Screen

The available options are discussed on the following pages.

Previous 60 Days

Press the **Previous 60 Days** button to display the first Previous 60 Days menu screen shown in Figure 11-4.

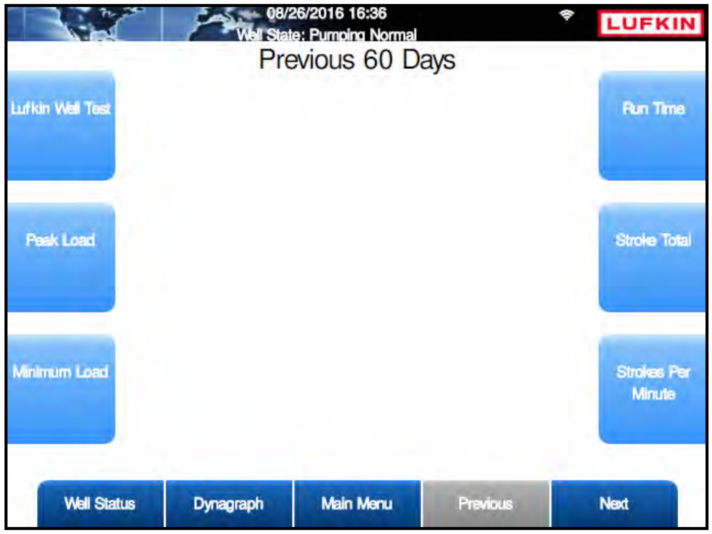

Figure 11-4. Previous 60 Days Menu Screen 1 of 2

Press the **Next** button to display the second menu screen shown in Figure 11-5.

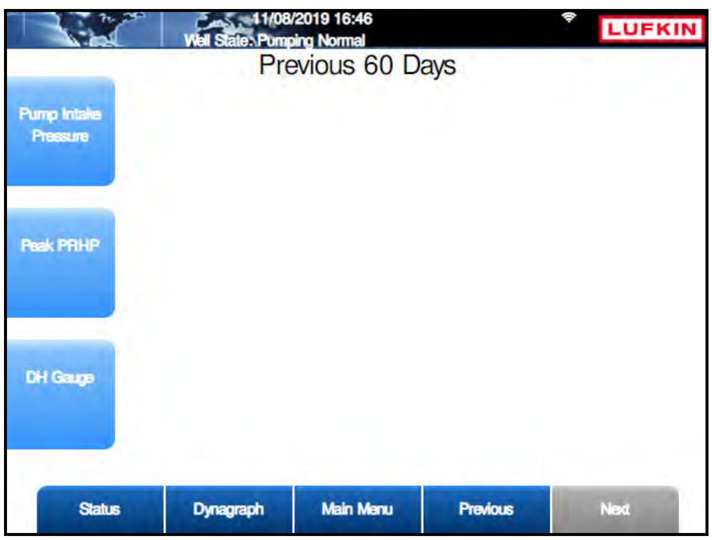

Figure 11-5. Previous 60 Days Menu Screen 2 of 2

These screens provide several options for displaying historical data from the previous 60 days. These options are discussed on the following pages.

Lufkin Well Test

From the first Previous 60 Days menu screen, press the **Lufkin Well Test** button to display the LWT 60 Day History screen shown in Figure 11-6 below.

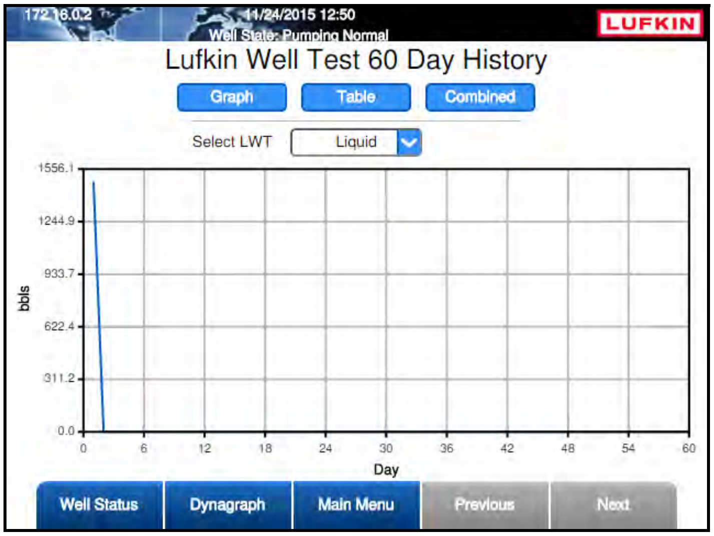

Figure 11-6. Lufkin Well Test 60 Day History Screen

This screen shows the calculated production volume (measured in barrels per day) for the previous 60 days using the Lufkin Well Test (LWT) algorithm. Data is displayed as a graph, a table, or a combined view of both formats for the following:

- Liquid
- Water
- Oil
- Gas

Press <**ENTER**> to display the drop-down list. Use the up or down arrow keys to highlight the desired display option and then press <**ENTER**> again.

Press the **Next** or **Previous** buttons to navigate between the pages.

Press <**ESC**> to return to the Previous 60 Days menu screen.

Peak Load

From the first Previous 60 Days menu screen, press the **Peak Load** button to display the Peak Load 60 Day History screen shown in Figure 11-7.

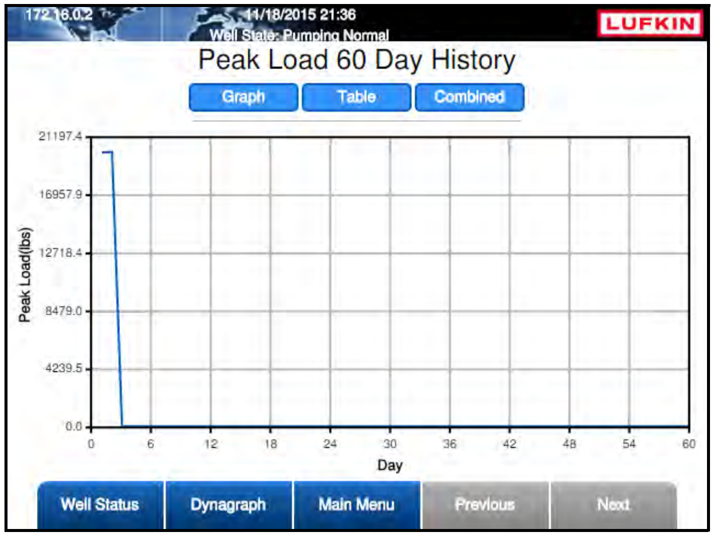

Figure 11-7. Peak Load 60 Day History Screen

This screen shows the highest value for the peak load recorded for each of the previous 60 days. This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Press the **Next** or **Previous** buttons to navigate between the pages of data.

Minimum Load

From the first Previous 60 Days menu screen, press the **Minimum Load** button to display the Minimum Load 60 Day History screen shown in Figure 11-8 below.

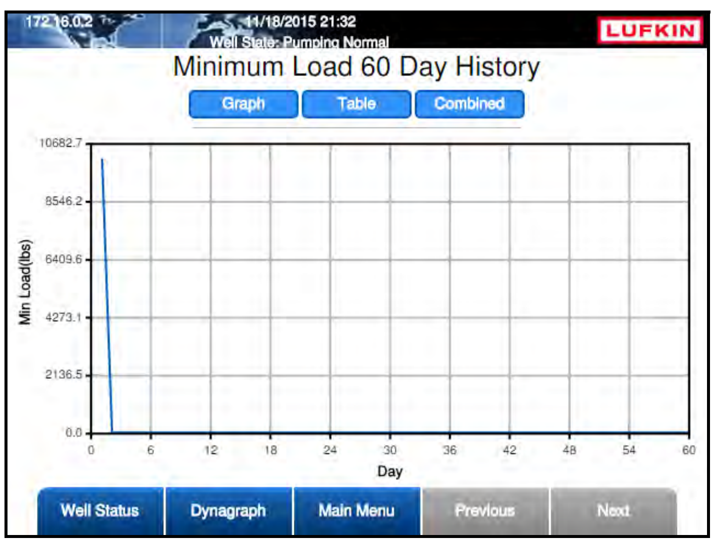

Figure 11-8. Min Load 60 Day History Screen

This screen displays the lowest value for minimum load (measured in pounds) recorded for each of the previous 60 days. This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Press the **Next** or **Previous** buttons to navigate between the pages of data.

Run Time

From the first Previous 60 Days menu screen, press the **Run Time** button to display the Run Time 60 Day History screen shown in Figure 11-9.

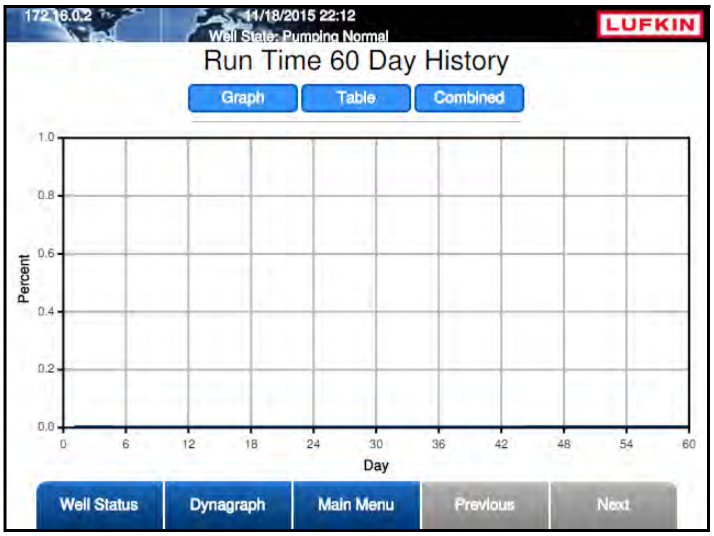

Figure 11-9. Runtime 60 Day History Screen

This screen shows the run time percentage for each of the previous 60 days. This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Press the **Next** or **Previous** buttons to navigate between the pages of data.

Stroke Total

From the first Previous 60 Days menu screen, press the **Stroke Total** button to display the Stroke Total 60 Day History screen shown in Figure 11-10.

This screen displays the total number of strokes completed by the pumping unit during a set time period. This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

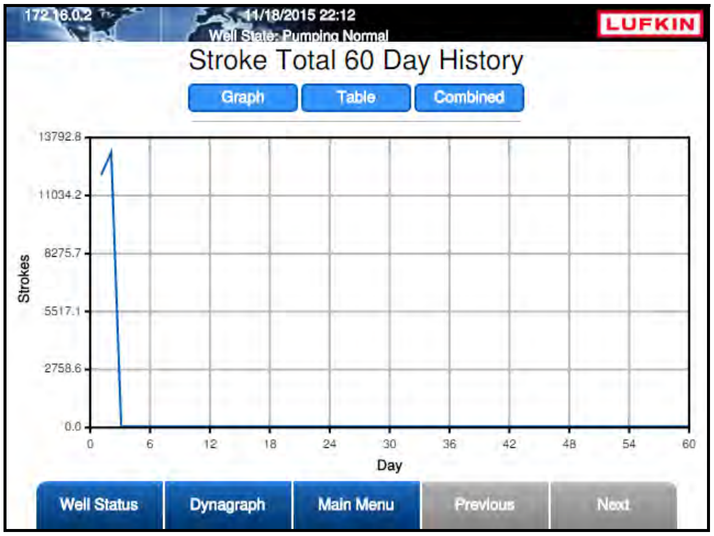

Figure 11-10. Stroke Total 60 Day History Screen

Press the **Next** or **Previous** buttons to navigate between the pages of data.

Press <**ESC**> twice to return to the Historical RPC Status menu screen or press the **Main Menu** button to return to the Main Menu screen.

Strokes Per Minute

From the first Previous 60 Days menu screen, press the **Strokes Per Minute** button to display the Strokes Per Minute 60 Day History screen shown in Figure 11-11.

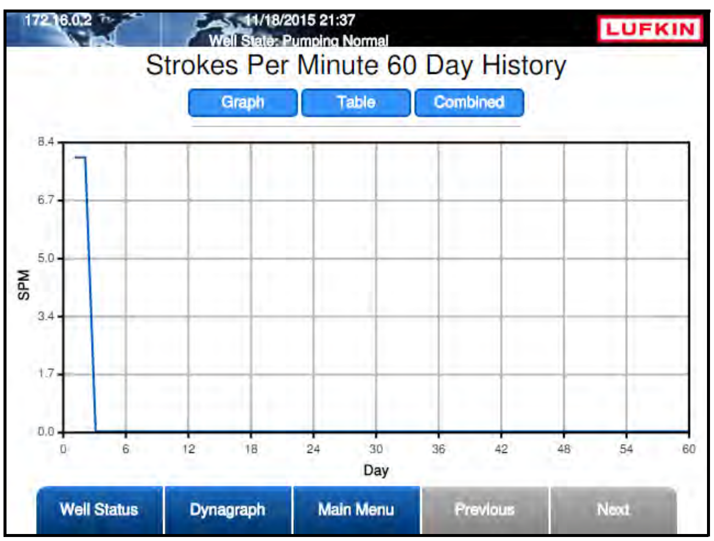

Figure 11-11. Stroke Per Minute 60 Day History Screen

This screen displays the number of strokes per minute completed by the pumping unit during the previous 60 days. This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Press the **Next** or **Previous** buttons to navigate between the pages of data.

Pump Intake Pressure

From the second Previous 60 Days menu screen, press the **Pump Intake Pressure** button to display the Pump Intake Pressure 60 Day History screen shown in Figure 11-12.

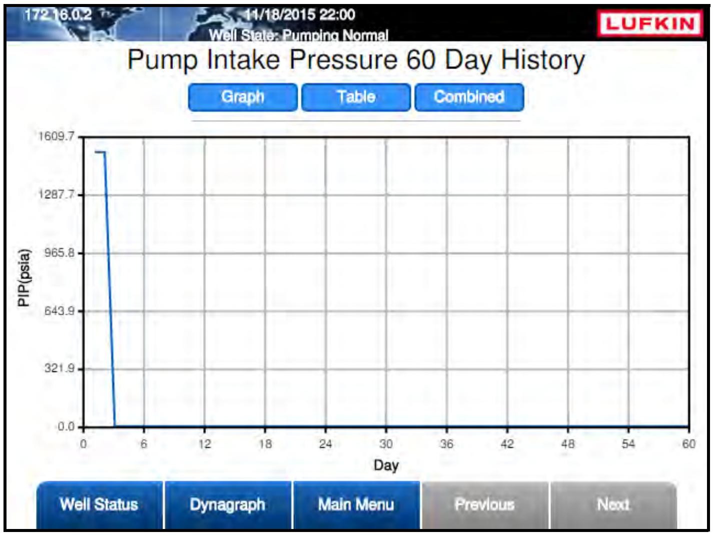

Figure 11-12. Pump Intake Pressure 60 Day History Screen

This screen displays the measured values for pump intake pressure (PIP) for each of the previous 60 days. This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Press the **Next** or **Previous** buttons to navigate between the pages of data.

Peak PRHP (Polished Rod Horsepower)

From the second Previous 60 Days menu screen, press the **Peak PRHP** button to display the Peak Polished Rod Power 60 Day History screen shown in Figure 11-13.

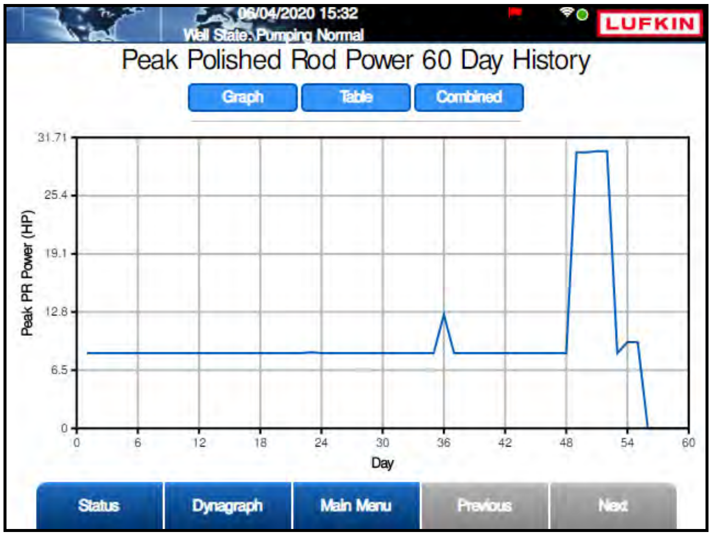

Figure 11-13. Peak Polished Rod Power 60 Day History Screen

This screen displays the highest value for polished rod horsepower recorded for each of the previous 60 days. This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Press the **Next** or **Previous** buttons to navigate between the pages of data.

Downhole Gauge

From the second Previous 60 Days menu screen, press the **DH Gauge** button to display the DH Gauge 60 Day History screen shown in Figure 11-13.

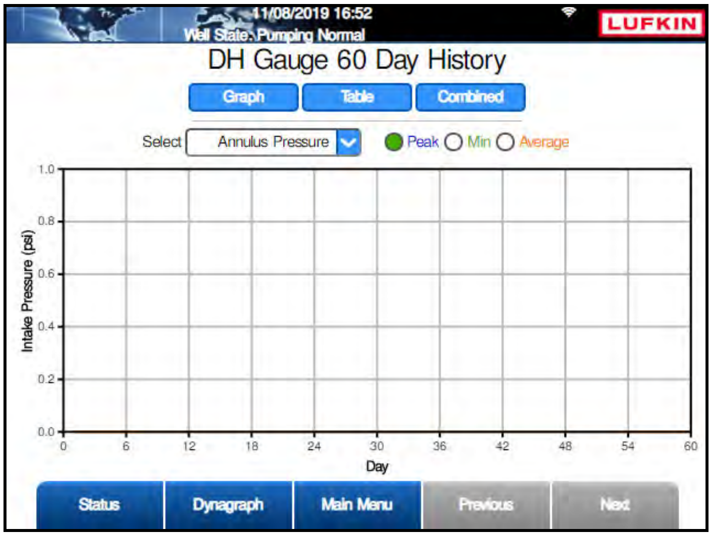

Figure 11-14. Downhole Gauge 60 Day History Screen

This screen displays the peak, minimum, and average values for downhole gauge data recorded for each of the previous 60 days. The following data is available from the drop-down list:

- Annulus Pressure
- Tubing Pressure
- Annulus Temperature
- Tubing Temperature
- Vibration X
- Vibration Z
- Tool Current
- Tool Voltage

Select the desired data option from the drop-down list and then press <**ENTER**>.

