Lufkin Well Manager™
Rod Pump Control

User Manual

True Wellhead Manager
Lufkin Well Test
Downhole Pump Card

LUFKIN
AUTOMATION

Lufkin Automation
811 Willow Oak Drive
Missouri City, Texas 77489
Tel: 281.495.1100 Fax: 281.495.6333
www.lufkinautomation.com

Lufkin Well Manager™ Rod Pump Control

User Manual

INSTRUCTIONS FOR

INSTALLATION AND OPERATION OF THE

LUFKIN WELL MANAGER ROD PUMP

CONTROL AND ANALYSIS SYSTEM

LUFKIN
AUTOMATION

Lufkin Automation
811 Willow Oak Drive
Missouri City, Texas 77489
Tel: 281.495.1100 Fax: 281.495.6333
www.lufkinautomation.com

Revision Record

Lufkin Well Manager™ — Rod Pump Control User Manual

Date	Revision No.	Section	Description
3/1/11	3.00	All sections	First release.

Part No. 099.5000

Limited Warranty

Lufkin Automation warrants the Product it manufactures, including all parts and components thereof to be free from defects in material and workmanship. Lufkin Automation will, at its option, either repair or replace such a Product, subject to the conditions of this Limited Warranty. This Limited Warranty commences on the date of shipment of the Product and shall remain in effect for a period of one year except for shop repairs and service repair exchange (SRE) items, which carry a 90-day warranty.

This Limited Warranty does not apply if failure is caused or contributed by any of the following: (1) improper handing, storage or installation (2) abuse, (3) unsuitable application of the product, (4) lack of reasonable and necessary maintenance, (5) repairs made or attempted by other than Lufkin Automation, (6) neglect or accident, (7) damage by wind, freezing, lightning, Act of God or other cause or (8) damage in transit or during installation. This Limited Warranty applies only to Products that have been installed and maintained in strict accordance with the Lufkin Automation installation procedure and to Products that have been connected to the supply voltage marked on the Product. The Limited Warranty does not apply to any Product on which the serial number has been altered, effaced or removed.

IMPLIED WARRANTIES, WHEN APPLICABLE, SHALL COMMENCE UPON THE SAME DATE AS THE EXPRESS WARRANTY PROVIDED ABOVE, AND SHALL EXTEND ONLY FOR THE DURATION OF THE EXPRESS WARRANTY. SOME STATES DO NOT ALLOW LIMITATION ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATIONS MAY NOT APPLY TO YOU. THE ONLY REMEDY PROVIDED TO YOU UNDER AN APPLICABLE IMPLIED WARRANTY AND THE EXPRESS WARRANTY SHALL BE THE REMEDY PROVIDED UNDER THE EXPRESS WARRANTY, SUBJECT TO THE TERMS AND CONDITIONS CONTAINED THEREIN, LUFKIN AUTOMATION SHALL NOT BE LIABLE FOR INCIDENTAL AND CONSEQUENTIAL LOSS AND DAMAGES UNDER THE EXPRESS WARRANTY AND APPLICABLE IMPLIED WARRANTY, OR CLAIMS FOR NEGLIEGENCE, EXCEPT TO THE EXTENT THAT THIS LIMITATION IS FOUND TO BE UNENFORCEABLE UNDER APPLICABLE STATE LAW. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES SO THE ABOVE LIMITATION OR EXCLUSION MAY NOT APPLY TO YOU.

Lufkin Automation will repair or replace, at its option, any Product which is found to be defective in material or workmanship. The Limited Warranty does not cover the labor costs of repair or replacement of the unit or part unless done at our factory. If you elect to ship the part or Product to Lufkin Automation, authorization to return the Product to the factory must first be obtained from Lufkin Automation and shipping instructions received from Lufkin Automation must be followed. Lufkin Automation is not responsible for the cost of removal of the Product or its components, damage due to removal or any other expenses incurred in shipping the Product or parts to or from the factory or for the installation of the repaired or replacement unit. The owner must bear these expenses and should insure the shipment against loss or damage in transit.

This Limited Warranty gives the owner specific legal rights and the owner may also have other rights, which vary from State to State. Lufkin Automation does not authorize any person to create for it, any other obligations of liability in connection with its Product.

Safety Procedures

- Park vehicles upwind of the wellhead. Stand upwind when installing or dismantling equipment.

WARNING: Injection fluid lines operate at high pressure. If breaking loose flange connections or opening valves, use all proper energy isolation procedures and wear proper personal protection equipment.

WARNING: Hydrogen sulfide gas (H_2S) may be present in high concentrations in injection fluids and around injection wellheads. Be sure to have proper H_2S detection equipment on your person and practice all recommended safety precautions when working around injection wellheads.

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

Table of Contents

Section 3: Technical Specifications

Section 4: Parts Lists

Section 5: Hardware Configuration

Section 6: Installing the System

Section 7: Wiring the System

Section 8: RPC Parameter Programming

Section 9: Lufkin Parameter Programming

Section 10: Status Screens

Section 11: Historical Data

Section 12: Dynagraph Cards

Section 13: System Starting and Stopping

Section 14: Reset Malfunctions

Section 15: Notepad

Section 16: Alarm Clearing

Section 17:System Diagnostics Tools

Section 18: Quick-Start Feature

Section 19: LWM Flash Upgrade Utility Software

Section 20: Troubleshooting

Appendix A: Auto Downtime Feature

Appendix B: Valve Checks, Counter Balance Effect, and Residual Friction

Appendix C: Well State List

Appendix D: AGA-3 and NX-19 Definitions

Appendix E: Pump Intake Pressure and Lufkin Well Test Theory

Appendix F: Linear Pumping Unit Application

Appendix G: IEC Compliance Statements

Index

Section 1

Introduction to this Manual

This section explains the topics covered in this manual and how to use this manual.

The topics covered in this section include:

The Lufkin Automation Lufkin Well Manager™ for Rod Pump Control (RPC) can perform a wide range of operations. Every attempt is made to provide enough information and explain each procedure clearly so that you can easily and quickly learn how to operate this controller. Please take the time to understand how this manual is organized, and how to use this manual before reading how to install and operate the controller.

1.1 Manual Overview

The *Lufkin Well Manager™ — Rod Pump Control User Manual* is designed to provide you with information about the Lufkin Well Manager RPC hardware specifications, installation procedures, and system operations. All information in this manual falls into three categories.

Category One introduces you to this manual and to the Lufkin Well Manager RPC. A breakdown of the topics covered is:

- Typographical conventions used
- How to obtain technical support when needed
- Description of Lufkin Well Manager RPC system
- Description of the Lufkin Well Manager RPC system components
- Technical specifications
- Parts lists

Category Two explains how to install the Lufkin Well Manager RPC and its components, how to program the Lufkin Well Manager RPC, and how to use the Lufkin Well Manager RPC analysis capabilities. A breakdown of the topics covered is:

- Installing and Wiring the Lufkin Well Manager RPC system
- Programming and operating the Lufkin Well Manager RPC

Category Three provides you with an index for quick and easy access to specific information you need.

Other hardware and software components may be used in conjunction with the Lufkin Well Manager RPC. Refer to the components' respective manuals for specific information about these products.

1.2 How to Use this Manual

This section explains the typographical conventions used throughout this manual. Typographical conventions are used to represent keyboard functions and to highlight important operations.

1.2.1 Entering Data and Executing Commands

All keys used to execute commands are presented in bold type, preceded by the word "press", and are surrounded with the less-than symbol (<) and the greater-than symbol (>). For example, if you are instructed to press the ENTER key, it is explained to you as:

Press **<ENTER>**.

1.2.2 Displayed Messages

All messages that are displayed on the optional LED graphics display are represented in bold, uppercase type:

ALARM ALERT

1.2.3 Section Levels

Each chapter has up to three section levels. The three section level headings are presented as:

X.X First Level

X.X.X Second Level

Third Level

1.2.4 Procedural Steps

A procedure that must be followed in a specific order is numbered similar to the following:

1. Perform step one first.

2. Perform step two second.

3. Perform step three third.

1.2.5 Shorthand Method for Interface Menu Selection

A shorthand access method for selecting menu options using the Lufkin Well Manager RPC interface is provided throughout this manual to quickly explain the procedure required to get to your desired operation.

To the right of many paragraphs, you will find a box displaying "MENU" (shorthand access method) and below it numbers separated with a forward slash (/). For example, the box to the right of this paragraph represents the following:

MENU
2/1/4

1. From the **MAIN Menu** screen, select option **2. PROGRAM**.

2. From the **Programming Menu** screen, select option **1. RPC APPLICATION**.

3. From the **RPC Parameters Menu** screen, select option **4 PUMPING UNIT PARAMETERS**.

1.2.6 Notes

Notes draw your attention to important messages within this manual. For example:

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

1.3 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 Time. You can also e-mail us at lufkinautomationsupport@lufkin.com.