This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

24 Hour VSD Speed

This feature is not used with this controller.

24 Hour On/Off Percentage Runtime

From the Historical RPC Status menu screen, press the **24 Hour On/Off Percentage Runtime** button to display the 24 Hr On/Off Percentage Runtime screen shown in Figure 11-15.

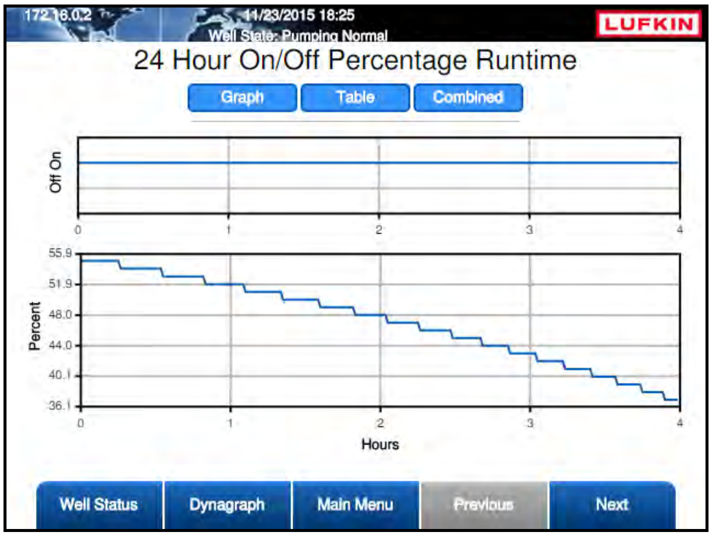

Figure 11-15. 24 Hr On/Off Percentage Runtime History Screen

This plot displays a record of the runtime activity for the previous 24 hours. The LWM 2.0 controller takes one sample point each minute (1440 in a 24-hour period) and uses it to represent that minute's activity. This data represents activity for the previous 24-hour period, and is not linked to gauge off time (GOT). It is a moving window of data from the time that you start viewing the data and moving back in time for the last 24 hours.

The plots show time as the x-axis. The time 0.0 (shown on the left of the plot) is the present time. Time numbers increase as you read to the right going back in time. The top of the plot indicates if the pump was on or off and the resulting percent run trend plotted below.

This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Last 20 Runtimes

From the Historical RPC Status menu screen, press the **Last 20 Runtimes** button to display the Last 20 Runtimes screen shown in Figure 11-16.

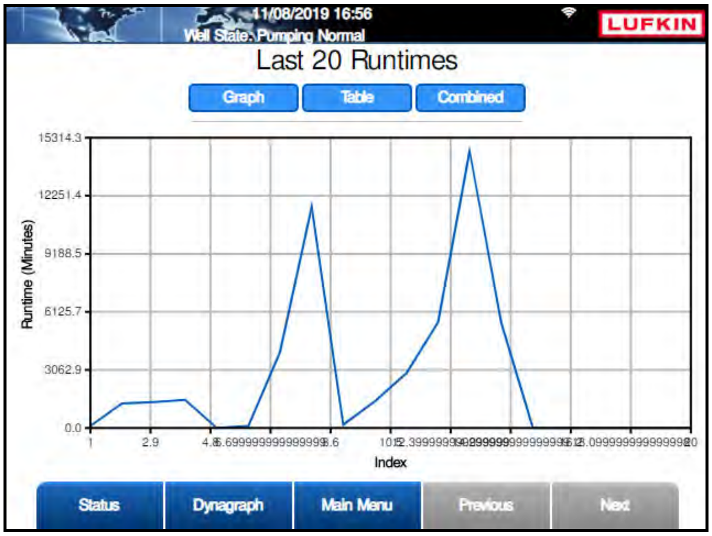

Figure 11-16. Last 20 Runtimes History Screen

This plot displays the previous 20 runtime periods measured in minutes. The plot shows the runtimes on the x-axis and the runtime on the y-axis.

This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Last 400 Loads

From the Historical RPC Status menu screen, press the **Last 400 Loads** button to display the Last 400 Loads screen shown in Figure 11-17.

This plot displays the last 400 load values prior to a shutdown decision versus time. This plot is included to ensure that you have a record of a LWM 2.0 controller shutdown decision due to a peak or minimum load violation. The dynagraph card record might not capture events of these types since the card data is only updated at the bottom of a stroke, and a peak or minimum load violation would call for a shutdown before the end of the present stroke.

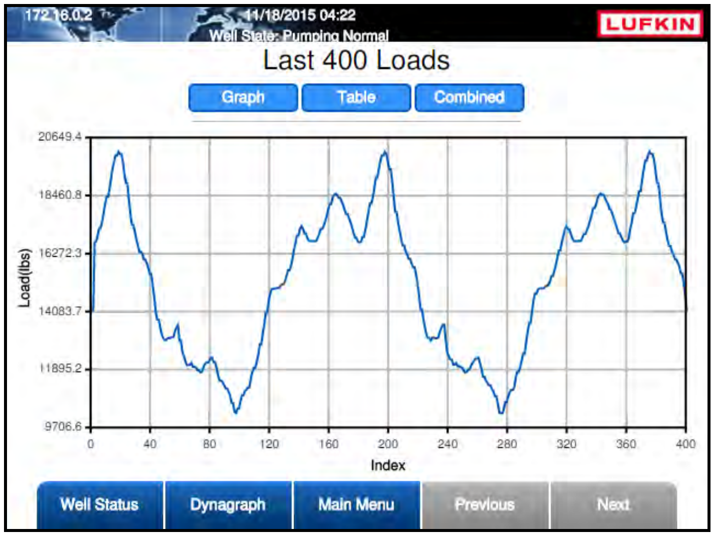

Figure 11-17. Last 400 Loads History Screen

This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

2880 Historical

From the Historical RPC Status menu screen, press the **Last 20 Runtimes** button to display the 2880 Historical menu screen shown in Figure 11-18 below.

Figure 11-18. 2880 Historical Status Menu Screen

The 2880 Historical status screens are discussed on the following pages.

Last 2880 Average PIP

From the 2880 Historical menu screen, press the **Last 2880 Average PIP** button to display the Last 2880 Avg PIP screen shown in Figure 11-19.

Every tenth stroke the current PIP value is captured and added to this data buffer. The most recent 2880 values are stored and available for display as a plot or table.

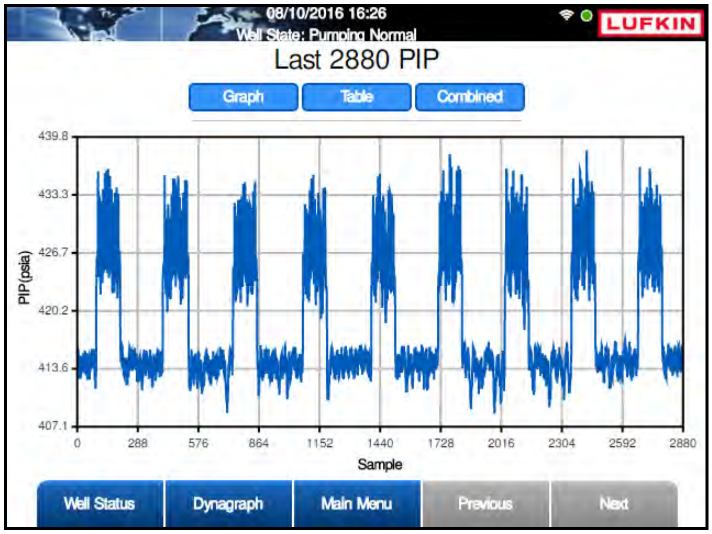

Figure 11-19. Last 2880 Avg PIP History Screen

This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

2880 DH Gauge

From the 2880 Historical menu screen, press the **2880 DH Gauge** button to display the 2880 DH Gauge screen shown in Figure 11-20.

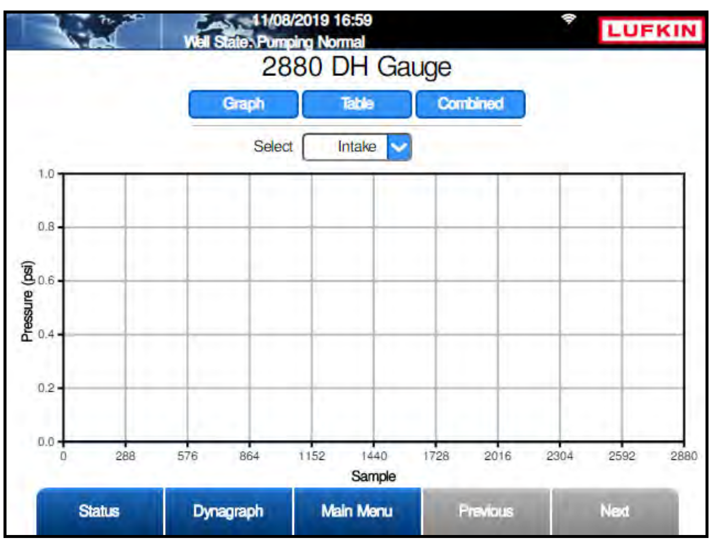

Figure 11-20. 2880 Downhole Gauge Historical Status Screen

Every tenth stroke the current downhole pressure value is captured and added to this data buffer. The most recent 2880 intake and tubing pressure values are stored and available for display as a plot or table.

To view this data, select **Intake** or **Tubing** from the drop-down list and then press <**ENTER**>.

This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Historical AGA Data

From the Historical Status menu screen, press the **AGA** button to display the Historical AGA menu screen shown in Figure 11-21.

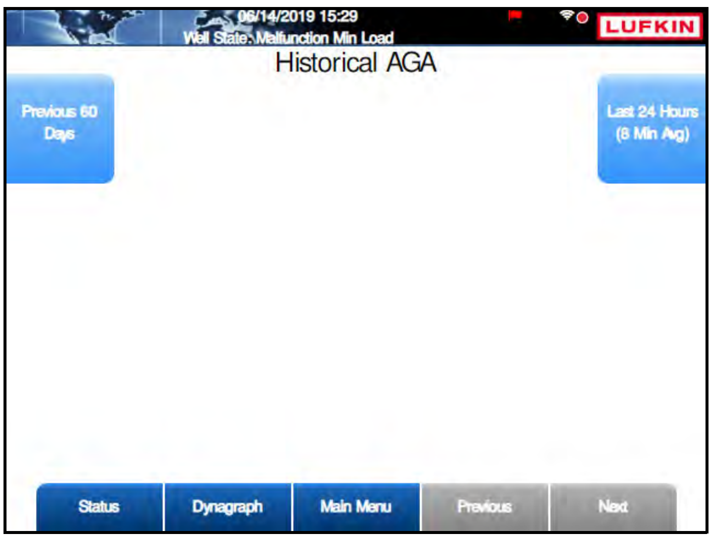

Figure 11-21. Historical AGA Menu Screen

The historical AGA data is discussed in the following pages.

AGA Previous 60 Days

From the Historical AGA menu screen, press the **Previous 60 Days** button to display the Previous 60 Days screen shown in Figure 11-22.

This screen shows the AGA calculation results for each of the previous 60 days. This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

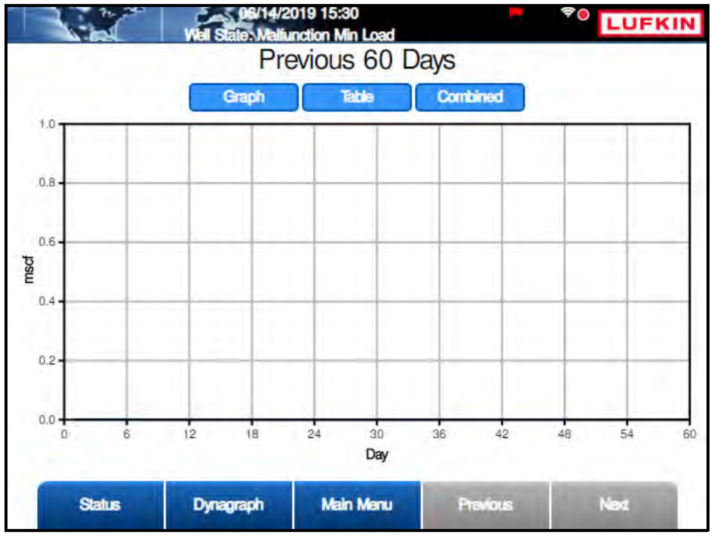

Figure 11-22. AGA Previous 60 Days Screen

Press the **Next** or **Previous** buttons to navigate between the pages of data.

Press <**ESC**> to return to the Historical AGA menu screen.

Last 24 Hours (8 Minute Averages)

From the Historical AGA menu screen, press the **Last 24 Hours (8 Min Avg)** button to display the Last 24 Hours (8 Minute Averages) screen shown in Figure 11-23.

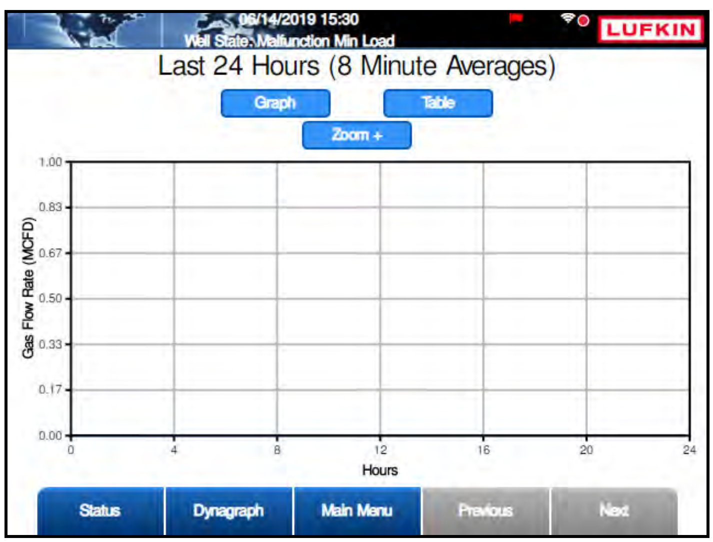

Figure 11-23. AGA Last 24 Hours (8 Minute Averages) Screen

This screen shows 8 minute averages of the AGA calculation results for the last 24 hours. This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Press the **Next** or **Previous** buttons to navigate between the pages of data.

Auxiliary Function Data

From the Historical Status menu screen, press the **Auxiliary Function** button to display the Auxiliary Function Data menu screen shown in Figure 11-24 below

Figure 11-24. Auxiliary Function Screen

The controller maintains records for configured auxiliary inputs. Data is available for the current 24-hour period and for the past 60 days.

These data screens are discussed in the following pages.

Analog Input 24 Hour

From the Auxiliary Function menu screen, press the **Analog Input 24 Hour** button to display the Analog Input 24 Hour screen shown in Figure 11-25 below.

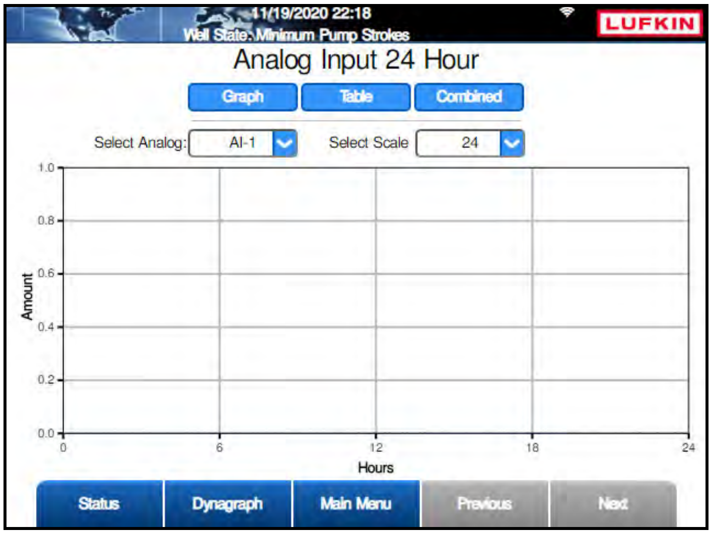

Figure 11-25. Analog Input 24 Hour Screen

The values of a selected configured auxiliary analog input are collected over the previous 24-hour period and can be displayed as either a graphical plot or as a table. This data consists of 180 values that are an average value for an eight-minute interval.

Use the arrow keys to highlight the **Select Analog** field and then press <**ENTER**> to display the drop-down list of available analog inputs. Use the up or down arrow keys to select the desired input and then press <**ENTER**> again.

Use the right arrow key to highlight the **Select Scale** field and then press <**ENTER**> to display the drop-down list of time ranges for the graph. Options are:

- 4 Hours
- 8 Hours
- 12 Hours
- 24 Hours

Use the up or down arrow keys to select the desired time range and then press <**ENTER**> again.

This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Press <**ESC**> to return to the Auxiliary Function Data screen.

Analog Input 60 Day

From the Auxiliary Function menu screen, press the **Analog Input 60 Day** button to display the Analog Input 60 Day screen shown in Figure 11-28 on page 11-22.

The average value of the selected configured auxiliary analog input for each of the previous 60 days is stored and can be displayed as either a graphical plot or as a table.