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

Description of the Lufkin Rod Pump Controller System

This section describes the major components making up the Lufkin Well Manager rod pump controller (RPC) control and analysis system. A basic description about the control capabilities is described in “Control Capabilities of the Lufkin Well Manager RPC” on page 2-7.

The topics covered in this section include:

Note: Technical specifications for the Lufkin Well Manager RPC and the transducers that can be used with it are provided in section 3, "Technical Specifications."

2.1 Lufkin Well Manager RPC

The Lufkin Well Manager RPC 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. The Lufkin Well Manager RPC 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.

The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC 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.

2.1.1 Motor Control Relay

The motor control output from the Lufkin Well Manager RPC is a semiconductor switch that sinks a DC control current. An interposing relay is required for the interface with the motor control panel. Many control relay options are available. Two of the commonly used relay options are:

- Solid-state relay (Part No. 179.3000) that has an input voltage of nominal 12 VDC and an optically isolated solid-state output switch with a rating of 50 Amps at 660 VAC. The output switch is a thyristor type that opens on the next zero crossing of the AC waveform after removal of input excitation.

- Electro-mechanical “ice cube” relay kit (Part No. 530.4670) with transient suppression diode and mounting socket that works well in applications interfacing with PLC or other “smart” motor starters/controls. Contacts are rated for 12 Amps at 240 VAC maximum.

2.1.2 Communication Protocol

The Lufkin Well Manager 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.

2.1.3 Common Hardware Platform

The Lufkin Well Manager RPC operates on the Lufkin Automation LWM hardware platform. Using this common platform reduces the number of spare parts that must be kept on hand, simplifies training, and provides you with a single source for rod pump, injection well, and progressing cavity pump automation.

2.2 12 Volt Power Supplies

The standard Lufkin Well Manager RPC system is powered by 85 to 264 VAC, 50/60 Hz primary power.

A 12-VDC power supply is included to provide the DC voltage required by the electronics.

2.3 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. The field leads do not require crimp lugs.

2.4 Analog and Digital Transducers

A load input device (transducer), such as the 101TL beam mounted transducer or the polished rod load cell (PRLC), is used with the Lufkin Well Manager RPC to measure the polished rod load. A low-level load signal is generated by the load input device and transmitted through a cable to the Lufkin Well Manager RPC. In the Lufkin Well Manager RPC, the load signal is amplified and conditioned for use.

A position input device such as the AT-03 inclinometer generates an analog position signal and transmits it through a cable to the controller. In the controller, the position signal is amplified and conditioned for use.

The 101TL combo load/position transducer is a single-unit transducer that generates both a load and analog position signal through a cable to the Lufkin Well Manager RPC.

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

2.4.1 Most-Common Transducer Combinations

The Lufkin Well Manager RPC is designed to work with input signals for polished rod load and surface stroke position. A number of transducer combinations are available to provide both signals. The two most common combinations are described below, although local conditions may dictate that some other combination is best for a particular application.

PRLC and Hall-Effect Transducers

The PRLC 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.

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.

Two Hall-Effect transducers are used. 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 Lufkin Well Manager RPC 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.

101TL and Inclinometer Transducers

The 101TL beam transducer and inclinometer are the preferred combination method for simple well control when accurate pump card analysis is not required. They are easy to install and have lower ongoing maintenance requirements.

The 101TL provides a qualitative measurement of load on the rod string as reflected in strain of the top flange of the walking beam. Models are available for either weld-on or clamp-on installation. The weld-on method is preferred for permanent installations. Its advantages are that it has a small, easily protected, working loop for the signal cable and it is located on top of the beam away from service crew activity. The disadvantages are that it needs to be field-calibrated during installation and it provides a less accurate load signal than a PRLC.

The inclinometer provides an analog position signal directly proportional to the tilt of the walking beam. Inclinometers can be mounted in the wiring junction box of the beam transducer to provide a combination load and position device that can be easily installed. Inclinometers are also available in a separate magnet-mount package. This separate load and position device combination is preferred for Mark II geometry pumping units. Advantages of the inclinometer include easy installation and no pumping unit dimensional data needs to be programmed. The disadvantage is a less accurate dynagraph shape.

2.5 Motor Starter

A motor starter provides power to the pumping unit. When connected to the Lufkin Well Manager RPC, the motor starter can be turned off when pump off is achieved and restarted after downtime expires.

2.6 Telemetry System

Most Lufkin Well Manager RPCs are configured with a telemetry system to provide a data link between the Lufkin Well Manager RPC and a host computer. Several types of telemetry systems are available.

- VHF, UHF, or microwave radio system
- Hardwire system
- A combination of both radio and hardwire systems

A telemetry system is not required for rod pump control, but data telemetry is an integral part of many RPC applications. The Lufkin Well Manager RPC provides one communication channel available via two communication (DB-9 or RJ-11) ports.

A DB-9 connector on the Lufkin Well Manager RPC front panel provides serial RS-232 data that can be accessed using a laptop computer installed with Lufkin Automation *Dynalink* software. No special cable is required; a nine-pin male–to–nine-pin female RS-232 cable available at any electronics and/or computer supply store serves the purpose.

A RJ-11 connector is provided to connect to the data telemetry equipment. A signal cable to connect between this RJ-11 socket and the telemetry equipment is required. Power terminals are provided for equipment that operates at 13.8 VDC. Antennas and coaxial cables may also be required and are available. Contact your Lufkin Automation representative for more information.

2.7 Laptop Computer Software

Lufkin Automation offers *Dynalink* as laptop computer software that can read and write all data to the Lufkin Well Manager RPC. *Dynalink* operates in the Windows 95, 98, NT, 2000, or XP environment. Data can be saved from the Lufkin Well Manager RPC and retrieved for later reviewing and/or printing.

2.8 Host Computer

The host (central) computer can be either a PC-compatible desktop or laptop with a hard drive, an asynchronous communication port, and a printer.

2.9 Host Computer Software

SCADA (supervisory control and data acquisition) software can be installed in a desktop “host” computer. The Lufkin Well Manager RPC can be equipped with a radio interface and a radio, hardline wiring, or some other form of telemetry system that allows you to communicate with it. The SCADA performs data communications functions, wellsite polling, automatic data retrieval, trending, and analysis functions. For a complete explanation of the SCADA systems available, contact your Lufkin Automation representative.

2.10 Control Capabilities of the Lufkin Well Manager RPC

Lufkin Automation was formed by the forging together of two companies that pioneered the field of rod pump control: Delta-X and Nabla corporations.

Delta-X was an established leader in the arena of control from surface dynagraph analysis. The patented single setpoint control method was very effective and the large LCD graphics interface was very user friendly.

Nabla had established a reputation in the design and analysis field with *DIAG* and *SROD* software. They introduced the first rod pump control that calculated the downhole pump card at the well site and made control decisions from analysis of that downhole card. Nabla had also developed a control algorithm for using digital signals from the motor shaft and the crank arm that did not require a polished rod load input signal. When instantaneous motor speed is known and a speed/torque curve for the motor is used, the work being done by the motor can be calculated and used as a control decision input. This motor power control concept offers low cost control since a load cell is not required.

The Lufkin Well Manager RPC uses a powerful new hardware platform that combines the strengths of Delta-X and Nabla by implementing the control algorithms developed by both companies. The Lufkin Well Manager RPC combines the proven single setpoint surface control technology of Delta-X, the downhole pump card control expertise of Nabla, and the low cost motor power technology of Nabla. New features made possible by the additional computing power and memory size are added to the Lufkin Well Manager RPC. An overview of the controller’s capabilities is presented below.

2.10.1 Operating Modes

The Lufkin Well Manager RPC has three rod pump control operating modes:

- **Host** — The Lufkin Well Manager RPC starts and stops the pumping unit based on a user command. A minimum control capability for peak and minimum load and for end device–checking is available when in Host mode. 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.

- **Timed** — The Lufkin Well Manager RPC will cycle 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. A minimum control capability for peak and minimum load and for end device–checking is available.

- **Normal** — This mode is “normally” the operating mode of choice, and can include the following features:

  - Primary control functions (page 2-8)
  - Pump off control actions (page 2-9)
  - Load and position options (page 2-10)
  - Malfunction control functions (page 2-10)
  - Peak energy management (page 2-13)
  - Well performance measurements and records (page 2-13)

  All normal operating mode features are described below.

2.10.2 Primary Control Functions

The basic purpose of the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC can use any of the following three 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 Lufkin Well Manager RPC. 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.

- **Motor power** — This method uses Hall-Effect inputs from the motor shaft and crank arm. Motor power control is the least sophisticated of the control methods. It is suitable for stable wellbore conditions typical of mature primary recovery wells with little or no gas. No dynagraph data is available, so analysis capabilities are minimal. This approach is low cost since a load cell is not required. Motor power is a "fallback" control method that the Lufkin Well Manager RPC can return to if the load signal input is lost.

2.10.3 Pump Off Control Actions

When a pumped off condition is detected, the Lufkin Well Manager RPC is capable of either cycling off the well or adjusting a speed control output to a variable speed drive.

- **On/Off Cycle Control** — Setting the proper downtime or idle time is as important as setting the proper pumped off limit. Downtime can be programmed by the operator based on experience or production tests.

The Lufkin Well Manager RPC also offers an *auto downtime* feature to help determine the optimum downtime for a given well. The auto downtime algorithm steps through a series of incrementing downtime steps and records the average pumping time for each step. The resulting "build up" curve is analyzed to find the knee indicating that fluid level in the wellbore is approaching the static level and then an optimum downtime is selected. The auto downtime feature is discussed at length in appendix A, "Auto Downtime."

- **Variable Speed Control** — The Lufkin Well Manager RPC control algorithm adjusts an analog output to maintain a desired pump fill level. The variable speed function is compatible with both the downhole pump card control method and the surface card control method. Optional analog output hardware is required.

2.10.4 Load and Position Input Options

The Lufkin Well Manager RPC is designed to accept load and position inputs from a number of devices as further discussed on page 2-4. Briefly, load input can be from a beam mounted strain gauge device or a polished rod load cell. Position input can be analog from an inclinometer or digital 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. See "Malfunction Control Functions" below.

2.10.5 Malfunction Control Functions

The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC also checks for malfunctioning signal input devices.

The Lufkin Well Manager RPC allows for a programmable number of re-tries when a malfunction event occurs. On the first occurrence, the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC clears the consecutive count and continues with usual operation. If the condition continues for the programmed number of re-tries, the Lufkin Well Manager RPC 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:

- **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.

- **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.

- **Low Fluid Load** — Shuts down the well if the fluid load calculated from the downhole pump card falls below a minimum allowed level for the programmed number of allowed pump off strokes. Fluid load is calculated by subtracting the average downstroke load of the pump card from the average upstroke load of the pump card. Fluid load checking is an alternative method to detect pumping equipment failures, such as rod parts or the traveling valve not closing. This feature also affords high fluid level detection capability since high fluid level in the well bore reduces the amount of fluid load on the pump. Load and position inputs are required. This feature is only available when the Downhole control method is selected.

- **Peak Torque** — Shuts down the well if the calculated maximum torque for a stroke exceeds the allowed limit. The Lufkin Well Manager RPC 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.

- **Loss of RPM Transducer** — Detects the loss of the motor RPM Hall-Effect switch input. Without this input, the Lufkin Well Manager RPC 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.

- **Loss of Crank Arm Transducer** — Detects the loss of the crank arm Hall-Effect switch input. Without this input, the Lufkin Well Manager RPC 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.

- **Low Motor RPM** — The Lufkin Well Manager RPC 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.

- **Belt Slippage Detection** — The Lufkin Well Manager RPC 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.

- **Logic Expression** — The Lufkin Well Manager RPC can monitor wellhead conditions other than load and position. Analog or digital signals from a variety of sensors or transmitters can be used to monitor flow line pressure or temperature, casing pressure, stuffing box leak detector, or level transmitters on a local tank battery, to name a few. A logic expression can be programmed in the Lufkin Well Manager RPC using these inputs to make decisions to start or stop the pumping unit, or to turn on one of the extra digital outputs to start a chemical pump, sound an alarm, etc. For information about the logic expression capabilities, see "Logic Expressions" in section 9, "Lufkin Parameter Programming."

2.10.6 Peak Energy Management

Oil producers may have contracts with their electric power provider to minimize power consumption during peak demand times of the day in return for a more attractive rate. The Lufkin Well Manager RPC has a feature that allows the user to program for shutdown during peak periods. The Peak Energy Management feature allows you to program the desired period of the day and on which days to enable the function. All normal operation is suspended when the Lufkin Well Manager RPC is in a Downtime Peak Energy Management state. Normal operation resumes at the end of the programmed period. For more information about peak energy management, see "Gauge Off Time and Peak Energy Management" in section 8, "RPC Parameter Programming."

The Lufkin Well Manager RPC also can respond to a global shutdown command issued by SCADA software for emergency situations that require the wells to be shut down.

2.10.7 Well Performance Measurements and Records

Lufkin Well Test

The Lufkin Well Manager RPC includes a Lufkin Well Test (LWT) algorithm to calculate the total fluid production of the pumping unit. The algorithm also can shut down the pumping unit once a fluid production "allowable" is reached.

Inferred Production Algorithm (IPA), a "basic" method of fluid production calculation, was included in earlier firmware versions for the Lufkin Well Manager RPC. Lufkin Well Manager RPCs operating with application firmware version 4.66 or higher offer an "advanced" well test algorithm that incorporates the new pump intake pressure (PIP) calculation capabilities. This newer Lufkin Well Test (LWT) fluid production algorithm and the PIP feature are discussed further in appendix E , "Pump Intake Pressure and Lufkin Well Test Theory."

AGA-3 Gas Flow Rate and Volume

Equations to perform American Gas Association (AGA-3) rate and volume calculations are embedded in the Lufkin Well Manager RPC firmware. An orifice plate meter run with a Delta-P transmitter is required to measure pressure drop across the orifice plate. For more accurate results, a line pressure transmitter and a line temperature transmitter can be added. Optional analog input expansion board hardware must be added to the Lufkin Well Manager RPC control. The present flow rate in MCF per day is updated once a second and volume in MCF is accumulated. The AGA-3 feature is discussed in detail in appendix D, "AGA Definitions."

Special firmware is available for the optional input expansion board that can provide audit trail information and calibration features to make the AGA-3 algorithm results suitable for Custody Transfer. For more information about the custody transfer capability, contact your Lufkin Automation representative.

Coil Tracking
The amount of time that the Lufkin Well Manager RPC is in a particular alarm condition can be accumulated. These alarm flags are referred to as “coils.” A record of how many minutes each configured alarm/coil was set for the day is maintained for each of the most-recent 60 days. For more information about coil tracking, contact your Lufkin Automation representative.

Memory Registers
The Lufkin Well Manager RPC has three features that you can use to work with data in memory registers. They provide the ability to configure:

- Eight register alarms based on any of the measured or calculated values in the controller memory files
- Ten historical plots from any physical input or calculated value in the Lufkin Well Manager RPC
- Ten register calculations that are a combination of values from different register logs to obtain new values that can be used for monitoring and creating register alarms

Polished Rod and Pump Horsepower Calculation
Each stroke, the Lufkin Well Manager RPC calculates the polished rod horsepower (PRHP) from the surface card and the pump horsepower from the downhole card. You can enter a reference PRHP immediately after a hot oil treatment. The Lufkin Well Manager RPC stamps that reference entry with the date and time. You can also set a peak PRHP limit. If the calculated PRHP exceeds the set peak limit, an alarm flag is set to alert you that it can be time to treat for paraffin again.

Rodometer and Pumpometer
The Lufkin Well Manager RPC has separate resettable accumulators to keep count of the number of pump cycles for a rod string and a pump. This feature is another tool for monitoring the operation of the pumping equipment.

Last 400 Load Values

The Lufkin Well Manager RPC maintains a buffer for the last 400 load samples prior to the last shutdown decision. Dynagraph buffers are only updated at the end of each stroke. A peak or minimum load violation will cause a shutdown before the completion of the stroke. The dynagraph history might therefore not have recorded the load violation. This buffer will have captured that load limit violation.

Daily History Buffers

The Lufkin Well Manager RPC maintains an historical record for the previous 24 hours of the following:

- Previous 1440 minutes indicating if the pump was on or off
- Speed control output level from the Lufkin Well Manager RPC to the variable speed drive for each of the previous 1440 minutes
- Previous 180 eight-minute averages of the calculated gas flow rate

60 Day History Buffers

The Lufkin Well Manager RPC has a realtime clock, and therefore it can perform functions at programmed times of the day. A user-programmed gauge off time tells the Lufkin Well Manager RPC when to perform daily record storage functions. The Lufkin Well Manager RPC maintains an historical record of the previous 60 days of the following:

- Run time for the day in percent
- Inferred production for the day in barrels
- Highest value for the polished rod load for the day
- Lowest value for the polished rod load for the day
- Gas production volume for the day in MCF
- Highest value for polished rod horsepower for the day

Valve Check and CBE

The Lufkin Well Manager RPC will record polished rod load versus time and save a buffer with that data for analysis. The buffer is a maximum of 1200 load points sampled every 200 milliseconds. You can record up to four minutes of data. A Pause/Resume feature gives you more than four minutes to collect that data however. The analysis feature includes the ability to:

- Record standing valve (SV) and traveling valve (TV) load values
- Calculate TV leakage in barrels per day
- Calculate residual friction (RF)
- Record counterbalance (CBE)

The valve check feature is discussed in detail in appendix B, "Valve Checks, Counter Balance Effect, and Residual Friction."