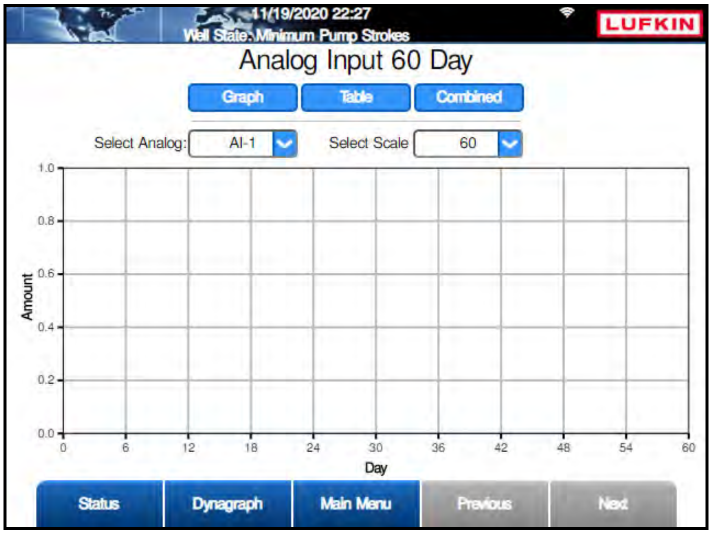

Figure 11-26. Analog Input 60 Day Screen

Use the arrow keys to highlight the **Select Analog** field and then press <**ENTER**> to display the drop-down list of available analog inputs. Use the up or down arrow keys to select the desired input and then press <**ENTER**> again.

Use the right arrow key to highlight the **Select Scale** field and then press <**ENTER**> to display the drop-down list of time ranges for the graph. (Options are 30 days and 60 days.) Use the up or down arrow keys to select the desired time range and then press <**ENTER**> again.

This data can be displayed in a graph, a table, or a combined view of both formats. Press the appropriate button for the desired display option.

Press <**ESC**> to return to the Auxiliary Function Data screen.

Accumulator 24 Hour

From the Auxiliary Function menu screen, press the **Accumulator 24 Hour** button to display the Accumulator 24 Hour screen shown in Figure 11-27.

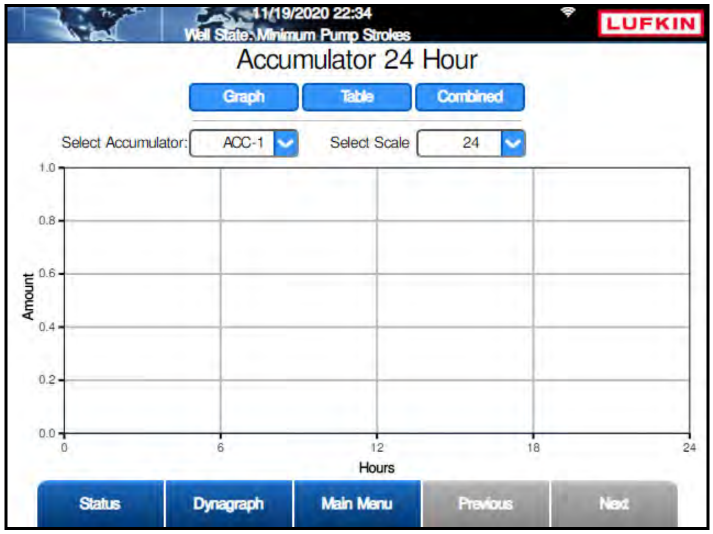

Figure 11-27. Accumulator 24 Hour Screen

For each configured accumulator, a history is maintained of the total scaled value accumulated in each of the previous 180 eight-minute sample periods during the previous 24-hour period. This data can be displayed in a graph, a table, or a combined view of both formats.

Use the arrow keys to highlight the **Select Accumulator** field and then press <**ENTER**> to display the drop-down list of available accumulator inputs. Use the up or down arrow keys to select the desired input and then press <**ENTER**> again.

Use the right arrow key to highlight the **Select Scale** field and then press <**ENTER**> to display the drop-down list of time ranges for the graph. Options are:

- 4 Hours
- 8 Hours
- 12 Hours
- 24 Hours

Use the up or down arrow keys to select the desired time range and then press <**ENTER**> again.

Press <**ESC**> to return to the Auxiliary Function Data screen.

Accumulator 60 Day

From the Auxiliary Function menu screen, press the **Accumulator 60 Day** button to display the Accumulator 60 Day screen shown in Figure 11-28.

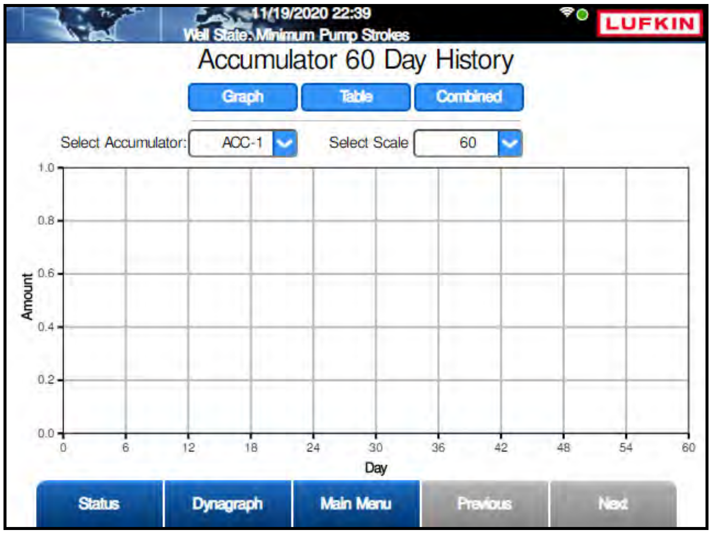

Figure 11-28. Accumulator 60 Day Screen

A history of the total scaled value for each configured accumulator input is maintained for each of the last 60 days. This data can be displayed in a graph, a table, or a combined view of both formats.

Use the arrow keys to highlight the **Select Accumulator** field and then press <**ENTER**> to display the drop-down list of available accumulator inputs. Use the up or down arrow keys to select the desired input and then press <**ENTER**> again.

Use the right arrow key to highlight the **Select Scale** field and then press <**ENTER**> to display the drop-down list of time ranges for the graph. (Options are 30 days and 60 days.) Use the up or down arrow keys to select the desired time range and then press <**ENTER**> again.

Press <**ESC**> to return to the Auxiliary Function Data screen.

Pulse Accumulator 24 Hour

From the Auxiliary Function menu screen, press the **Pulse Accumulator 24 Hour** button to display the Accumulator 24 Hour screen shown in Figure 11-29.

Figure 11-29. Pulse Accumulator 24 Hour Screen

For each configured pulse accumulator, a history is maintained of the total scaled value accumulated in each of the previous 180 eight-minute sample periods during the previous 24-hour period. This data can be displayed in a graph, a table, or a combined view of both formats.

Use the arrow keys to highlight the **Select Pulse** field and then press <**ENTER**> to display the drop-down list of available pulse accumulator inputs. Use the up or down arrow keys to select the desired input and then press <**ENTER**> again.

Use the right arrow key to highlight the **Select Scale** field and then press <**ENTER**> to display the drop-down list of time ranges for the graph. Options are:

- 4 Hours
- 8 Hours
- 12 Hours
- 24 Hours

Use the up or down arrow keys to select the desired time range and then press <**ENTER**> again.

Press <**ESC**> to return to the Auxiliary Function Data screen.

Pulse Accumulator 60 Day

From the Auxiliary Function menu screen, press the **Pulse Accumulator 60 Day** button to display the Accumulator 60 Day screen shown in Figure 11-30.

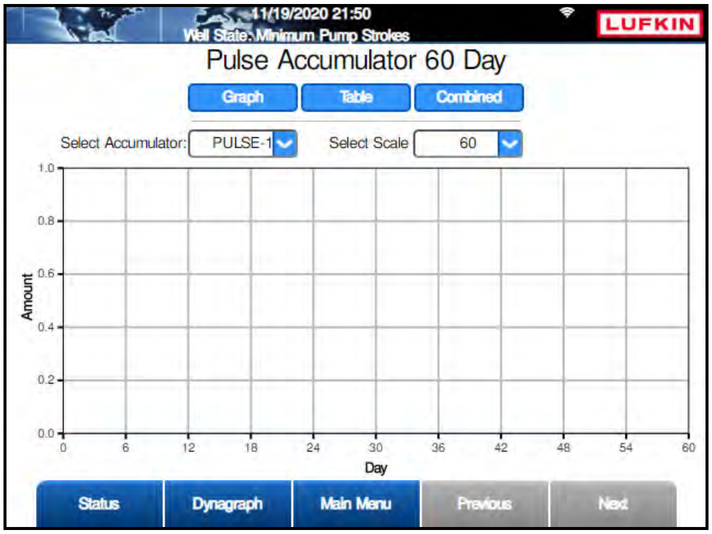

Figure 11-30. Accumulator 60 Day Screen

A history of the total scaled value for each configured pulse accumulator input is maintained for each of the last 60 days. This data can be displayed in a graph, a table, or a combined view of both formats.

Use the arrow keys to highlight the **Select Pulse** field and then press <**ENTER**> to display the drop-down list of available pulse accumulator inputs. Use the up or down arrow keys to select the desired input and then press <**ENTER**> again.

Use the right arrow key to highlight the **Select Scale** field and then press <**ENTER**> to display the drop-down list of time ranges for the graph. (Options are 30 days and 60 days.) Use the up or down arrow keys to select the desired time range and then press <**ENTER**> again.

Press <**ESC**> to return to the Auxiliary Function Data screen.

Section 12: Well States

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Section Overview

The LWM 2.0 controller will be in only one of a number of well states at any given time. The current well state is displayed on the top line of every screen.

A well state can indicate a phase of normal operation, or it may alert the user to a problem with the LWM 2.0 controller's input devices or the pumping equipment.

Types of Well States

There are three types of well states. These types are discussed below.

Well States Involved in Downtime

A well state that includes the word Downtime (or the acronym DT) in a well state, with two exceptions, tells the user that the controller will automatically start the pumping unit when the programmed downtime elapses. The two exceptions to this general rule are:

- Downtime Global Off Command well state: When the controller receives a Global Off command from a connected SCADA system, it keeps the pumping unit shut down until told to do otherwise.
- Downtime Peak Energy Management well state: The controller keeps the pumping unit in a downtime state for the entire period programmed for Peak Energy Management.

Well States Involved in Malfunctions

The word Malfunction (Malf) in a well state means that the controller detected a malfunction with equipment and that an operator must take action to return the unit to a pumping condition.

Well States Not Observed

Some well states may not be observed on the local interface because they are transient well states having a very short duration. For example the Stopped well state quickly changes to one of the downtime or malfunction states to give the user more complete information about why the unit stopped. Other well states will typically be observed only through host computer software, since an onsite operator will be using other local interface screens such as Load Calibration.

Well State Descriptions

The well states that can be displayed are described in the following tables.

Normal Well States While Pumping

Well State	Definition
Starting Unit	Controller has pulled digital output low to start the pumping unit and is in the process of checking that the unit actually started. Checks of position input, then load input are performed to make that determination.
Min Pump Strokes	Controller will pump for the programmed number of strokes with no analysis of dynagraph data.
Pumping-Normal Mode	Controller is performing all enabled functions.
Pumping-Host Mode	Controller has been user-programmed to operate in Host Operation mode and is currently programmed to run the pumping unit.
Pumping-Timed Mode	Controller has been user-programmed to operate in the Timed Operation mode.
BS Calibration	The operator is presently performing a bottom of stroke adjustment on the crank arm Hall-Effect transducer.

Normal Well States While Not Pumping

Well State	Definition
Initializing	Well state during boot-up period when power is first turned on or the Reset button has been pushed.
Downtime Power-On Delay	Initial well state following Initializing. The controller waits the programmed number of seconds before starting the pumping unit.
Starting Alert	Digital Output 3 is held low for the programmed number of seconds to sound an optional audible start alert device.
Stopping Unit	The controller has made a decision to stop the pumping unit. In this well state, load and position inputs are checked until they become static indicating that the pumping unit has actually stopped.
Stopped	A transient condition that users are not likely to see.
Downtime Pump Off	The controller detected a pumped off condition and was successfully able to stop the pumping unit.
Downtime Malf Setpt	The Malfunction setpoint in the surface dynagraph has been violated and the controller has successfully stopped the pumping unit. controller will start the pumping unit after the programmed downtime elapses. If the Malf setpoint violation was due to a transient wellbore condition, the consecutive malfunction counter will be cleared, and normal operation will continue. If the Malf setpoint violation occurs repeatedly for the number of consecutive allowed violations, the controller will arrive at the Malf/ Setpoint well state.

Normal Well States While Not Pumping (Continued)

Well State	Definition
Downtime Peak Load	Peak Load Allowed Limit in the surface dynagraph has been violated and the controller has successfully stopped the pumping unit. The controller will start the pumping unit after the programmed downtime elapses. If the peak load violation was due to a transient wellbore condition, the consecutive malfunction counter will be cleared, and normal operation will continue. If the peak load violation occurs repeatedly for the number of consecutive allowed violations, the controller will arrive at the Malf/Peak Load well state.
Downtime Min Load	Min. Load Allowed Limit in the surface dynagraph has been violated and the controller has successfully stopped the pumping unit. The controller will start the pumping unit after the programmed downtime elapses. If the Min. Load violation was due to a transient wellbore condition, the consecutive malfunction counter will be cleared, and normal operation will continue. If the Min. Load violation occurs repeatedly for the number of Consecutive Allowed violations, the controller will arrive at Malf/Minimum Load well state.
Downtime HOA in Off	This well state does not indicate any trouble with controller system. The operator may want to check why the H-O-A switch has been placed in the Off position since the well is probably not pumping. (This well state is applicable only if digital inputs have been wired to H-O-A switch contacts and programmed for Hand and Auto use.)
Downtime Host Mode	Indicates that controller has been deliberately programmed to keep the pumping unit shut down until further operator action.
Downtime Timed Mode	Indicates that controller has been deliberately programmed to cycle the pumping unit in the Timed Operation mode. The pumping unit will start after the programmed Set Off Time elapses.
Downtime Low RPM	Low RPM Allowed Limit has been violated and the controller has successfully stopped the pumping unit. The controller will start the pumping unit after the programmed downtime elapses. If the Low RPM violation was due to a transient well bore condition, the consecutive malfunction counter will be cleared and normal operation will continue. If the Low RPM violation occurs repeatedly for the number of Consecutive Allowed violations, the controller will arrive at Malf/Low RPM well state.
Downtime Global Off CMD	An all-call Global Off command has been received from the host software to stop the pumping unit. The controller will remain in the downtime mode until an operator programs otherwise.
Downtime Valves Measure	A local user has programmed the controller to record and/or analyze valve and counterbalance effect loads. Typically observed only via host software, since an onsite user is using other screens to complete the valve check routine.
Downtime Low Fluid Load	The Fluid Load Allowed Limit has been violated and the controller has successfully stopped the pumping unit. The controller will start the pumping unit after the programmed downtime elapses. If the low fluid load violation was due to a transient well bore condition, the consecutive malfunction counter will be cleared, and normal operation will continue. If the low fluid load violation occurs repeatedly for the number of Consecutive Allowed violations, the controller will arrive at Malf/Low Fluid Load well state.

Normal Well States While Not Pumping (Continued)

Well State	Definition
Downtime Peak Torque	Peak Torque Allowed Limit has been violated and the controller has successfully stopped the pumping unit. The controller will start the pumping unit after the programmed downtime elapses. If the Peak Torque violation was due to a transient well bore condition, the consecutive malfunction counter will be cleared, and normal operation will continue. If the Peak Torque violation occurs repeatedly for the number of Consecutive Allowed violations, the controller will arrive at Malf/Peak Torque well state.
Downtime Low Power	The controller has stopped the pumping unit because the present average downstroke pseudo motor power dropped below the set reference power. The operator should look for a potential load signal input failure.
Downtime No RPM Signal	The controller lost input pulses from the motor RPM Hall-Effect transducer and has successfully stopped the pumping unit. The controller will start the pumping unit after the programmed downtime elapses. If the loss of RPM pulses was due to a transient condition, such as the H-O-A switch being momentarily turned off, the consecutive malfunction counter will be cleared, and normal operation will continue. If the loss of RPM pulses occurs repeatedly for the number of Consecutive Allowed violations, the controller will arrive at Malf/No RPM Signal well state.
Downtime No Crank Sig	The controller lost input pulses from the crank arm Hall-Effect transducer and has successfully stopped the pumping unit. The controller will start the pumping unit after programmed downtime elapses. If the loss of crank switch pulses was due to a transient condition, such as the H-O-A switch being momentarily turned off, the consecutive malfunction counter will be cleared, and normal operation will continue. If the loss of crank switch pulses occurs repeatedly for the number of Consecutive Allowed violations, the controller will arrive at Malf/No Crank Signal well state.
Downtime Peak Energy	Peak Energy management function has been enabled and the controller has the pumping unit shut down during the programmed Peak Energy Management Period. The controller will return to the programmed operating and control mode after the energy management period.
Downtime Operator Stop	The controller has stopped the pumping unit in response to an operator command. Operator command may be via the local keypad or from host software via the data telemetry link. The pumping unit will automatically restart after the programmed downtime elapses.
Downtime PIP Override	The Pump Intake Override (PIP) feature has been enabled and the calculated PIP has fallen below the programmed PIP Setpoint for the consecutive number of strokes allowed. The controller has successfully stopped the pumping unit and will restart after the programmed downtime elapses.
Downtime Prod Cutoff	The Lufkin Well Test (LWT) Cutoff Control feature has been enabled and the calculated fluid production since the last Gauge Off time has reached the programmed allowed daily production. The controller has successfully stopped the pumping unit. The unit will remain down until the next Gauge Off time at which time it will automatically restart.
DT IO Shutdown DBR	(VSD systems only) The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a DBR alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.

Normal Well States While Not Pumping (Continued)

Well State	Definition
DT IO Shutdown Vibration Switch	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a vibration switch alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Pressure Switch	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a pressure switch alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Casing Pressure	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a casing pressure alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Tubing Pressure	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a tubing pressure alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Flowline Pressure	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a flowline pressure alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Pump Switch	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a pump switch alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Environmental Pot	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by an environmental pot alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Facility Shutdown	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a facility shutdown alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown PLC	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a PLC alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Run Status	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a run status alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Output	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by an output alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown StuffBox Leak Detector	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a stuffing box leak detector alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Kill Switch	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a kill switch alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.

Normal Well States While Not Pumping (Continued)

Well State	Definition
DT IO Shutdown Upstream Pressure	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by an upstream pressure alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Delta Pressure	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a delta pressure alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Tank Level	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a tank level alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Speed Sensor	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by a speed sensor alarm. The pumping unit remains in a downtime state until the alarm condition has been cleared.
DT IO Shutdown Custom1-5	The controller has stopped the pumping unit in response to an IO Shutdown command triggered by one of five user-defined custom alarms. The pumping unit remains in a downtime state until the alarm condition has been cleared.
Line loading State	The Line Loading feature of the controller has been enabled and the feature is active. Normal pump off control is overridden.

Well States Indicating Equipment Problem or Operator Override

Well State	Definition
Loss of Programming	Controller has lost the programmed parameters and has therefore returned to default conditions.
Pumping/HOA in Hand	Well State only when digital inputs are wired to contacts on the H-O-A switch and programmed for Hand and Auto use. Two digital inputs are required. This state indicates that the H-O-A switch has been set to a position to override well control by controller.
Unable to Run	Controller is trying to start the pumping unit but does not see dynamic load and position signals to confirm that the unit is actually pumping. Conditions such as drive belts thrown off, motor overloads tripped, or operator selection of H-O-A position would lead to this well state.
Pumping/Bad Load	Controller has detected a problem with the load input signal. In the event of a load signal input problem, the controller reverts to a secondary control method of internal percent timer. The well is cycled off/on using the programmed downtime and the percent run for the previous 24 hours.
Pumping/Bad Position	With analog position input only, the controller has detected a problem with the position input. In the event of an analog position signal input problem, the controller reverts to a secondary control method of internal percent timer. The well is cycled off/on using the programmed downtime and the percent run for the previous 24 hours.
Unable to Stop	The check during the Stopping Unit well state continued to see dynamic load or position after the maximum allowed Stopping Unit time of 3 minutes and 30 seconds. The operator should check the position of the H-O-A switch.

Well States Indicating Equipment Problem or Operator Override (Continued)

Well State	Definition
Downtime Bad Pos Signal	The controller has detected a problem with the position input and is cycling the pumping unit base on historical run time and programmed downtime; i.e., an internal percent timer type of control.
Downtime Bad Load Signal	Only with analog position input, the controller has detected a problem with the load input and is cycling the pumping unit base on historical run time and programmed downtime; i.e., an internal percent timer type of control.
Malf/Peak Load	Refer to Downtime Peak Load above. The pumping unit will stay down until a reset malfunctions is done by the operator.
Malf/Min Load	Refer to Downtime Min Load above. The pumping unit will stay down until a reset malfunctions is done by the operator.
Malf/Setpoint	Refer to Downtime Malf Setpoint above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malf/Low RPM	Refer to Downtime Low RPM above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malf/No RPM	Refer to Downtime No RPM Signal above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malf/No Crank	Refer to Downtime No Crank Sig above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malf/Peak Torque	Refer to Downtime Peak Torque above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malf/Low Fluid Load	Refer to Downtime Low Fluid Load above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malf/Lockout	The controller’s lockout feature has been enabled and the primary power has been off for longer than the programmed time limit. Operator intervention is required to return to normal operation.
Malfunction IO Shutdown DBR	Refer to DT IO Shutdown DBR above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Vibration Switch	Refer to DT IO Shutdown Vibration Switch above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Pressure Switch	Refer to DT IO Shutdown Pressure Switch above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Casing Pressure	Refer to DT IO Shutdown Casing Pressure above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Tubing Pressure	Refer to DT IO Shutdown Tubing Pressure above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Flowline Pressure	Refer to DT IO Shutdown Flowline Pressure above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Pump Switch	Refer to DT IO Shutdown Pump Switch above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.

Well States Indicating Equipment Problem or Operator Override (Continued)

Well State	Definition
Malfunction IO Shutdown Environmental Pot	Refer to DT IO Shutdown Environmental Pot above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Facility Shutdown	Refer to DT IO Shutdown Facility Shutdown above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown PLC	Refer to DT IO Shutdown PLC above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Run Status	Refer to DT IO Shutdown Run Status above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Output	Refer to DT IO Shutdown Output above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown StuffBox Leak Detector	Refer to DT IO Shutdown StuffBox Leak Detector above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Kill Switch	Refer to DT IO Shutdown Kill Switch above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Upstream Pressure	Refer to DT IO Shutdown Upstream Pressure above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Delta Pressure	Refer to DT IO Shutdown Delta Pressure above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Speed Sensor	Refer to DT IO Shutdown Speed Sensor above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Tank Level	Refer to DT IO Shutdown Tank Level above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.
Malfunction IO Shutdown Custom1-5	Refer to DT IO Shutdown Custom1-5 above. The pumping unit will stay down until a Reset Malfunctions command is done by the operator.

Section 13: Troubleshooting

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Section Overview

This section attempts to provide a field technician with sufficient information to help determine the cause of a malfunction or downtime state. Problem well states, setpoint violations, malfunctions, and input problems are discussed.

Well States

The present well state in many cases will be the first indicator that a problem exists with the LWM 2.0 system. The well state can point you to the part of the system that should be checked.

The following table lists the problem well states and the possible sources for problems.

Problem Well States and Possible Solutions

Well State	Possible Solution
Unable to Run Unable to Stop	Check for problem with the LWM 2.0 controller output, the motor starter panel, or the H-O-A switch position.
Downtime Bad Load or Pumping Bad Load Downtime Minimum Load or Malfunction Minimum Load Downtime Peak Load or Malfunction Peak Load	Check load cell and load cable.
Downtime Bad Position or Pumping Bad Position Downtime No RPM or Malfunction No RPM Downtime No Crank or Malfunction No Crank	Check for problem with position input.
Loss of Configuration Load Not Calibrated	Need to complete or restore parameter programming.

Refer to “Well State Descriptions” on page 12-4 for more information on well states and the situations in which they occur.

Load/Position Data and Dynagraphs

The Last 400 Loads historical screen or the Shutdown Event Log screen may give insight into a Bad Load well state. If the 400 Load plot is flat line at either full scale or zero, a loose connection in the load cell cable could be the problem. If the Last 400 Load Plot or the shutdown cards record an isolated load “spike,” an intermittent conductor in the load cell cable is probably the cause.

Setpoint Violations and Malfunctions

The LWM 2.0 controller is programmed with a series of setpoints that determine how the controller reacts to situations that occur during pumping operation.

The following is a list of setpoint violations that can occur:

- **Pumpoff Setpoint**: Used for surface card application.
- **Pump Fillage Setpoint**: Used for downhole card application. If the calculated downhole pump card fillage is equal to or less than this value for the number of allowed strokes, the pumping unit is stopped for a downtime cycle.
- **Peak Load**: The maximum allowed value for load input. If the load exceeds this limit, the controller instantly shuts down the pumping unit with no consecutive stroke delay. Units are in pounds. The default value will be the full scale of the programmed load end device.
- **Minimum Load**: The lowest allowed value for load input. If the load falls below this value, the controller instantly shuts down the pumping unit with no consecutive stroke delay. The default value is zero.
- **No RPM**: This is a time delay setpoint, measured in seconds. It is designed to allow the pumping unit time to accelerate up to operating speed. When the unit starts up, the controller waits a predefined number of seconds before checking for No RPM violations.
- **No Crank**: This setpoint specifies the number of motor revolutions that the controller should wait before it detects the first crank switch input. If a crank switch input is not detected within this number of motor revolutions, the controller declares a No Crank alarm and stops the pumping unit. If the unit is pumping extremely slow and it causes this reference revolution value to be near 300, you may need to program a higher value than the default of 300 revolutions.
- **Low Motor RPM**: Like the No RPM setpoint, this is also a time delay setpoint, measured in seconds. It is designed to allow the pumping unit time to accelerate up to operating speed. When the unit starts up, the controller waits a predefined number of seconds before checking for Low Motor RPM violations.
- **Peak Torque**: The maximum allowed torque value in thousands of inch-pounds. If the controller calculates a torque value greater than this limit at the completion of a stroke, the pumping unit shuts down early in the next upstroke.
- **Malfunction Setpoint**: States the number of consecutive strokes that the surface malfunction setpoint has been violated. This feature shuts down the well if surface load on the upstroke falls below the malfunction setpoint for the programmed number of consecutive strokes.
- **Low Fluid Load**: The controller analyzes the realtime downhole dynagraph and uses this data to calculate fluid load for each pump stroke. If the fluid load drops below this low limit, the pumping unit is stopped for a downtime cycle early in the next upstroke.
- **Motor Power**: This setpoint defines the minimum amount of motor power needed to keep the pumping system running. When the amount drops below this value, the controller shuts down the pumping unit.
- **Belt Slippage**: When in the Pumping Normal mode well state, the controller counts the Motor Rev/Stroke for each stroke. At the end of each stroke, the count is compared to the Reference Rev number programmed above. If the current Motor Rev/Stroke count is greater than the Reference Rev by greater than this Belt Slippage percentage, the controller sets an alarm flag to indicate possible belt slippage. No other control action is taken. The default value is 5%.

- **Peak PRHP**: This is the value at which the controller will set an alert flag to advise the operator that a paraffin treatment may be required. This value is a high limit.

These can be viewed on the Violation Status Data screen shown in Figure 13-1.

Figure 13-1. Violation Status Screen

To reset these malfunctions and restart the controller, press the **Reset Malfunction** button on the Main Menu screen.

Inputs to the LWM 2.0 Controller

Information is provided for troubleshooting the following input problems:

- Load signals
- Load cells and cables
- Analog and digital position signals
- Keypad

These are discussed in the following paragraphs.

Load Signal Input

The load input signal should be a smoothly varying voltage signal. Signal magnitude should increase in the early part of the upstroke, and decrease in the early part of the downstroke. An erratic load signal generally indicates a load signal cable problem. The voltage levels you should check are as follows:

- **Excitation Voltage**: The excitation voltage must read +5.0VDC. If the 5.0VDC excitation is not present, either the voltage regulator on the analog input board has failed or an external short is pulling down the voltage level. To check for an external short, disconnect the load cell cable leads and check the excitation voltage again.

- **Signal Voltage**: The differential load signal is connected to terminals 2 and 3 on Terminal Block 1 (TB1). Terminal 2 should be a few MVDC positive with respect to terminal 3. The magnitude of the signal depends on the type of load device used. These types and their outputs are discussed below.
  - **Polished rod load cell output** is 2 mVDC/Volt of excitation at full rated load of either 30,000 pounds or 50,000 pounds. Therefore, the signal voltage will be somewhere between 0 and 10 mVDC.
  - **Beam-mounted load transducer output** should swing through approximately a 4 millivolt range as the pumping unit goes through a pump cycle. The center point of that swing varies from installation to installation, but typically falls between -10 MV and +20 MV. The mid-point of the load signal should never exceed +100 MV. Exact numbers are not important, but a swing of less than 2 MV usually indicates a problem with either the beam transducer or the mounting welds. If the high point of the signal is above 20 MV, it will be necessary to change the gain setting for the load transducer from the default value of 64 to a lower setting according to the table below.

Load Transducer Gain Settings

Highest Signal Level	Gain Setting
<20 MV	64
>19MV but <75 MV	32
>74 MV	1 or 2

Load Cell and Cable

The cable to the load cell can frequently be the cause of load input problems. Some simple checks using an ohmmeter can help isolate a problem.

1. Disconnect the wiring at the LWM 2.0 controller before taking any readings.
2. Leave the connection in place at the load device end.
3. From the LWM 2.0 controller end of the cable, measure the resistance between wire color pairs as shown below.

Ohmmeter readings depend on the load cell type in use. These types are discussed below:

- **Beam mounted transducer**
  - Red to Black: 350 ±5
  - Green to White: 350 ±5
  - Red to Green, Red to White, Black to Green, and Black to White: These should all read 262 ±5.
  - Each wire to earth ground: Ohmmeter on the highest scale; open circuit or infinite resistance
- **Polished Rod Load Cell**
  - Red to Black: 693 to 770
  - Green to White: 693 to 707

For both types of load devices, each wire to earth ground should read greater than 10 M.

Note: It is best to make these measurements with the pumping unit in operation, since cable problems may be intermittent and show up at only a certain point in the stroke as the cable flexes.

If the ohmmeter readings indicate a problem, move to the load device itself and repeat the ohmmeter checks right on the input connector to the device. This second set of checks will help you decide if the problem is in the cable or in the device.

Digital Position Signal Inputs

The digital position input is actually two discrete inputs from the Hall-Effect transducers. The Hall-Effect inputs are connected to terminal strip TB1 on the communication module. The communication module has a voltage regulator that provides excitation voltage for the Hall-Effect transducers. Voltage levels are as follows:

- **Excitation Voltage**: Terminal 19 (labeled +5V) of terminal strip TB1 must measure +5.0 VDC. If the excitation voltage is not correct, either the voltage regulator in the communication module has failed, or an external short exists in the Hall-Effect cables. To check for an external short, disconnect the Hall-Effect cable leads and check the excitation voltage again.
- **Signal Voltage**: The RPM signal on terminal 20 and the CSW signal on terminal 22 of TB1 are pulled up to the module +5 VDC reference voltage through a 150-ohm resistor. Therefore, the voltage level on these terminals should be at about +4 VDC when the Hall-Effect is not sensing a magnetic field or the leads are disconnected. When the Hall-Effect transducer does sense the presence of the magnet, the input terminal will be pulled down to about 0.2 VDC and the LED should illuminate. The Hall-Effect transducers are polarity-sensitive. If the wrong side of the crank arm magnet is stuck to the crank arm, the Hall-Effect transducer will not sense the magnet. The side of the flat magnet that is attracted to the motor RPM magnet is the side that should be stuck to the crank arm.

Diagnostics

The LWM 2.0 RPC has diagnostic tools available for troubleshooting issues in the controller. From the first System menu screen, press or click the **Diagnostics** button to display the Diagnostics menu screen shown in Figure 13-2.

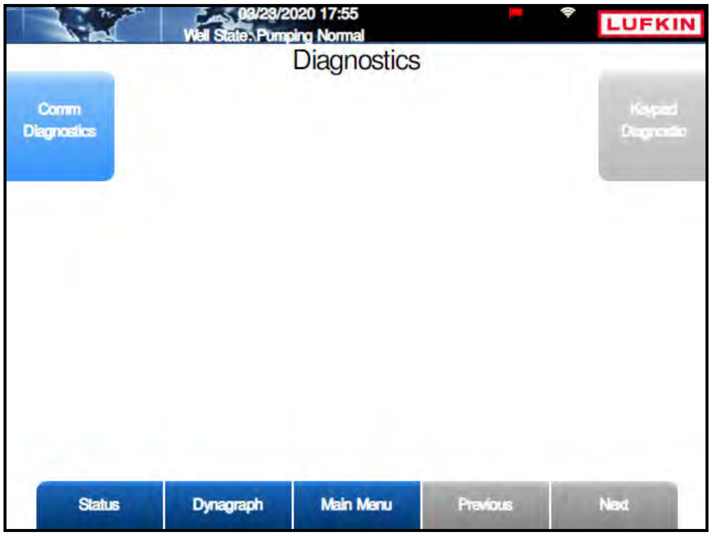

Figure 13-2. Diagnostics Menu Screen

Refer to “Diagnostics” on page 7-19 for details on using these diagnostic tools.

Outputs from the LWM 2.0 Controller

The digital outputs of the LWM 2.0 controller are semiconductor switches that sink a maximum of 250 milliamps DC continuous drain current per output. A built-in voltage clamp is included on the outputs for inductive transient protection. The maximum source voltage rating is 45 VDC.

An interposing relay is required for any output that is connected to switch a high voltage AC control circuit. These applications include a motor starter circuit, start alarm light or klaxon, etc. Interposing relays can be solid-state or electro-mechanical. Solid-state devices that are compatible with DMOS transistors can be directly connected to the digital outputs. When using electro-mechanical relays, it is recommended that a surge suppression diode be connected across the relay coil to suppress the inductive kick of the relay coil as the relay is de-energized.

Typically, the nominal +12 VDC supply (13.8 VDC actual) is used as the source voltage for the interposing relay. The positive terminal of the relay would be wired to one of the +12 VDC terminals provided on the upper left corner of the LWM 2.0 controller back panel. The negative terminal of the interposing relay is wired to the appropriate digital output terminal on terminal strip TB5 on the bottom edge of the motherboard.

When the LWM 2.0 controller turns off an output, the voltage level at the associated terminal will be pulled up to about 11 VDC. When the controller turns on an output, the voltage level at that terminal will be pulled down to less than 1 VDC.

Appendix A: Pump Intake Pressure and Lufkin Well Test Theory

Appendix Overview

This appendix describes the theory behind the Lufkin Well Test (LWT) feature that is used for calculating pump intake pressure and fluid production through the pump.

Overview of PIP and LWT

Lufkin Well Manager 2.0 controllers offer a Pump Intake Pressure (PIP) feature. This feature has an algorithm that can determine the pump fluid load by analyzing the downhole pump card. The fluid load value along with operator-entered values for casing and tubing pressures, pump plunger diameter, and pressure/volume/temperature (PVT) properties for the produced fluid are all used to calculate PIP. The PIP feature offers another well management tool for operators that do not aggressively pump wells, and therefore do not observe the dynagraph card typically associated with pump off or fluid pound.

The PIP feature may not add a great deal of value at well sites where the pumping system is designed with over-displacement and the well is being cycled on and off. On those wells, PIP has already been drawn down as far as possible.