Time Stamped Data

The Lufkin Well Manager RPC uses the realtime clock to date/time stamp historical performance actions. One buffer tracks 22 predefined significant events to let the user see the last time that the event occurred. This event log covers the full spectrum of the Lufkin Well Manager RPC control features. A second shutdown event log tracks the last 20 start/stop actions of the Lufkin Well Manager RPC.

Dynagraph Card Buffers

The Lufkin Well Manager RPC displays a realtime dynagraph trace for on-location analysis of present pumping conditions. If the Downhole control method is selected, the downhole pump card for the stroke just completed is displayed.

The Lufkin Well Manager RPC also stores a number of dynagraph cards as an historical record, which are the following:

- Stored Card — five most recent strokes
- Pump Up Card — single stroke at the last transition from minimum pump strokes to pumping
- Shutdown Card — buffer containing the last five strokes before a shutdown decision is recorded for each of the last two shutdown decisions
- Standard Card — operator-saved reference card
- Start Card — single-stroke card at the start of the minimum pump stroke well state
- Reference Pump Cards — twelve downhole pump cards for common pumping conditions provided as a quick analysis tool

All dynagraph cards can be displayed as surface card–only, downhole card–only, or both cards on the same screen with the downhole card displayed below the surface card.

Auto Downtime Plot
The Lufkin Well Manager RPC records and displays the pumping time (on the Y-axis) versus the downtime steps (on the X-axis) from the last time that the auto downtime algorithm was executed. This “buildup” curve is one more valuable piece of well data provided by the Lufkin Well Manager RPC. For more information about the auto downtime, see appendix A, “Auto Downtime Feature.”

Auxiliary Analog Input History
A Lufkin Well Manager RPC operating with version 4.05 or higher of the RPC application firmware can maintain a historical record of the average value of each configured auxiliary analog input. The local keypad/display interface will display a plot of eight-minute averages for the past 24 hours and the daily average for each of the last 60 days.

2.10.8 Start Alert Safety Feature
Discrete output number 3 on the Lufkin Well Manager RPC is hard coded as an alert output. The output is closed for a programmed number of seconds before the well is to be started. An optional 12-VDC warning beeper is available from Lufkin Automation that warns personnel in the area that the pumping unit is about to start. If a user desires, a beacon or horn can be connected to this output through an interposing relay to give an even more noticeable warning.

2.11 I/O Expansion Capability
The Lufkin Well Manager RPC modular design provides the ability to expand the I/O capacity to monitor and/or control other processes at oil production facilities. The firmware design provides for the following expanded I/O:

- Thirty-two analog inputs
- Eight analog outputs
- Sixty-four discrete points configurable as inputs or outputs
- Eight accumulators

2.12 Controller Operator Interface

Several parameters need to be defined to program the Lufkin Well Manager RPC. Programming is done through the local operator interface, which consists of a full-function LCD graphics display and 20-key keypad. This operator interface is menu-driven.

2.12.1 Operator Interface Keypad

The 20-key operator interface keypad (Figure 2-1) is mounted in the Lufkin Well Manager RPC enclosure. It is the quickest and easiest way to program the Lufkin Well Manager RPC. It allows you at the wellsite to program and calibrate the controller and access and display current and historical data without using a laptop computer. The keypad is not absolutely required for programming and calibration, because programming can also be done using the *LWM Screen Terminal* emulator interface program installed in your laptop computer.

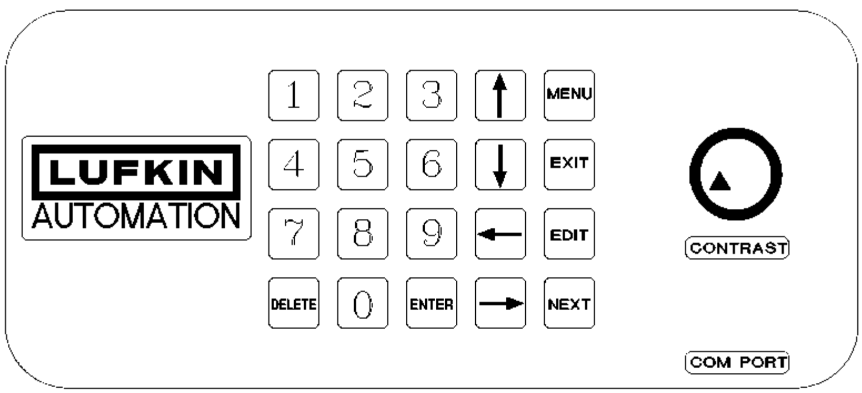


Figure 2-1. Operator Interface Keypad

Below is a description about each key's function on the keypad.

Key	Function
1 — 0	Selects an option from a menu screen or enters new data in fields on the programming screens.
↑ ↓ ← →	Changes setpoint position or cursor location in the direction specified by the arrow key. Also scrolls available options in several programming screen fields.
ENTER	Confirms a correct entry when changing programming data. When this key is pressed, data is updated.
EDIT	Selects the edit mode so that programming changes can be made. Edit mode is selected on a per-field basis.
NEXT	Selects the next screen for display. In some cases, **<NEXT>** is used to execute a control function. In those cases, screen prompts are provided.

Key	Function
EXIT	Displays the previously displayed menu. Cancels any changes made on the current screen if **<ENTER>** is not pressed.
MENU	Displays the Main Menu screen.
DELETE	Voids an incorrect numerical entry if **<ENTER>** is not pressed.

2.12.2 LCD Graphics Display

The Lufkin Well Manager RPC user interface is menu-driven. All menus and screens are displayed in the LCD graphics display.

The Main Menu screen (Figure 2-2) is the first screen that appears after the Lufkin Well Manager RPC is turned on and the initialization process is completed. This screen also appears any time after **<MENU>** is pressed on the operator interface keypad.

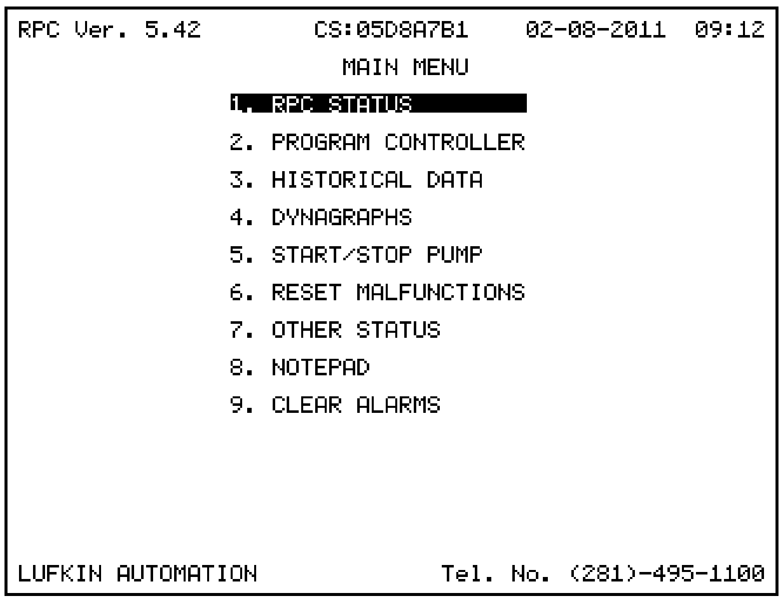


Figure 2-2. Main Menu Screen

The menu map (Figure 2-3) shows all screens available through the Lufkin Well Manager RPC operator interface.

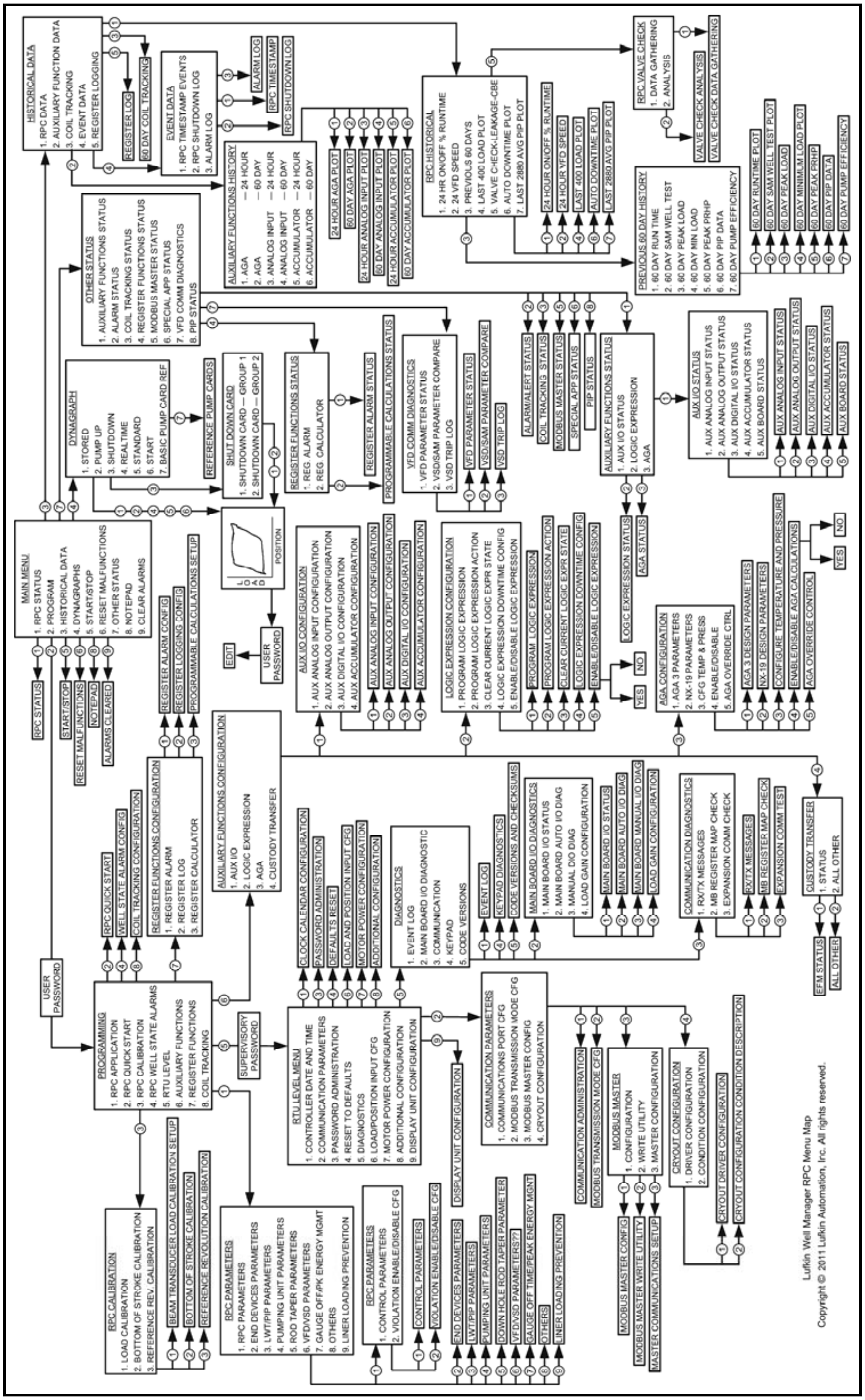


Figure 2-3. Lufkin Well Manager RPC Menu Map

2.12.3 Menu Option Selection

Two methods are available for selecting an option when a menu screen displays.

- Press the number key on the keypad that represents the desired option shown on the LCD display.

- Press <↑> and <↓> to highlight the desired option shown on the LCD display and then press **<ENTER>**.

2.12.4 Control Parameter Programming

Control parameters are edited (programmed) on a data field basis. To program a parameter, press <↑> or <↓> to highlight the desired parameter field, press **<EDIT>**, and then do one of the following:

- When the parameter is a numerical entry, use the number keys to enter the desired value. When the data field displays the desired number, press **<ENTER>** to complete the programming step.

- When the data field requires a text entry, press <↑> and <↓> to scroll through the available options. After the data field displays the correct entry, press **<ENTER>** to complete the programming step.

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

- Return to the Main Menu screen by pressing **<MENU>**.

- Return up one level in the menu tree by pressing **<EXIT>**. For example, if you are working with the Clock Calendar Configuration screen, pressing **<EXIT>** returns you to the RTU Level Menu screen.

2.13 Modbus Master Feature

The Lufkin Well Manager RPC can read and store data from other Modbus RTUs on location. This data is stored in the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC 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. An optional RS-485 expansion communication board must be added to the Lufkin Well Manager RPC, and a two-wire or four-wire RS-485 data cable network must be installed to connect the Lufkin Well Manager RPC master with each slave device.

The Modbus Master feature can be programmed to poll and collect data from a maximum of 10 slave devices. Up to 125 data registers can be read from each configured slave device. Data is polled automatically at a programmable interval.

The Lufkin Well Manager RPC can also be configured to write data to the slave devices. Desired values can be programmed for up to 25 registers in each slave device. The write function requires a manual command to execute.

The Lufkin Well Manager RPC control algorithm uses the Modbus Master feature to read data from and write commands to compatible models of variable speed drives.

For more information about the Modbus Master feature and how to configure Modbus and slave device parameters, see “Modbus Master and Slave Device Configuration” in section 9, “Lufkin Parameter Programming.”

Section 3

Technical Specifications

This chapter lists the specifications for the Lufkin Well Manager RPC and the transducers available for use with it.

The topics covered in this section include:

3.1 Lufkin Well Manager RPC

3.1.1 Enclosure

Enclosure Type:	NEMA4X fiberglass enclosure, hinged door with pad lockable hasp.
Height:	15.32 inch (38.9 cm)
Width:	13.31 inch (33.8 cm)
Depth:	6.70 inch (17.0 cm)
Weight:	Approximately 22 lbs (10 kg) including controller, operator interface, and data radio

3.1.2 Internal Component Layout

The Lufkin Well Manager RPC is modular in design with surface-mount components on all circuit board assemblies. Lufkin Well Manager RPC units intended for rod pump control include the following “modules” or components:

- A switching power supply mounted on the controller back panel converts primary AC voltage to 13.8 VDC for control circuit power.

- A motherboard, including the CPU and all memory devices plus eight discrete input/output points and two pulse inputs, is mounted on the backside of a hinged front panel. The motherboard includes two communication port connections.

- An analog input board with isolated power and signal lines plugs into the lower right corner of the motherboard. This module includes amplifiers and analog-to-digital conversion circuitry for both load and analog position inputs.

- An optional 320 x 240 liquid crystal display (LCD) is mounted on the backside of the hinged front panel underneath the motherboard. The LCD is connected to the motherboard by a 20-pin header. The LCD can be read from the front of the hinged panel through a panel cutout.

- An optional 20-key membrane keypad with an integral contrast adjust potentiometer is mounted on the front of the hinged front panel and connects to the motherboard with a ribbon cable.

- Optional auxiliary input and/or output capability can be added to the Lufkin Well Manager RPC by plugging expansion boards into the expansion port provided on the motherboard.

- Back panel space is provided for mounting a radio or other data transmission device. Power supply terminals (13.8 VDC) and mounting hole patterns for popular radios are included. Optional signal cables connect the RJ11 radio port to the radio input.

3.1.3 Environmental Operating Range

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

3.1.4 Power

Primary power to the switching power supply:	85 to 264 VAC, 50/60 Hz.
Power supply:	Rated for 42 Watts continuous.
Fuse AC input line:	1.5 amps, Slo-Blo
Motherboard power:	Input range 12 VDC to 13.8 VDC, current draw 500 MA maximum at 13.8 VDC

3.1.5 Brownout/Blackout Protection

A watch dog circuit initiates an orderly shutdown of the microprocessor and memory circuits if the DC input voltage level to the mother board falls below 11.0 VDC. Automatic lockout features protect memory read/write circuits when a power loss is detected. When proper voltage is re-applied, the Lufkin Well Manager RPC system automatically re-initializes.

3.1.6 Microprocessor and Memory

- Coldfire XCF/MCF5307 microprocessor operated at 33 MHz.
- 1024K bytes of battery-backed SRAM. The lithium batteries used will provide data retention for approximately one year without operating power.
- 4 megabytes of SDRAM for use as general operating memory.
- Standard Lufkin Well Manager RPC units include 4 megabytes of Flash ROM. Flash ROM may be expanded up to 32 megabytes.

3.1.7 Serial Communications

The Lufkin Well Manager RPC motherboard connects serial port 0 of the Coldfire microprocessor to two MX213E RS232 drivers. Only one driver at a time is active. The default active driver is connected to an RJ11 connector designated as the radio port. The second driver is connected to a DB9 connector designated as the laptop port. When a laptop computer is plugged in, and Lufkin Well Manager RPC interrogation software raises the DTR line, the second driver becomes the active driver and any activity on the RJ11 radio port is ignored. The second serial port of the Coldfire microprocessor is available through the expansion board bus.