The LWT algorithm provides automated fluid volume adjustments for pump slippage, fluid shrinkage, and tubing movement. Pump slippage can be either a user-entered value, or the controller will use the leakage value from a completed analysis of a Valve Check file. Fluid volume shrinkage calculations use the PVT properties programmed for the PIP feature.

Theory of PIP Calculated from Downhole Card

PIP can be easily and accurately calculated using a downhole pump card similar to the one illustrated in Figure A-1 on page A-4. Input data from the pump card includes fluid load, gross stroke, net stroke, and tubing movement if applicable.

Pump intake pressure, designated as Pp in Figure A-1 on page A-4, can be calculated from the formula:

$$P_p = P_d - F_o/A_p$$

The LWM 2.0 RPC uses an iterative process to solve for pump intake pressure. This process involves the following steps:

1. D_p, A_p, and P_t are entered by the user as known values.
2. The LWM 2.0 RPC measures F_o, GS, and NS from analysis of the downhole pump card. The remaining unknown is P_d (Pump Discharge Pressure).
3. Knowing GS and NS, barrels of free gas through the pump are calculated.

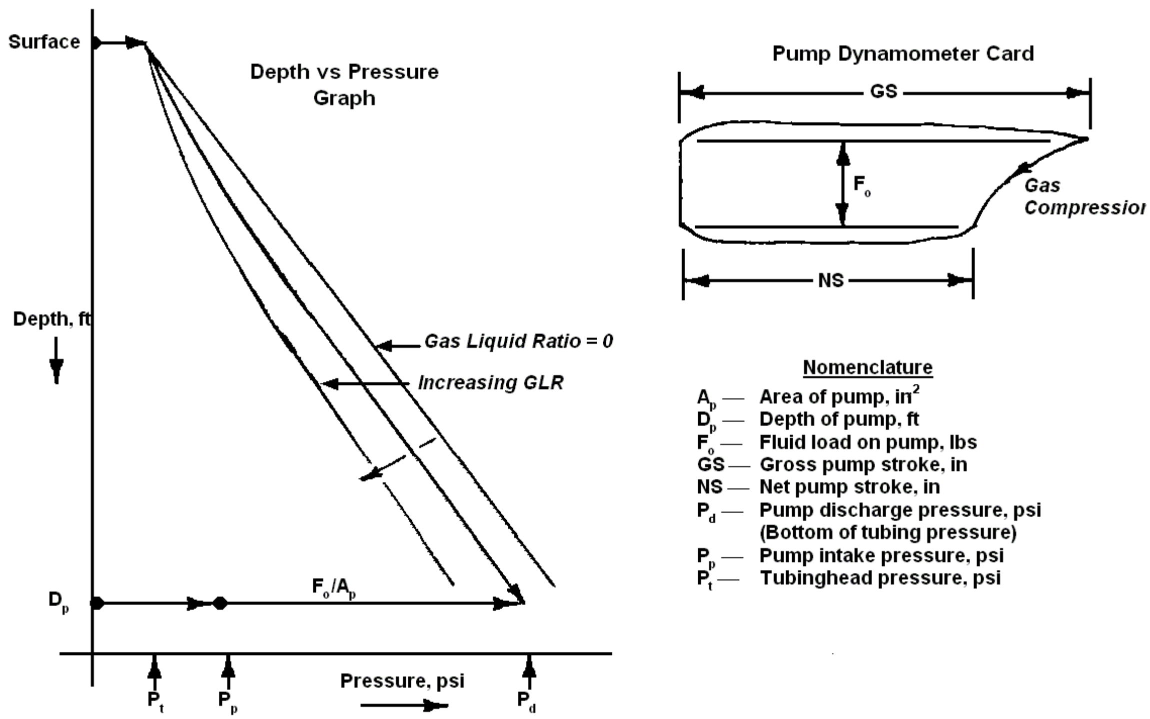

Figure A-1. Pump Intake Pressure from Dynamometer Data

4. P_p is estimated, and SCF of free gas per day and SCF of solution gas per day (SCF = standard cubic feet at atmospheric pressure) are calculated.
5. Free gas and solution gas are added to determine tubing GLR (GLR = total SCF/bbl of liquid).
6. P_d is calculated from flowing tubing gradient technology.
7. P_d from the equation is substituted, P_p is calculated, and then it is compared to the estimated P_p in step 4.
8. If the comparison differs, the LWM 2.0 RPC continues to iterate to converge on a solution. Convergence to within ±10 psi is acceptable.

Fluid load (the most important item) is the load difference between upper and lower load lines that are carefully selected and drawn on the pump card (see Figure A-2). This load should not include friction and fluid inertia effects.

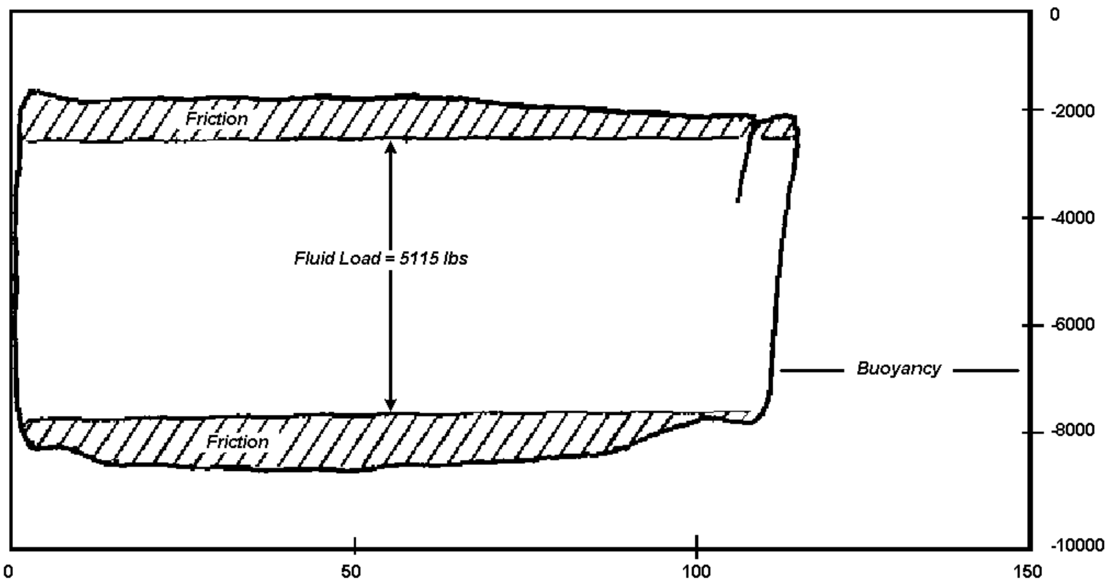

Figure A-2. Fluid Load Measured from Pump Card

The LWM 2.0 RPC automatically draws load lines after it analyzes the downhole dynagraph card.

The upper line is drawn near the top of the pump card to exclude upstroke friction and fluid inertia effects. Upstroke friction includes pump friction (normally small), friction along the rod string (fluid friction and drag friction), and stuffing box friction. Fluid inertia effects are common in relatively shallow wells with large bore pumps handling essentially incompressible fluids (no free gas). Fluid inertial effects are compounded in wells with pump bores larger than the tubing ID.

As on the upstroke, the lower line is drawn to exclude friction on the downstroke. Ideally, the lower load line should fall below zero load by the same amount as buoyancy. The accuracy of the buoyancy calculation depends on good load measurements, precise rod design information, and a known tubing fluid gradient. Since the buoyancy force is not always precise, the shape of the pump card should take precedence in drawing the lower load line. Because frictional forces tend to go to zero and change sense at the top and bottom of the stroke, “knees” are formed, which aid in drawing the upper and lower fluid load lines.

Also, if the pump is not filling (fluid pound or gas interference), a “nose” is formed on the upper right side of the pump card. If the nose tends to come to a point, the upper fluid load line is drawn to the point, which tends to split the nose. This is logical because upstroke friction adds to pump load and downstroke friction subtracts from pump load.

Figure A-3 shows the algorithms LWM 2.0 RPC uses to pick the fluid load line.

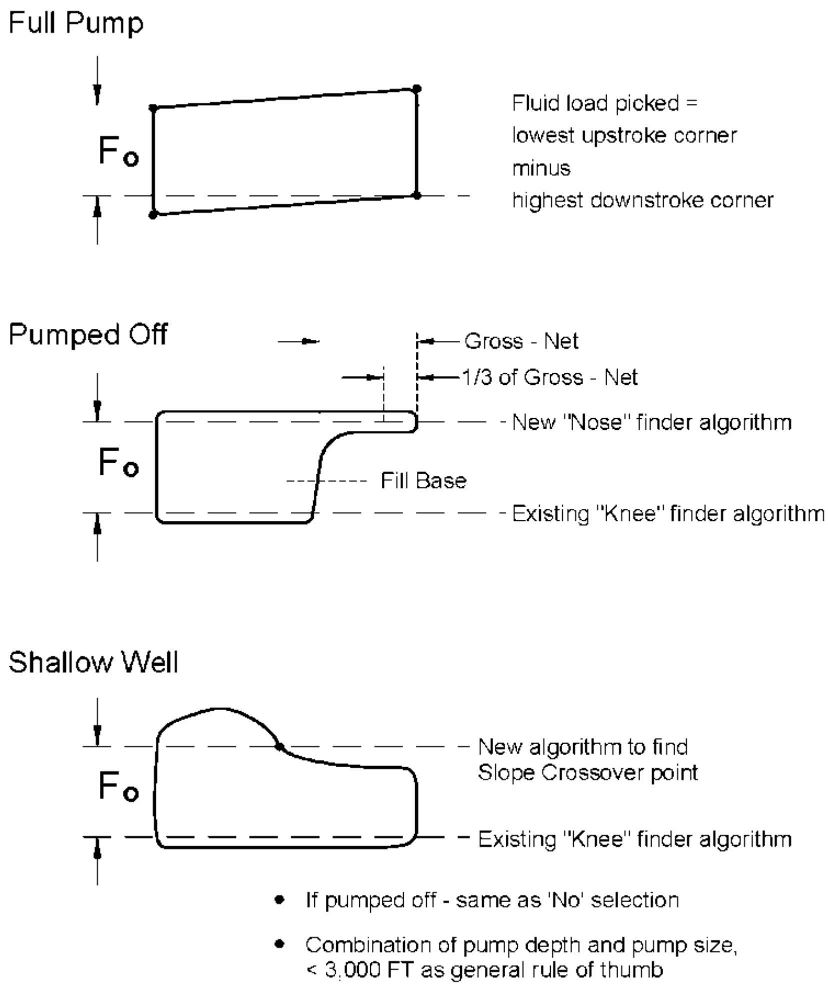

Figure A-3. PIP Fluid Load Detection

Theory of LWT Calculated from a Downhole Card

The Lufkin Well Test algorithm can be configured to work in the Advanced mode or the older Basic mode.

Advanced LWT Algorithm

The Advanced Lufkin Well Test algorithm is based on analysis of the downhole dynagraph card. Figure A-4 illustrates the relevant concepts from the pump card.

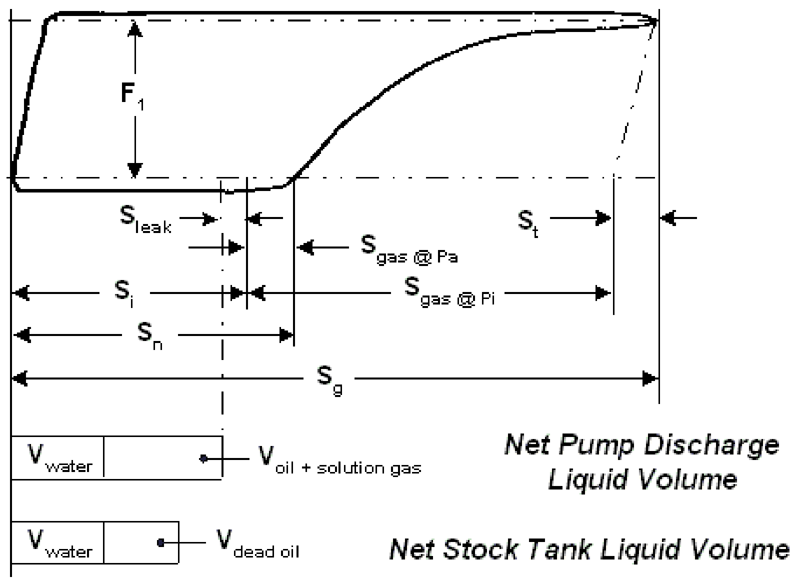

Figure A-4. Elements of LWT Analysis of Downhole Pump Stroke

The following effects are used to calculate oil, water, and tubing gas volume produced with each stroke:

The amount of free gas and solution gas metered into the pump barrel each stroke is a function of the pump intake pressure. Using the results of the PIP calculation, the net stroke loss due to free gas (S gas at P_i) and solution gas (S gas at P_a) can be quantified.

Net stroke loss due to tubing movement (S_t) is calculated from a simple Hook's Law model. Fluid volume lost due to traveling valve/plunger leakage can be accounted for from measured valve check data or from a user-entered "known" leakage.

The percentage of water volume is calculated from a user-entered percentage water cut.

Basic LWT Algorithm

The Basic Lufkin Well Test algorithm is based on a much more simplistic analysis of dynagraph cards. The Basic LWT analysis may work from either the surface or downhole dynagraph. The basic formula for the IPA fluid production calculation is

$$P_D = C \times D^2 \times S_p \times K - Leakage$$

Where:

P_D = pump displacement in barrels

C = mathematical constant to calculate cross sectional area (in2) of pump plunger from pump diameter, and to convert cubic inches to barrels

D^2 = diameter of the pump plunger in inches

S_p = effective pump plunger stroke length in inches

K = calibration factor

The “inferred” part of the Basic Lufkin Well Test is the effective plunger stroke length, S_p. The user programs the surface stroke length and the LWM 2.0 RPC analyzes the dynagraph shape each stroke to “infer” the percentage of that stroke that is effectively lifting fluid. The method used for inferring the effective pump plunger stroke is linked to the control method selected, such as Surface control or Downhole control.

Basic LWT from Surface Card

If the Surface control method is selected, the LWM 2.0 RPC analyzes the surface dynagraph at the end of each stroke to infer the S_p for that stroke. The load coordinate of the surface POC setpoint is used as a reference line. From the first point in the downstroke where the dynagraph load crosses that reference line to the bottom of the stroke is considered the effective plunger stroke length. Figure A-5 illustrates the shorter S_p inferred when the well is pumped off.

The accuracy of the IPA volume calculations is only as good as the data programmed into the LWM 2.0 RPC. Variables such as pump plunger diameter and surface stroke length are significant factors that can cause the inferred production results to be inaccurate if they are not properly programmed. The location of the POC setpoint in an “illogical” part of the surface dynagraph can also introduce errors. The POC setpoint should typically be at about the standing valve load level.

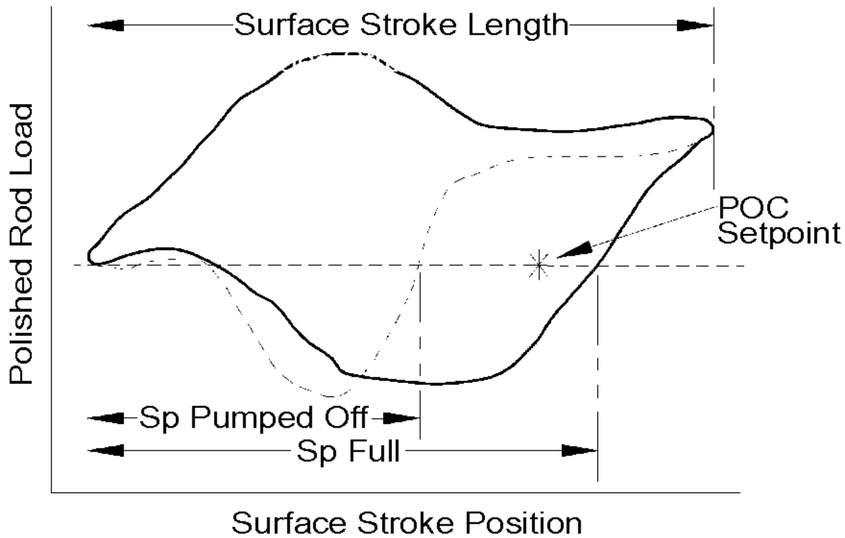

Figure A-5. SP Inferred From Surface Dynagraph

Basic LWT from Downhole Pump Card

If the Downhole control method is selected, the LWM 2.0 RPC infers the effective plunger stroke length S_p by analyzing the downhole pump card (see Figure A-6). The net stroke length value selected by the percent pump fillage algorithm is used as S_p in the fluid volume calculation. The accuracy of the downhole pump card depends on the accuracy of data programmed in the LWM 2.0 RPC. Accurate pumping unit dimensions, rod string data, etc. are parameters that can cause the downhole pump card to be distorted if they are not properly programmed. Distortions in the pump card can lead to an incorrect net stroke determination and therefore an incorrect IPA fluid volume. The fill base value illustrated in Figure A-6 is not an obvious parameter.

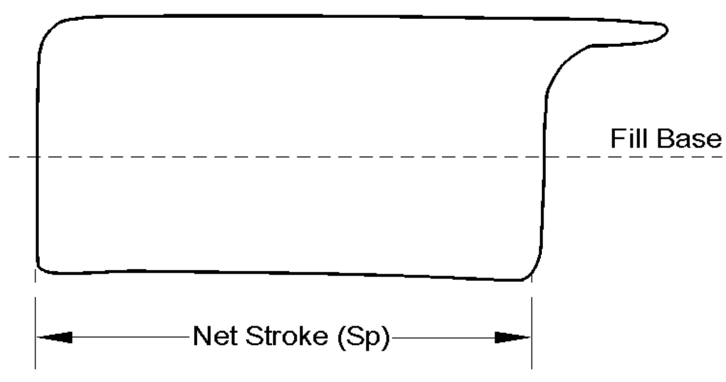

Figure A-6. SP Inferred From Downhole Pump Card

The fill base value is a percentage level at which the LWM 2.0 RPC starts to check the downstroke of the dynagraph for the knee, which indicates that the plunger has reached liquid in the pump barrel. Zero percent is the minimum load level of the pump card and 100 percent is the maximum load level of the pump card. The fill base parameter was added to give the LWM 2.0 RPC more flexibility to analyze pump cards that might have “steps” in the very early part of the downstroke due to tubing movement or other pumping system anomalies. If you feel that the LWM 2.0 RPC has selected the wrong net stroke, adjust the fill base up or down to bring the LWM 2.0 RPC net stroke selection into agreement with your visual analysis.