The two serial ports on the motherboard are separately programmable for a baud rate of 300, 1200, 2400, 4800, 9600, 19200, 38400, or 115200 baud.

The RJ11 Radio port has programmable time delays for key up and key down.

Communication protocol is Modbus RTU with a data format of eight data bits, no parity, and one stop bit. Extended Lufkin Automation Modbus (ELAM) protocol is used for RTU addresses of 248 and above. ELAM supports up to 2,295 RTUs on the same communication channel, allows larger data block sizes to be transmitted, and has a multiple instruction read/write capability.

3.1.8 Standard Rod Pump Control Inputs and Outputs

Analog Inputs: Lufkin Well Manager RPC has two analog inputs dedicated for use as a load signal and an analog position signal.

- Load input uses an isolated regulated 5 VDC excitation and incorporates a CS5531 Delta-Sigma analog-to-digital converter with an ultra low noise programmable gain instrumentation amplifier.
- Analog position input is powered by an isolated regulated 8 VDC and is digitized by a CS5529 Delta-Sigma analog-to-digital converter.

Digital Inputs: Lufkin Well Manager RPC motherboard has two optically isolated digital inputs dedicated for RPM and Crank Switch Hall-Effect transducer inputs. In addition, four other general-purpose discrete points can be configured as either inputs or outputs for use in Logic Expression applications.

Digital Outputs: Lufkin Well Manager RPC motherboard has four discrete points that are dedicated as outputs for the Rod Pump Control application.

3.2 Transducers

Technical specifications are provided below for the following transducers:

- Polished rod load cell
- 101TL beam mounted transducer
- AT-03 inclinometer
- 101TLS Combo transducer
- Hall-Effect transducers

3.2.1 Polished Rod Load Cell

Operating range:	0 to 30,000 lbs or 0 to 50,000 lbs.
Max Input voltage:	15 VDC
Zero offset:	0 mV at zero load
Output voltage:	2 mV/V ±1% at rated load
Output impedance:	350 Ω in each signal lead
Connector:	Molex plug connection

3.2.2 101TL Beam Mounted Transducer

Material:	Steel
Max input voltage:	12 VDC
Output impedance:	175 Ω in each signal lead

3.2.3 AT-03 Inclinometer

Angular range from level:	±45°
Input voltage range:	4 to 15 VDC
Linearity:	±1%
Operating temperature range:	-40° to 150° F (-40° to +65° C)
Connector:	Terminal block connections

3.2.4 101TLS Combo Transducer

Material:	Steel with fiberglass enclosure
Angular range from level:	±45°
Input voltage range:	4 to 15 VDC
Linearity:	±1%
Operating temperature range:	-40° to 150° F (-40° to +65° C)
Connector:	Terminal block connections

3.2.5 Hall-Effect Transducers

Supply Voltage Range:	4.5 to 24 VDC
Operating Point:	350 gauss typical
Output:	Open-collector, sink up to 25 MA
Operating temperature range:	-40 to 185° F (-40° to +85° C)
Storage temperature range:	-85° to 338° F (-65° to +170° C)

Section 4

Parts Lists

This section provides parts lists having all the Lufkin Well Manager RPC components available, including transducers, cables, and optional accessories. It also describes how you can order these parts from Lufkin Automation.

The topics covered in this section include:

4.1 Lufkin Well Manager RPC Unit

Part Description	Part No.
Power Supply	194.0016
Mother board with load/position analog input board	520.5000B
Load/position Analog Input Board	520.5001A
Fuse, 1½ Amp, Slo-Blo	181.0018

4.2 Operator Interface Systems

Part Description	Part No.
Controller Operator Interface LCD	530.5010C
Keypad and Contrast Adjust Membrane	184.5000A
LWMScreen Terminal software	090.7050
Dynalink	090.7000
Lufkin Automation *LWM Flash Upgrade Utility* software	090.7040

4.3 Transducers

Part Description	Part No.
101TL Beam Mount, Weld-On	060.6381A
101TL Beam Mount, Clamp-On	060.0474
Polished Rod Load Cell, 30K	062.1000
Polished Rod Load Cell, 50K	062.1001
PRLC Spherical Washer Set	062.0004
AT-03 Inclinometer, magnet mount	060.0414B
101TL Combo Load/Position Transducer, weld-on	060.0424A
101TL Combo Load/Position Transducer, clamp-on	060.0425
Motor RPM Hall-Effect	510.4055B
Crank Hall-Effect	510.4055B
Motor Magnet	640.5002B
Crank Magnet	291.5000

4.4 Accessories

Part Description	Part No.
Load Cell Cable with molded Molex plug and flexible cable connector/seal — 50 feet	510.5200
Load Cell Cable Support Kit	069.0004
Solid-State Relay	179.3000
Mechanical Relay, Socket and Diode	530.4670
Stepdown Transducer — 75 VA	161.7513
Transformer Fuse – 0.6 Amp Slo-Blo	181.0051

4.5 Cables

Cabling needs differ depending on the input device installed. For unusual cabling requirements, contact your Lufkin Automation representative.

Part Description	Part No.
4-Conductor Shielded Cable* (25 feet recommended; specify length required)	509.8004
7-Conductor Shielded Cable* (50 feet recommended; specify length required)	509.1700
8-Conductor Shielded Cable	509.8008
14 Ga. THHN** (used for power control wiring)	Not Applicable

* Actual cable lengths may vary depending on installation method used and pumping unit size.

** 14 Gauge wire and other interconnecting wire provided by customer.

4.6 Documentation

Part Description	Part No.
Lufkin Well Manager™ — Rod Pump Control User Manual	099.5000

4.7 How to Order Parts

Call your local Lufkin Automation representative or contact the factory in Houston directly at 281.495.1100.

Section 5

Hardware Configuration

You must ensure that the Lufkin Well Manager RPC hardware is configured properly in order to obtain accurate input data and have pump control.

The topics covered in this section include:

5.1 Overview of the Hardware Configuration

The following items pertaining to hardware configuration must be checked to ensure that the Lufkin Well Manager RPC is properly configured for the meter run inputs and valve control actuation:

- Battery disconnect jumper is on both pins
- 4-20 MA transmitters are configured

5.2 Battery Disconnect Jumper Pins

Many of the parameters programmed for rod pump control are stored in RAM on the Lufkin Well Manager RPC microprocessor circuit board (motherboard). This memory is supported during power outages by a lithium battery located near the top of the motherboard. Battery disconnect jumper pins are located next to the battery. A jumper is installed at the factory to connect the two pins to place the battery in service. It is recommended that you ensure that the shorting jumper is on both pins so that the battery is included in the circuit. Failure to include the battery will cause the Lufkin Well Manager RPC to loose programming when the power switch is turned off.

To check the jumper configuration, open the front panel of the Lufkin Well Manager RPC to view the motherboard and locate the battery jumper just above the green battery. If an optional expansion board assembly is mounted on the motherboard, look downward from the top between the expansion board and the motherboard. The green battery should be easy to notice. The battery jumper is just above the end of the battery nearest the door hinge.

If the jumper is not connecting the two pins, you need to temporarily unplug the expansion board to move the jumper so that the two pins are connected.

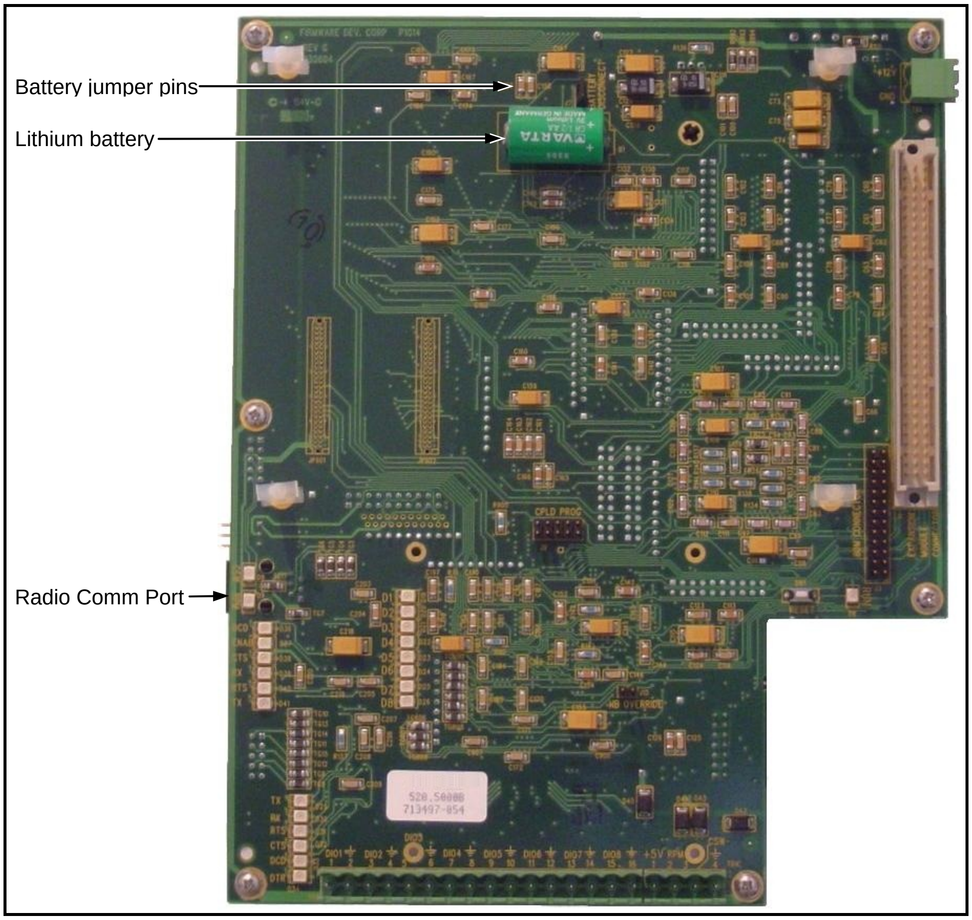


Figure 5-1. Mother Board Showing Lithium Battery, Battery Jumper Pins, and Radio Communication Port

5.3 4–20 MA Transmitters

The Lufkin VSD expansion board (Part No. 520.5003A) is shipped with all eight inputs configured as voltage inputs. Termination resistor jumpers are provided and mounted on only one of the two pins. To change the inputs to be used for current input, move the jumpers to the right to connect the two pins and place the 250-Ohm termination resistor in the input circuit. See Figure 5-2 to locate the termination resistor jumpers.

Other expansion board models available use dipswitches to select the termination resistor. For expansion board 520.5023, dipswitch **SW2** is used. For the 520.505x family of expansion boards, dipswitch **SW3** is used. For both expansion boards, switches 1 through 8 are associated with the termination resistor for analog inputs 1 through 8, respectively. Turn on the switch to put the termination resistor in the loop.

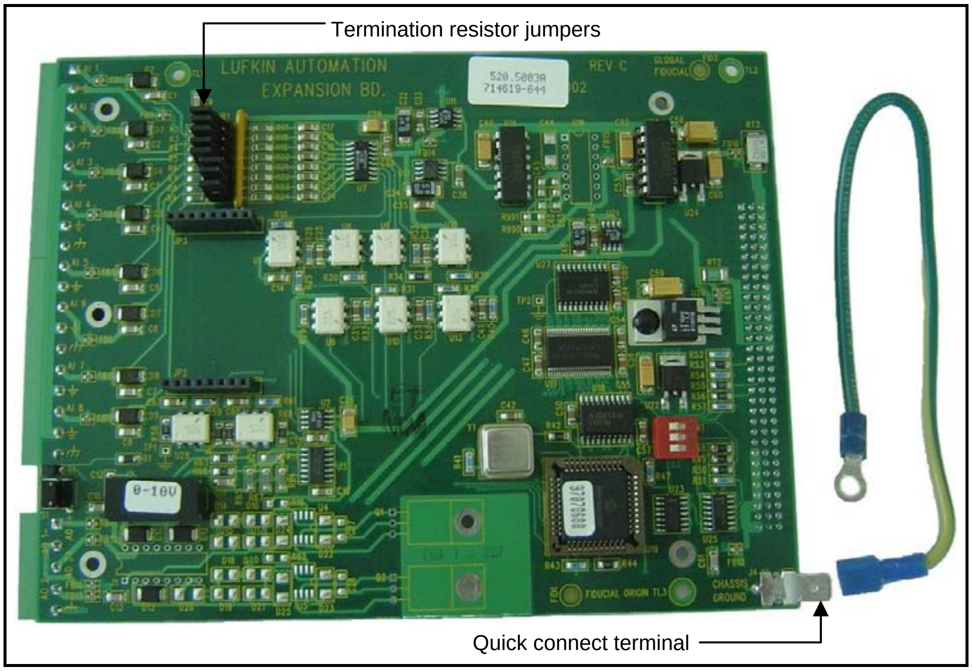


Figure 5-2. I/O Expansion Board Showing Termination Resistor Jumpers, Quick Connect Terminal for Earth Ground, and Ground Wire

A 16-pin header designated as **JP1** is located on the upper left edge of the installed expansion board to the right of the terminal block for connecting the analog inputs.

The jumper pins are not numbered. To identify the proper jumper for a given input, read the resistor designation located to the left of the **JP1** header and use the table below to reference it.

Analog Input	Termination Resistor
AI 1	R2
AI 2	R3
AI 3	R4
AI 4	R5
AI 5	R6
AI 6	R7
AI 7	R8
AI 8	R9

The I/O expansion board includes a 1/4-inch quick connect terminal for an earth ground (chassis ground). A green ground wire is included with this board, and it is imperative that the ground wire be connected to the hinge screw on the front panel. See Figure 5-2.

5.4 Radio Communications Port

The communications port on the motherboard (see Figure 5-1 on page 5-3) is most commonly connected with MDS Transnet or Freewave board-level radios. The port connector is labeled **RJ 12**. The signals are RS-232 and support Modbus RTU slave protocol.

Below is the pin-out configuration for RJ 12. When the motherboard is mounted vertically in the Lufkin Well Manager RPC, Pin 1 is located at the bottom of the connector.

Pin Out	Function
1	CD (input — not used)
2	TXD (output)
3	RXD (input)
4	Ground
5	RTS (output)
6	CTS (input — not used)

The wiring diagram in Figure 5-3 shows how the radio should be wired to the radio communication port (RJ 12) on the motherboard.

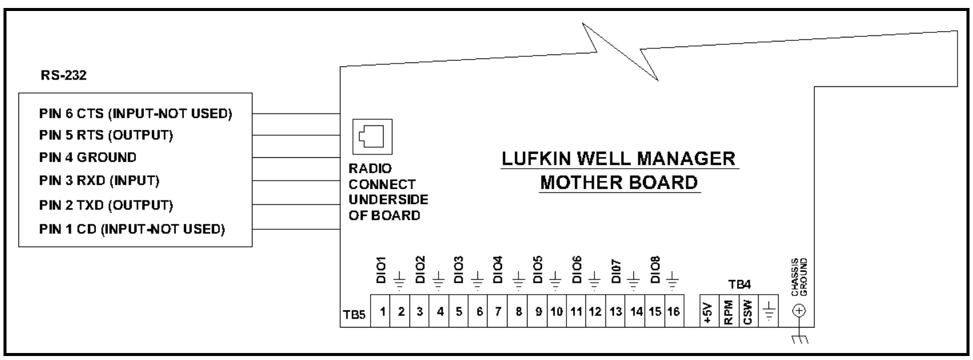


Figure 5-3. RPC Radio Communications Port Wiring Diagram

Radio Transmission Cable

If you need to construct a radio transmission cable to connect an MDS radio to the Lufkin Well Manager RPC, see Figure 5-4 for the proper wire-to-plug configuration.

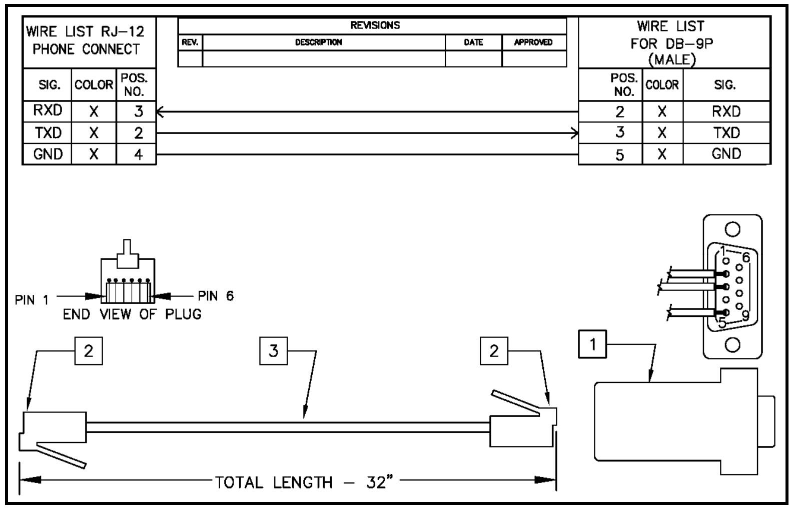


Figure 5-4. MDS Radio Transmission Cable Configuration

Baud Rate

The radio communications port can support data communication rates from 300 to 115,200 baud. The software controls baud rate on a slave-device basis. For information about configuring baud rate, see “Configuring Communication Parameters” in section 9, “Lufkin Parameter Programming.”