Calibration (K) Factor

The LWT K factor (calibration factor) is included in the fluid volume formula to correct for fluid volume lost from either slippage or shrinkage.

- **Slippage**
  The seal between the pump plunger and the pump barrel is generally not 100 percent effective. Therefore, a significant amount of fluid “slip” around the plunger in the upstroke may cause less fluid to reach the surface during each stroke.
- **Shrinkage**
  Fluid volume shrinkage is caused by gas held in solution by the higher pressures at the pump depth that breaks out of the solution at surface tank battery pressure levels thereby reducing the fluid volume.

The LWM 2.0 RPC allows a wide range of values for programming the K factor. Reasonable numbers to account for slippage and/or shrinkage would be in the range of 0.65 to 1.00. If the K factor has to be programmed outside of that range to obtain good agreement between the Basic Lufkin Well Test fluid volumes and other benchmark fluid production test equipment, further investigation is necessary.

- Double-check the programming input to the LWM 2.0 RPC.
- Check that abnormal pump wear and the resulting dynagraph distortion is not “fooling” the Basic LWT algorithm, and/or
- Check the calibration of the production test equipment used as the baseline.

Consider Formation Pressure Query Feature

In the LWT/PIP Parameters 3/3 Screen, a **Yes/No** option is provided in the **Consider Formation Pressure** field to specify whether to use the Consider Formation Producing Pressure query feature. This query should be answered affirmatively when the pump is set above “mid-perfs.” When the pump is at mid-perfs, the formation producing pressure is considered the same as pump intake pressure (PIP).

The following pages discuss two cases to help the decision on when to use the query. Consult Figure A-7 while reading the cases.

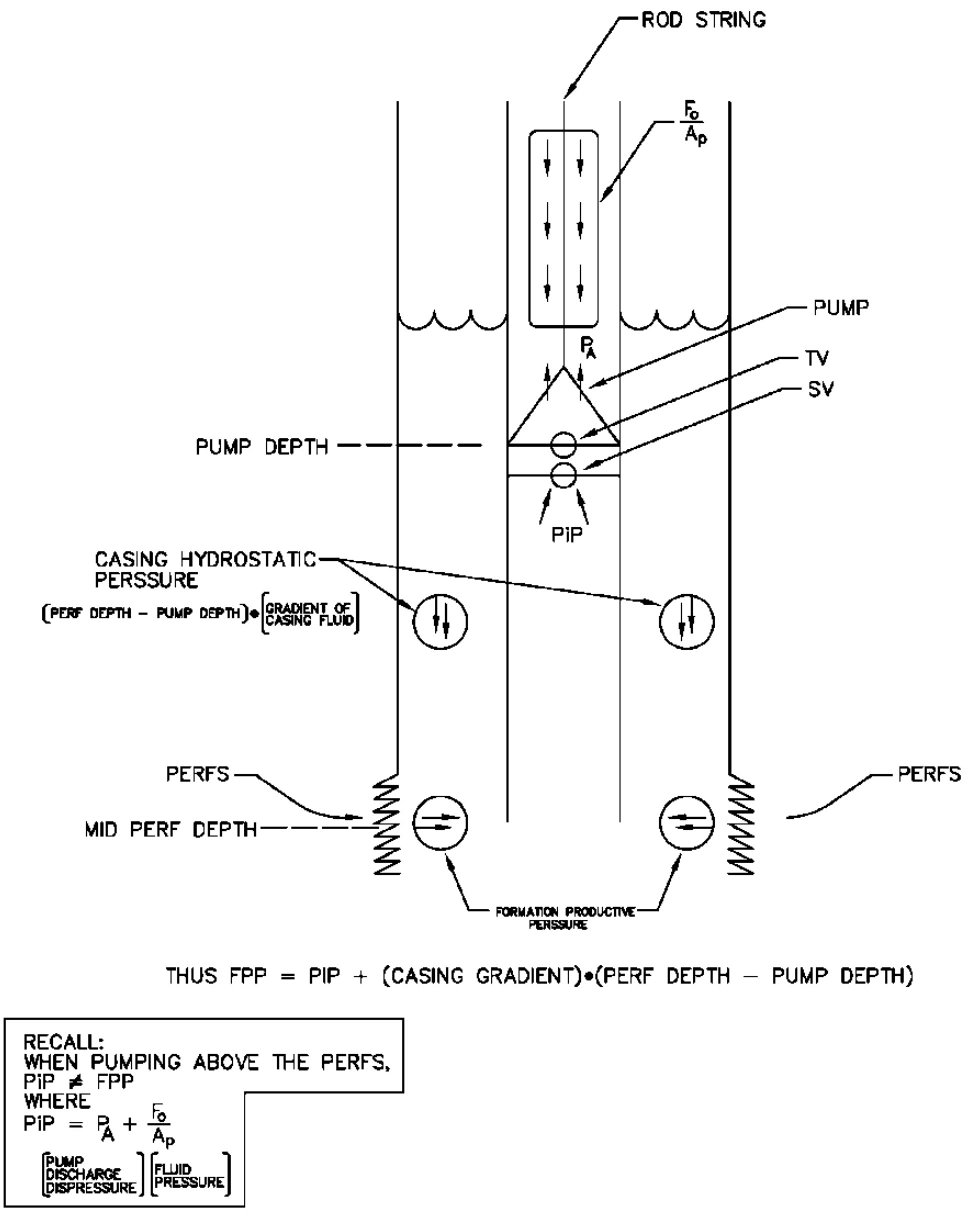

Figure A-7. Illustration Showing Pump Placement Above Perforations

Case 1

Suppose that the pump is set above mid-perfs. In this situation, the formation producing pressure (FPP) is not the same as PIP. You must consider the gradient of the casing and the difference in depth between the pump and mid-perfs. In the casing, the gas/liquid ratio (GLR) may be different than that the GLR in the tubing. Since you cannot accurately determine the casing gradient below the pump depth, you must approximate it with the tubing gradient. The equation relating FPP and PIP is:

$$FPP = PIP + Grad \times (Formation\ Depth - Pump\ Depth)$$

You must shut down from FPP, which in this case is not the same as PIP. Even though the pump may not be filling completely, which indicates that PIP must be below the bubble point pressure P_b, FPP may still be above P_b, which means that the well should remain running. However, when FPP becomes less than P_b, or an operator-specified limit above P_b, the well should be shut down. In this case, pump fillage is not used to determine whether or not to shut down the well. However, remember that the calculations are not accurate since casing gradient is being approximated with the tubing gradient.

Also, a gas separator should be used because pumping may be occurring when PIP is less than P_b. You need to separate the maximum amount of gas possible.

Case 2

Suppose that the pump is set at mid-perfs. FPP is considered the same as PIP. Then, even though incomplete fillages are not occurring, the pumping unit will shutdown when FPP≡PIP becomes less than P_b, or any operator-specified limit above P_b.

Also, in this case, when you have incomplete fillage, FPP≡PIP is less than P_b, the well must be shut down.

Finally, a gas separator is not required because you want to see when PIP is less than P_b. You want to see the gas as best as you can to know that you have fallen below P_b.

Appendix A: Expanded IO

Appendix Overview

The LWM 2.0 Expanded IO (EIO) option provides the capability to connect up to three additional Mark VIe UCPA controller modules to the existing well controller in an LWM 2.0 unit. These additional UCPA modules are referred to as the EIO modules.

Each additional EIO module adds the following IO points to the LWM 2.0 unit:

- Eight digital inputs and outputs
- Eight analog inputs
- Two analog outputs
- Two triggered digital inputs

This appendix discusses configuration procedures and available status information for the Expanded IO (EIO) option.

Expanded I/O Configuration

There are additional configuration screens available for expanded input and output programming. These additional screens can be accessed from the standard well controller configuration screens.

From the Setup menu screen, press the **General I/O** button to display the General Input/Output Configuration menu screen shown below.

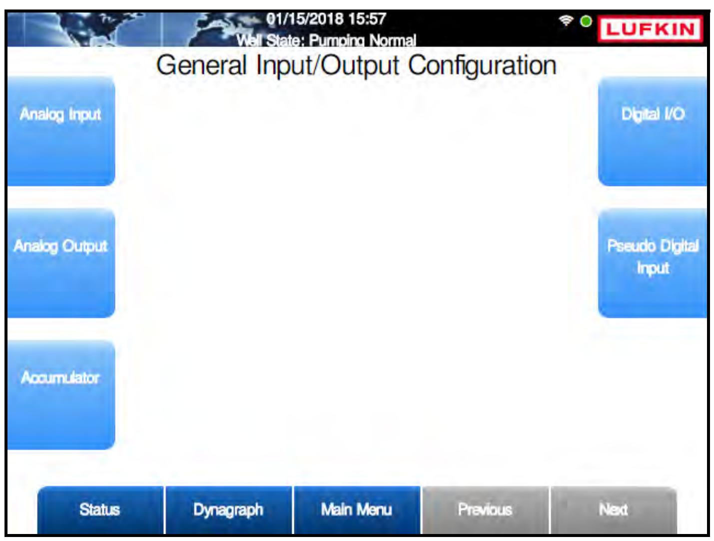

Figure A-1. General I/O Menu Screen

The expanded input and output configuration screens and their functions are discussed on the following pages.

Expansion Board Analog Input Configuration

From the General Input/Output Configuration menu screen, press the **Analog Input** button to display the Analog Input Configuration screen shown in Figure A-2.

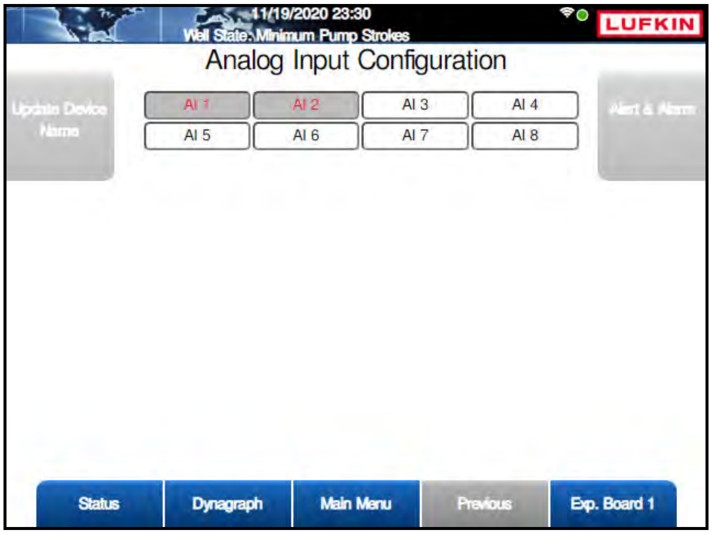

Figure A-2. Analog Input Configuration Screen with EIO

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the screen shown in Figure A-3 below.

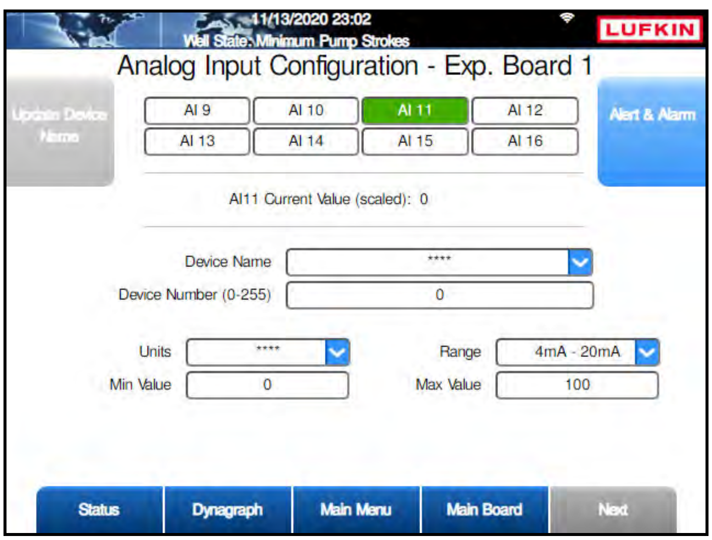

Figure A-3. Expansion Board Analog Input Configuration Screen

Use the arrow keys to highlight the analog input point to be configured and then press <**ENTER**>. Status information and available parameters are then displayed as shown above.

The **Current Value** field indicates the present scaled value of the highlighted input.

The parameters on this screen are identical to those on the main well controller's configuration screen. (Refer to "Analog Input Configuration" on page 8-43 for details on configuring analog input points.) Each point is configurable using the fields at the bottom of the screen. Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter.

Press or click the **Alert & Alarm** button to display the alert and alarm configuration options for the highlighted analog input point. These options are displayed in Figure A-4 below:

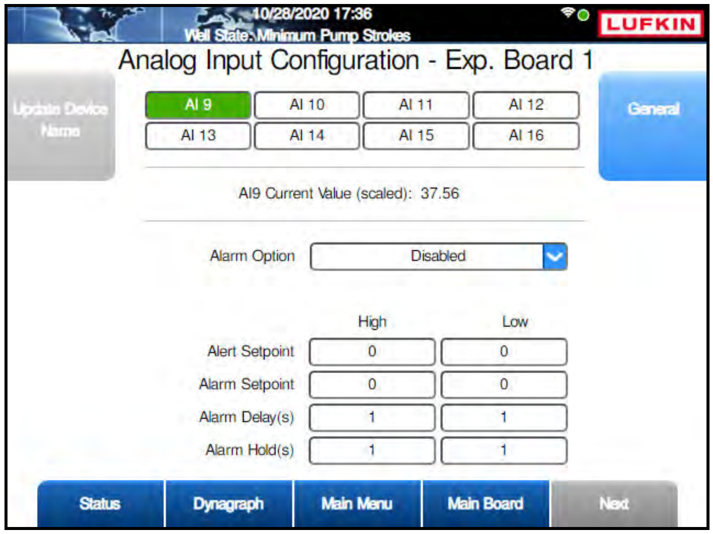

Figure A-4. Expansion Board Analog Input Alert And Alarm Configuration

Refer to “Analog Input Configuration” on page 8-43 for details on configuring alerts and alarms for analog input points.

Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Use the keypad to change numeric values and then press <**ENTER**> again.

Press or click the **Save** button to save all changes.

Press or click the **General** button to display the device general parameters.

Press the **Main Board** button to return to the main well controller analog input configuration screen.

Press <**ESC**> to return to the General Input/Output Configuration menu screen.

Expansion Board Analog Output Configuration

From the General Input/Output Configuration menu screen, press the **Analog Output** button to display the Analog Output Configuration screen shown in Figure A-5.

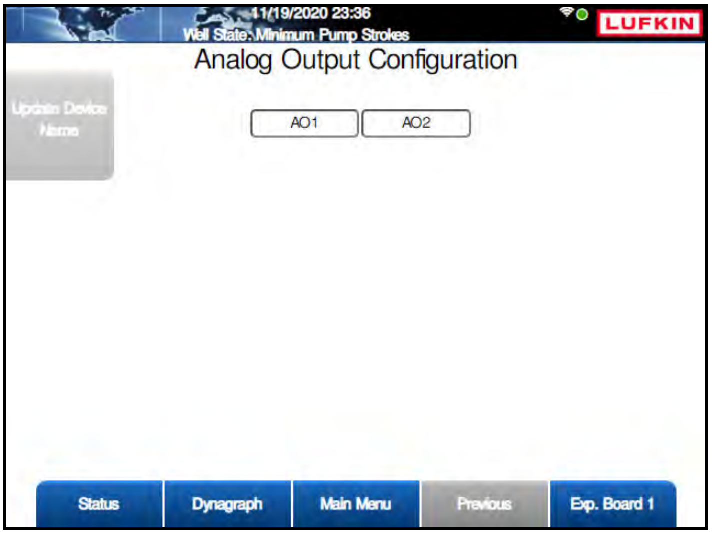

Figure A-5. Analog Output Configuration Screen with EIO

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the screen shown in Figure A-6 below.

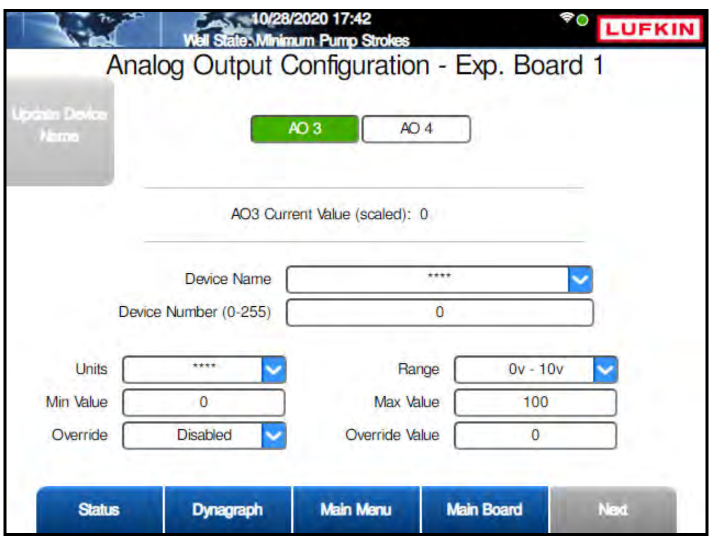

Figure A-6. Expansion Board Analog Output Configuration Screen

Use the arrow keys to highlight the analog output point to be configured and then press <**ENTER**>. Status information and available parameters are then displayed as shown above.

The **Current Value** field indicates the present scaled value of the highlighted output.

The parameters on this screen are identical to those on the main well controller's configuration screen. (Refer to "Analog Output Configuration" on page 8-45 for details on configuring analog output points.) Each point is configurable using the fields at the bottom of the screen.

Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Use the keypad to change numeric values and then press <**ENTER**> again.

Press the **Main Board** button to return to the main well controller analog output configuration screen.

Press <**ESC**> to return to the General Input/Output Configuration menu screen.

Expansion Board Digital Configuration

From the General Input/Output Configuration menu screen, press the **Digital I/O** button to display the Digital Configuration screen shown in Figure A-7 below.

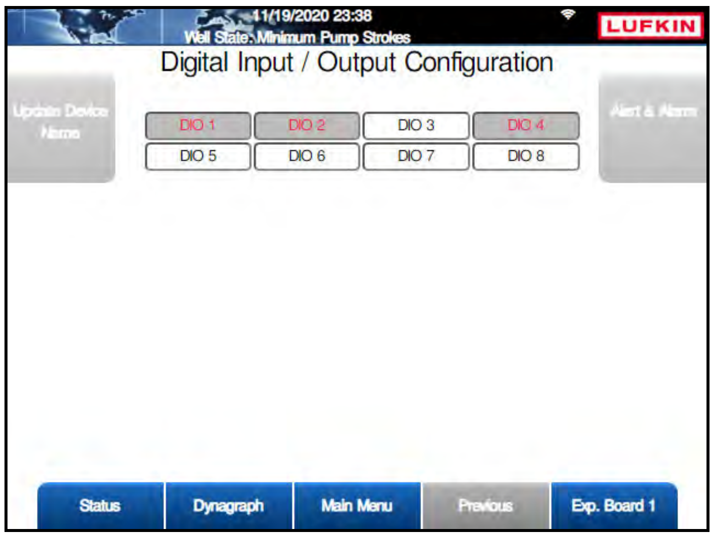

Figure A-7. Digital Input/Output Configuration Screen with EIO

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the screen shown in Figure A-8 below.

Figure A-8. Expansion Board Digital Input/Output Configuration Screen

Use the arrow keys to highlight the digital input or output point to be configured. Status information and available parameters are then displayed as shown in Figure A-8.

The **Current Value** field indicates the present scaled value of the highlighted point.

The parameters on this screen are identical to those on the main well controller's configuration screen. (Refer to "Digital Configuration" on page 8-47 for details on configuring digital input and output points.) Each point is configurable using the fields at the bottom of the screen.

Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Use the keypad to change numeric values and then press <**ENTER**> again.

When the selected point is an input, there are additional options for configuring alerts and alarms for that input point. Press or click the **Alert & Alarm** button to display the alert and alarm configuration options displayed in Figure A-9 below.

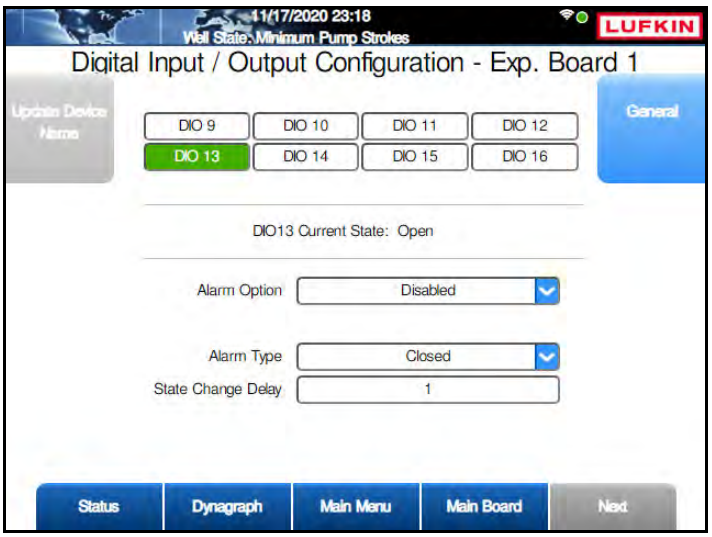

Figure A-9. Expansion Board Digital Input Alert And Alarm Configuration

Refer to "Digital Configuration" on page 8-47 for details on configuring alerts and alarms for digital input points.

Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Use the keypad to change numeric values and then press <**ENTER**> again.

Press or click the **Save** button to save all changes.

Press or click the **General** button to display the device general parameters.

Press the **Main Board** button to return to the main well controller digital input/output configuration screen.

Press <**ESC**> to return to the General Input/Output Configuration menu screen.

Expansion Board Accumulator Configuration

From the General Input/Output Configuration menu screen, press the **Accumulator** button to display the Accumulator Configuration screen shown in Figure A-10.

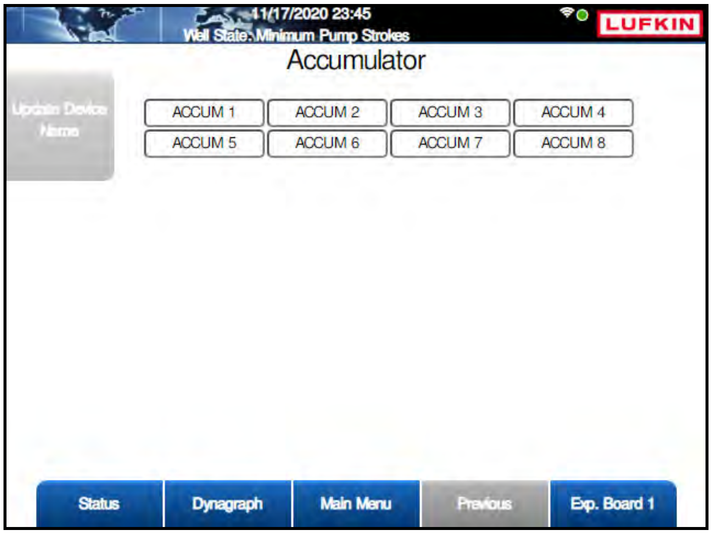

Figure A-10. Accumulator Configuration Screen with EIO

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the expansion board accumulator screen shown in Figure A-11 below.

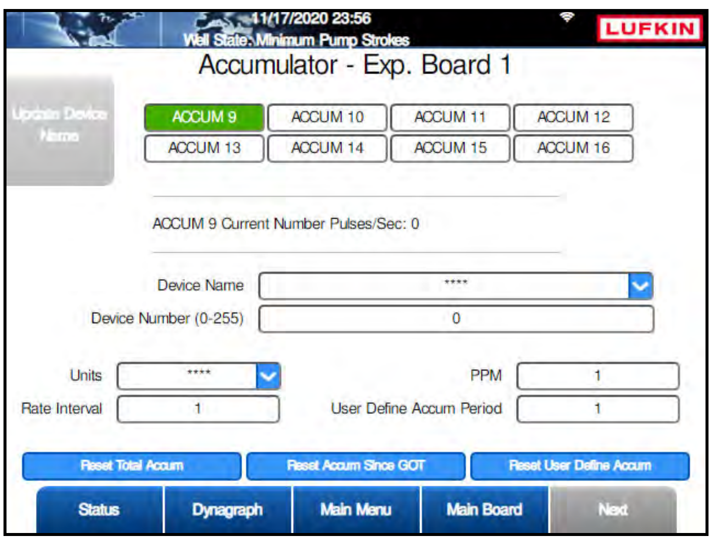

Figure A-11. Expansion Board Accumulator Configuration Screen

Use the arrow keys to highlight the accumulator input point to be configured and then press <**ENTER**>. Status information and available parameters are then displayed as shown above.

The **Current Number Pulses/Sec** status field indicates the present value of the highlighted input.

The parameters on this screen are identical to those on the main well controller's configuration screen. (Refer to "Accumulator Configuration" on page 8-49 for details on configuring accumulator input points.) Each point is configurable using the fields at the bottom of the screen.

Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Use the keypad to change numeric values and then press <**ENTER**> again.

Press the **Main Board** button to return to the main well controller accumulator configuration screen.

Press <**ESC**> to return to the General I/O menu screen.

Expansion Board Pseudo Digital Input Configuration

From the General Input/Output Configuration menu screen, press the **Pseudo Digital Input** button to display the Pseudo Digital Input Configuration screen shown in Figure A-12.

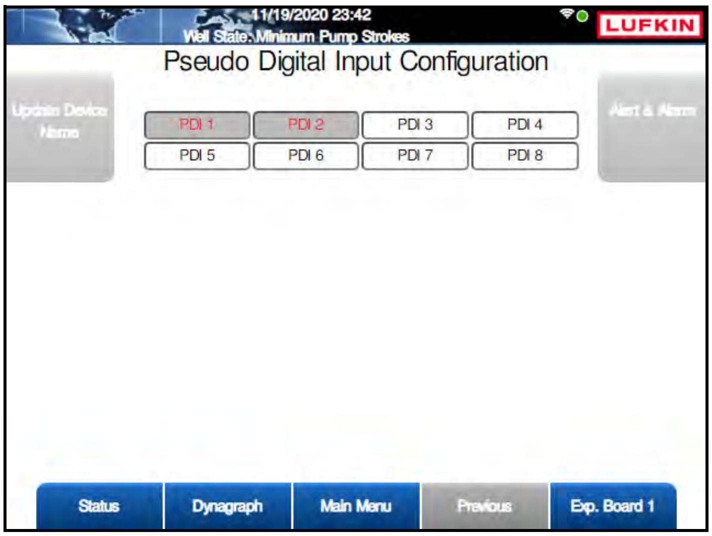

Figure A-12. Pseudo Digital Input Configuration Screen with EIO

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the screen shown in Figure A-13 below.

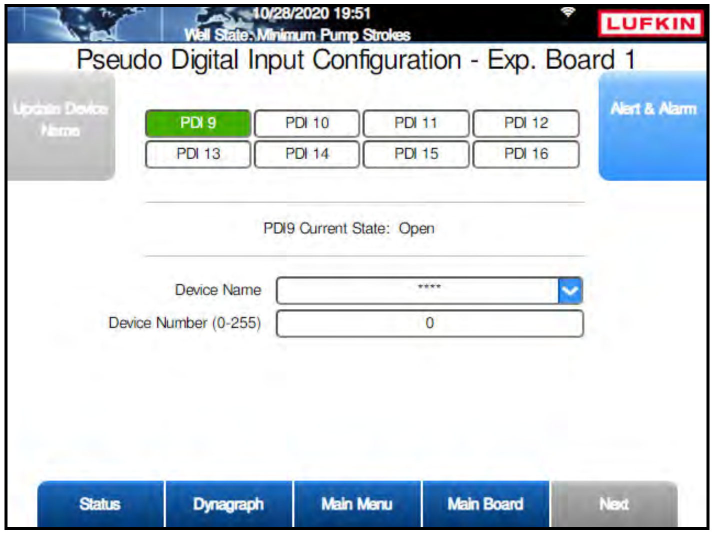

Figure A-13. Expansion Board Pseudo Digital Input/Output Configuration Screen

Use the arrow keys to highlight the pseudo digital input or output point to be configured. Status information and available parameters are then displayed as shown above.

The **Current Value** field indicates the present scaled value of the highlighted point.

The parameters on this screen are identical to those on the main well controller's configuration screen. (Refer to "Pseudo Digital Input Configuration" on page 8-51 for details on configuring pseudo digital input and output points.) Each point is configurable using the fields at the bottom of the screen.

Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Use the keypad to change numeric values and then press <**ENTER**> again.

When the selected point is an input, there are additional options for configuring alerts and alarms for that input point. Press or click the **Alert & Alarm** button to display the alert and alarm configuration options displayed in Figure A-9 below.

Figure A-14. Expansion Board Pseudo Digital Input Alert And Alarm Configuration

Refer to “Pseudo Digital Input Configuration” on page 8-51 for details on configuring alerts and alarms for digital input points.

Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Use the keypad to change numeric values and then press <**ENTER**> again.

Press or click the **Save** button to save all changes.

Press or click the **General** button to display the device general parameters.

Press the **Main Board** button to return to the main well controller pseudo digital input configuration screen.

Press <**ESC**> to return to the General Input/Output Configuration menu screen.

Expansion Board Pulse Configuration

From the General Input/Output Configuration menu screen, press the **Pulse** button to display the Pulse configuration screen shown in Figure A-15 below.

Figure A-15. Pulse Configuration Screen

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the expansion board accumulator screen shown in Figure A-11 below.

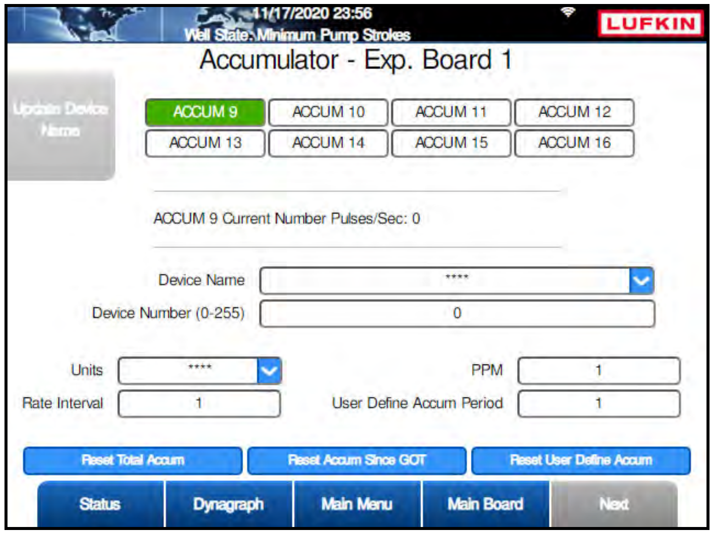

Figure A-16. Expansion Board Accumulator Configuration Parameters

Use the arrow keys to highlight the pulse input point to be configured and then press <**ENTER**> to display status information and available parameters for that point.

The **Current Number Pulses/Sec** status field indicates the present value of the highlighted input.

The parameters on this screen are identical to those on the main well controller's configuration screen. (Refer to "Pulse Configuration" on page 8-53 for details on configuring pulse input points.) Each point is configurable using the fields at the bottom of the screen.

Use the arrow keys to highlight the desired parameter and then press <**ENTER**> to edit the parameter. Use the keypad to change numeric values and then press <**ENTER**> again.

Press the **Main Board** button to return to the main well controller accumulator configuration screen.

Press <**ESC**> to return to the General I/O menu screen.

Press or click the **Save** button to save all changes.

Press <**ESC**> to return to the General I/O menu screen.

Expansion Board Input/Output Status

Press the **Hardware I/O Status** button to display the Hardware Input/Output Status menu screen shown in Figure A-17.

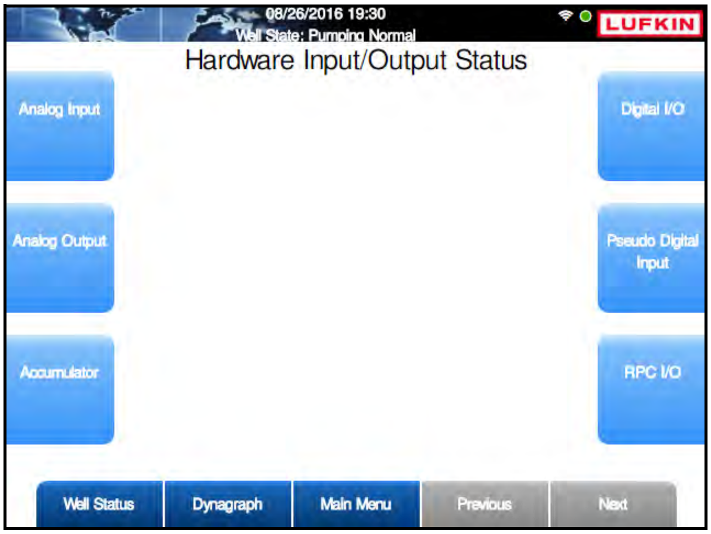

Figure A-17. Hardware Input/Output Status Menu Screen

There are additional status screens available for expanded input and output status data. These additional screens can be accessed from the standard well controller status screens.

The expanded input and output status screens are discussed on the following pages.

Expansion Board Analog Input Status

From the Hardware Input/Output Status menu screen, press the **Analog Input** button to display the Analog Input Status screen shown in Figure A-18.

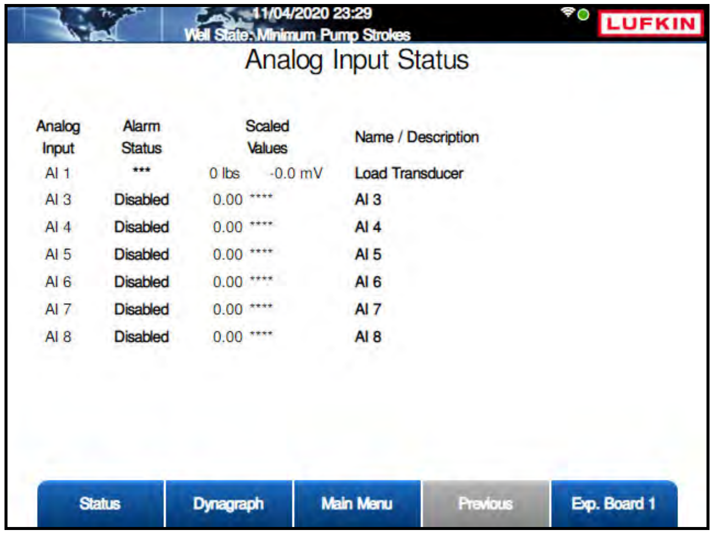

Figure A-18. Analog Input Status Screen

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the expansion board analog input status screen shown in Figure A-19 below.

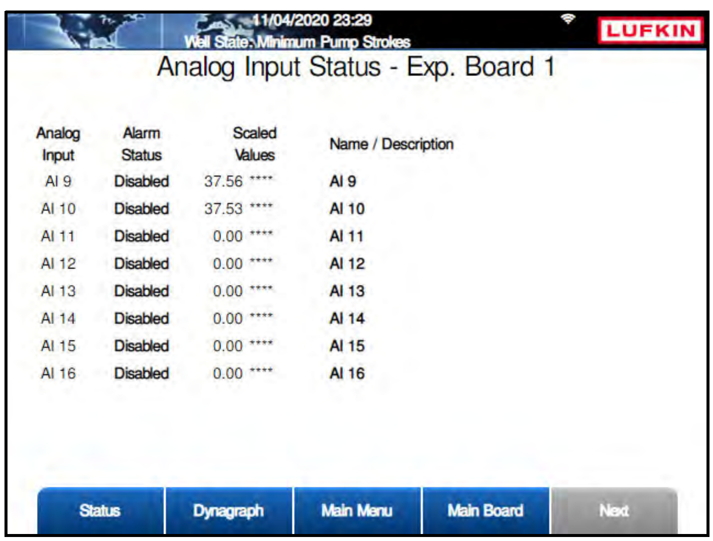

Figure A-19. Expansion Board Analog Input Status Screen

This screen displays status information for the expansion board's analog inputs. These inputs are configured using the Analog Input Configuration – Exp. Board 1 screen. For information about this screen, see "Expansion Board Analog Input Configuration" on page A-4.

Information about each data field is provided below:

- **Analog Input**: States the analog input channel number.

- **Alarm Status**: States whether an alarm is enabled or disabled for the channel.
- **Scaled Value**s: States the present value of the analog input in engineering units.
- **Name/Description**: States either the programmed virtual analog input number or the function description.

Press the **Main Board** button to return to the main well controller analog input status screen.

Press <**ESC**> to return to the Hardware Status screen.

Expansion Board Analog Output Status

From the Hardware Input/Output Status menu screen, press the **Analog Output** button to display the Analog Output Status screen shown in Figure A-20.

Figure A-20. Analog Output Status Screen

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the expansion board analog output status screen shown in Figure A-21.

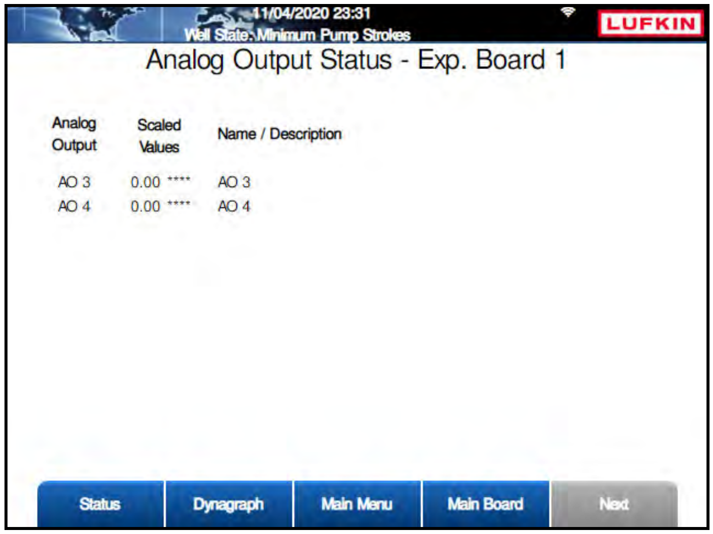

Figure A-21. Expansion Board Analog Output Status Screen

This screen displays status information for the expansion board's analog outputs. These outputs are configured using the Analog Output Configuration – Exp. Board 1 screen. For information about this screen, see "Expansion Board Analog Output Configuration" on page A-6.

Information about each data field is provided below:

- **Analog Output**: States the location of the output channel on the controller module. (See "Controller Module" on page 2-19 for more information.)
- **Scaled Values**: States the present value of the analog output in engineering units.
- **Name/Description**: States either the programmed virtual analog output number or the function description.

Press the **Main Board** button to return to the main well controller analog output status screen.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

Expansion Board Accumulator Status

Press the **Accumulator** button to display the Accumulator Status screen shown in Figure A-22.

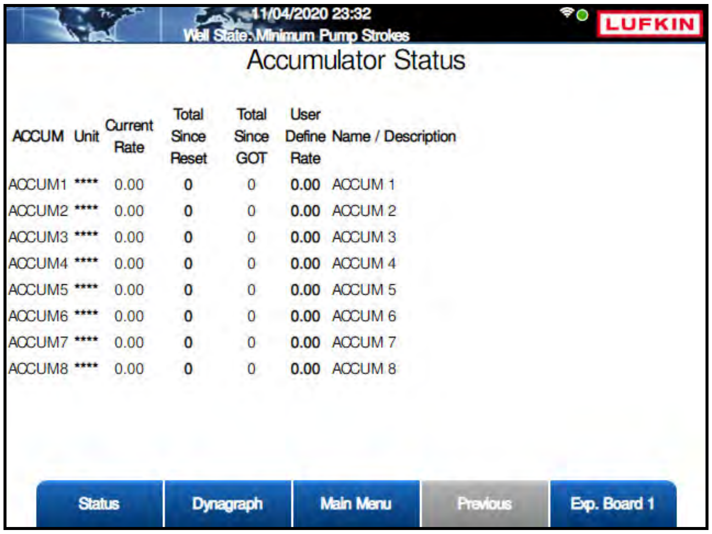

Figure A-22. Accumulator Status Screen

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the expansion board accumulator status screen shown in Figure A-23 below.

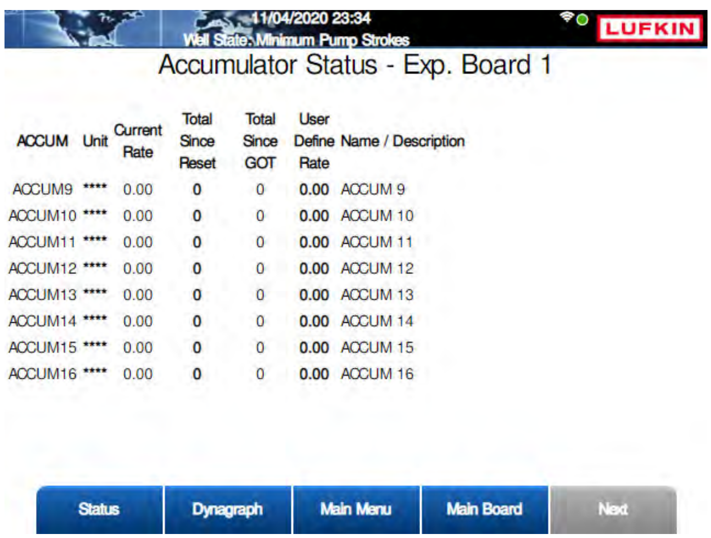

Figure A-23. Expansion Board Accumulator Status Screen

This screen displays status information for the expansion board's accumulator inputs. These inputs are configured using the Accumulator Configuration – Exp. Board 1 screen. For information about this screen, see "Expansion Board Accumulator Configuration" on page A-9.

The data fields are described below:

- **ACCUM:** States the location of the accumulator input channel on the expansion board. (See "Mark* VIe Controller Module" on page 1-16 for more information.)

- **Unit**: States the unit of measurement to be associated with each accumulator input.
- **Current Rate**: States the current recorded pulse rate for each input.
- **Total Since Reset**: States the total accumulation value since the last reset was performed.
- **Total Since GOT**: States the total accumulation value since the controller last updated the 60-day historical data buffers.
- **User Define Period**: States the user-defined number of days for the total accumulation value.
- **Name/Description**: Displays the programmed accumulator input name.

Press the **Main Board** button to return to the main well controller accumulator status screen.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

Expansion Board Digital Input/Output Status

Press the **Digital I/O** button to display the Digital Input/Output Status screen shown in Figure A-24.

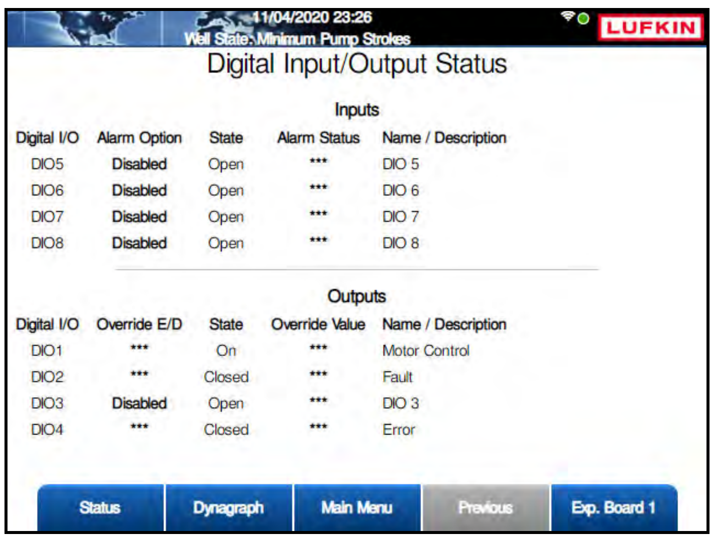

Figure A-24. Digital Input/Output Status Screen

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the expansion board digital input/output status screen shown in Figure A-23 below.

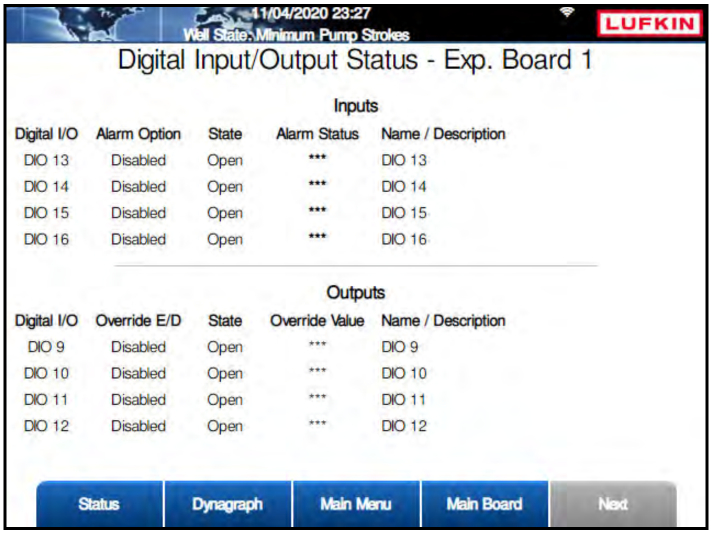

Figure A-25. Expansion Board Digital Input/Output Status Screen

This screen displays status information for the expansion board's digital inputs and outputs. These inputs and outputs are configured using the Digital Input/Output Configuration – Exp. Board 1 screen. (See "Expansion Board Digital Configuration" on page A-7 for details on that screen.)

The status information is grouped into input and output sections.

The input status information lists the following fields:

- **Digital I/O**: States the programmed virtual digital input number.
- **Alarm Option**: Indicates whether the alarm state is enabled or disabled for that channel.
- **State**: Indicates an open or closed state.
- **Alarm Status**: Indicates the current alarm status for that channel.
- **Name/Description**: States the location of the digital input point on the expansion board.

The output status information lists the following fields:

- **Digital I/O**: States the programmed virtual digital output number.
- **Override E/D**: Indicates whether the override function is enabled or disabled for that point.
- **State**: Indicates an open or closed state.
- **Override Value**: Indicates the current override status for that point.
- **Name/Description**: States the location of the digital output point on the expansion board.

Press the **Main Board** button to return to the main well controller digital input/output status screen.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

Expansion Board Pseudo Digital Input Status

Press the **Pseudo Digital Input** button to display the Pseudo Digital Input Status screen shown in Figure A-26.

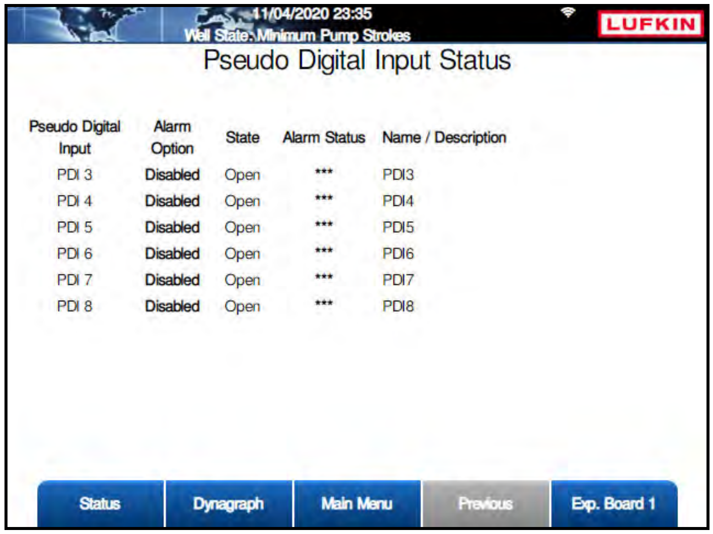

Figure A-26. Pseudo Digital Input Status Screen

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the expansion board digital input/output status screen shown in Figure A-23 below.

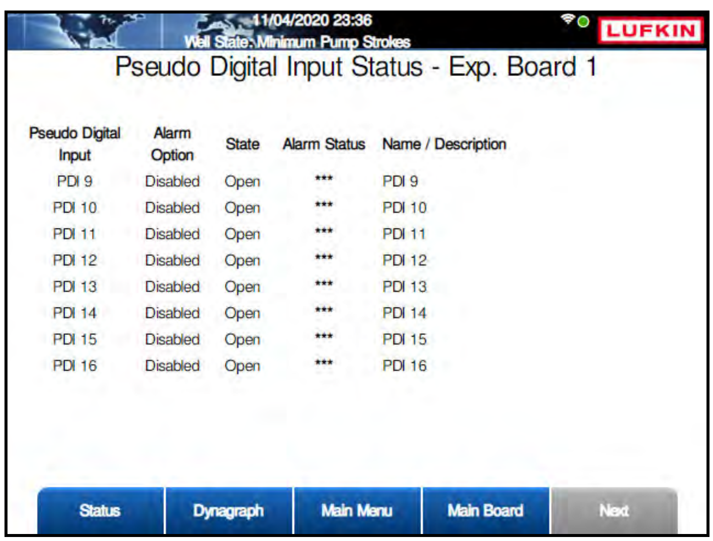

Figure A-27.

This screen displays status information for the expansion board's pseudo digital inputs. The following information is provided:

- **Pseudo Digital Input**: States the programmed pseudo digital input number.
- **Alarm Option**: Indicates whether the alarm state is enabled or disabled for that input point.
- **State**: Indicates an open or closed state.

- **Alarm Status**: Indicates the current alarm status for that input point.
- **Name/Description**: States the location of the pseudo digital (analog) input point on the expansion board.

Press the **Main Board** button to return to the main well controller pseudo digital input status screen.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

Expansion Board Pulse Status

From the second Hardware Input/Output Status menu screen, press the **Pulse** button to display the Pulse Status screen shown in Figure A-28.

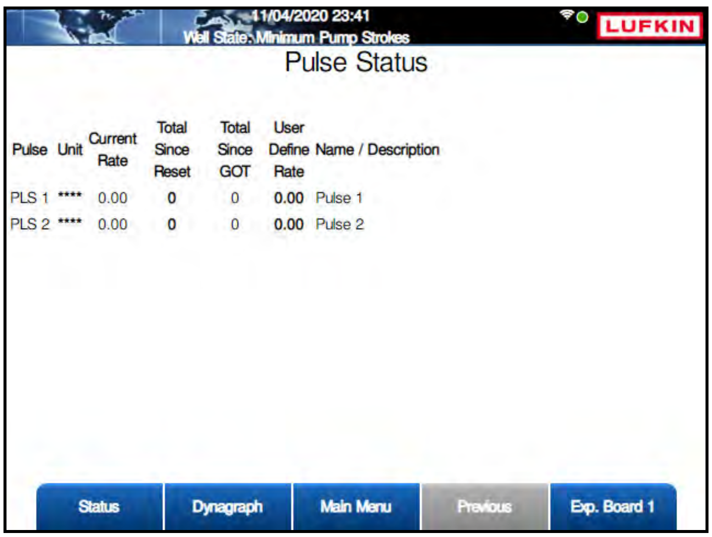

Figure A-28. Pulse Status Screen

When the EIO option is enabled, the **Expansion Board 1** button is visible in the bottom right corner of this screen. Press this button to display the expansion board pulse status screen shown in Figure A-19 below.

Figure A-29. Expansion Board Accumulator Status Screen

This screen displays status information for the expansion board's pulse inputs. These inputs are configured using the Pulse Configuration – Exp. Board 1 screen. For information about this screen, see "Expansion Board Pulse Configuration" on page A-12.

The data fields on this screen are described below:

- **Pulse:** States the location of the pulse input channel on the expansion board. (See "Mark* VIe Controller Module" on page 1-16 for more information.)
- **Unit**: States the unit of measurement to be associated with each accumulator input.
- **Current Rate**: States the current recorded pulse rate for each input.
- **Total Since Reset**: States the total pulse accumulation value since the last reset was performed.
- **Total Since GOT**: States the total pulse accumulation value since the controller last updated the 60-day historical data buffers.
- **User Define Period**: States the user-defined number of days for the total pulse accumulation value.
- **Name/Description**: Displays the programmed pulse input name.

Press the **Main Board** button to return to the main well controller pulse status screen.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

Expansion Board Health Status

From the second Hardware Input/Output Status menu screen, press the **EIO Health Status** button to display the Expansion I/O Board Health Status screen shown in Figure A-30.

Figure A-30. Expansion I/O Board Health Status Screen

This screen displays the connected state of the expansion I/O board. One of two messages is displayed:

- **Yes** indicates the EIO module is connected.
- **No** indicates the EIO module is disconnected. In this case, check the Ethernet cable between the EIO module and the network switch.

Press <**ESC**> to return to the Hardware Input/Output Status menu screen.

Historical Data

The main well controller maintains records for all configured auxiliary inputs. When the EIO feature is enabled, data is also recorded from the expansion board's auxiliary inputs. This data is displayed on the Auxiliary Function historical status screens.

Refer to "Auxiliary Function Data" on page 11-18 for details on viewing this data.

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