5.5 Auxiliary I/O Expansion Boards

The Lufkin Well Manager RPC motherboard has four auxiliary discrete points. However, the Lufkin Well Manager RPC is designed to accommodate optional expansion boards that can support expanded (auxiliary) inputs and outputs (I/O).

An expansion port header on the motherboard (**J1**) is used to plug in the initial expansion board. Snap-in standoffs secure both boards together. Additional expansion boards “piggy back” onto the initial expansion board. The system design accommodates a maximum of eight expansion boards. When all boards are plugged together, the maximum number of inputs and outputs possible is:

- Thirty-two analog inputs
- Eight analog outputs
- Sixty-four discrete points configurable as inputs or outputs
- Eight accumulator inputs

The auxiliary I/O is all “virtual” in that a logical input/output can be programmed to link to any appropriate physical hardware input/output point. For information about configuring auxiliary I/O points, see “Programming Auxiliary Analog Inputs and Outputs” in section 9, “Lufkin Parameter Programming.”

The four auxiliary discrete points on the motherboard must be configured as Board # 0. The table below provides the channel number designations.

Physical Marking	Channel #
DIO5 (TB5-9)	1
DIO6 (TB5-11)	2
DIO7 (TB5-13)	3
DIO8 (TB5-15)	4

5.5.1 Expansion Board Assembly 520.5003

Expansion board assembly 520.5003 adds eight analog inputs and two analog outputs.

Analog Inputs

Analog input points can be individually jumper-configured as either voltage inputs or current inputs.

- Voltage inputs supported by the firmware are 0 to 5 VDC and 1 to 5 VDC.
- Current inputs supported are 0 to 20 MADC and 4 to 20 MADC.

Analog inputs can also be used as “pseudo” digital input points. Analog input points are optically isolated from the motherboard analog common. If it is necessary to maintain that isolation, the 13.8-VDC power supply that powers the motherboard cannot be used to provide loop power for the transmitter. For information about loop power considerations, see “Loop Power Considerations” on page 5-11.

This expansion board assembly is shipped with all eight inputs configured as voltage inputs. To field-change them for use with a current input, move the mini jumper provided to connect the two pins and place a 250-Ohm termination resistor in the input circuit. A 16-pin header designated as **JPI** is located on the upper left edge of the installed expansion board to the right of the terminal block for connecting the analog inputs. The mini jumpers provided are mounted on only one of the two pins. Move the mini jumper to the right so that it connects both pins and includes the 250-Ohm termination resistor in the circuit. See Figure 5-5 to locate the termination resistor jumpers.

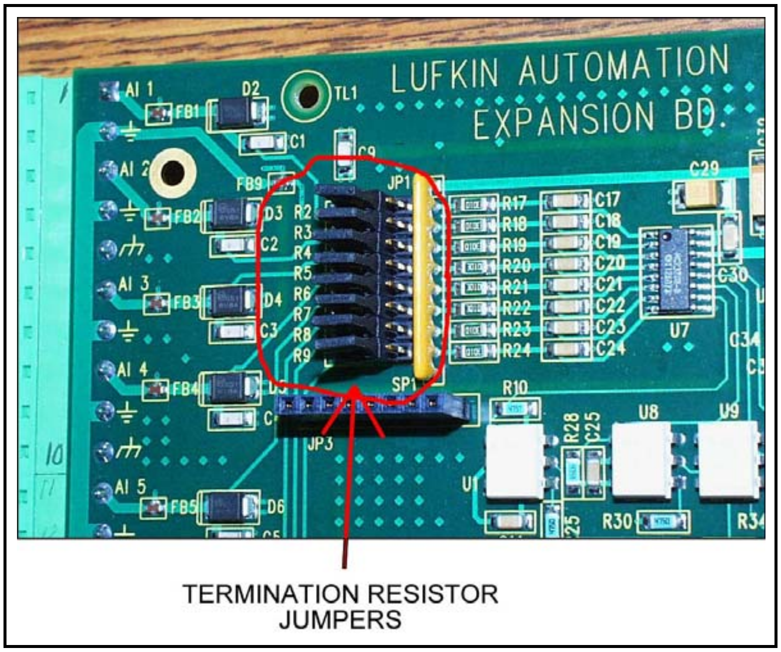


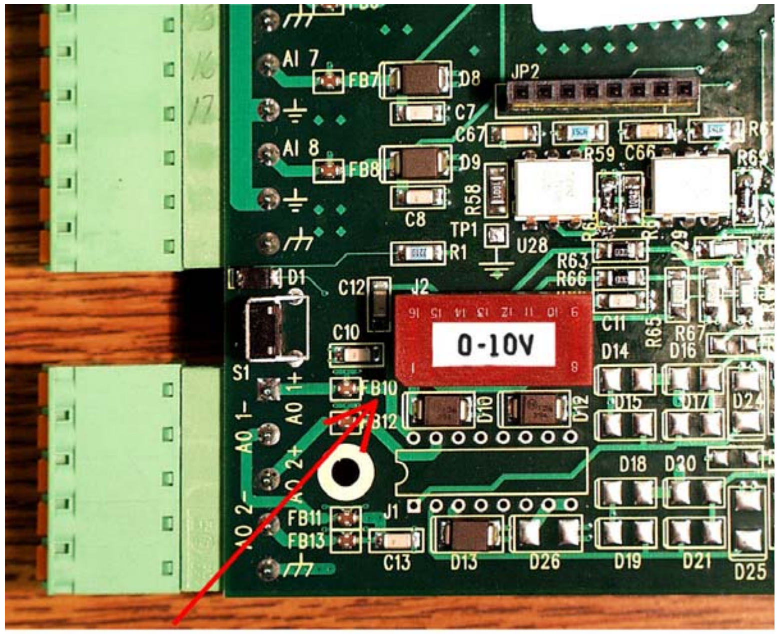
Figure 5-5. Analog Input Expansion Board Termination Resistor Jumpers

The jumper pins are not numbered. To identify the proper jumper for a given input, read the resistor designation located to the left of the **JP1** header and use the table below as reference.

Analog Input #	Termination Resistor
AI 1	R2
AI 2	R3
AI 3	R4
AI 4	R5
AI 5	R6
AI 6	R7
AI 7	R8
AI 8	R9

5.5.2 Analog Outputs

An isolated power supply is included on the expansion board to power the two analog outputs. Both analog outputs can be configured as either 0-to-5-VDC or 0-to-10–VDC outputs by selecting one of the two configuration header assemblies provided with this expansion board and plugging that header into the socket labeled **J2** located on the lower left corner of the expansion board (see Figure 5-6). Note the orientation of the configuration header with the Pin 1 corner down and to the left.



0-10V MODULE INSTALLED AT J2
NOTE POSITION OF PIN 1 (NOTCHED CORNER)

Figure 5-6. Analog Output Configuration Header

5.5.3 Expansion Board Assembly 520.5023

Expansion board assembly 520.5023 adds eight analog inputs and eight discrete points that may be firmware-configured as digital inputs or outputs. See the description above about expansion board #520.5003 for information about analog inputs. Termination resistors are put into a 4-20 MA loop with dipswitch **SW2** as explained in section 5.3 (“4–20 MA Transmitters” on page 5-3). An optional analog output board (Part No. 520.5027) is available. For an explanation of the outputs available, see “Expansion Board Assembly 520.5003” on page 5-7.

5.5.4 Expansion Board Assemblies 520.505x

The 520.505x (Type 5) family of expansion boards can add eight analog inputs, eight discrete points that can be configured as either digital inputs or outputs, two analog outputs, and a turbine meter input. For more details about this group of expansion boards, contact your Lufkin Automation representative.

5.5.5 Expansion Board Number Configuration

Each expansion board has a three-position dipswitch used to set the board's address (board number). See Figure 5-7 to help you locate the switches. On the expansion board 520.5023 assembly, the dipswitch is labeled **SW3** and on the 520.505x (Type 5) series of boards, it is labeled **SW6**.

Dipswitches are labeled differently but the switch elements and the address setting as described below are all the same

The dipswitch sets the board number "offset". The "offset" approach is used since the motherboard is always considered Board #0. The offset dipswitch setting prevents a user from accidentally setting one of the expansion boards as Board #0. Set the three switches for the binary equivalent of the desired board number, minus 1.

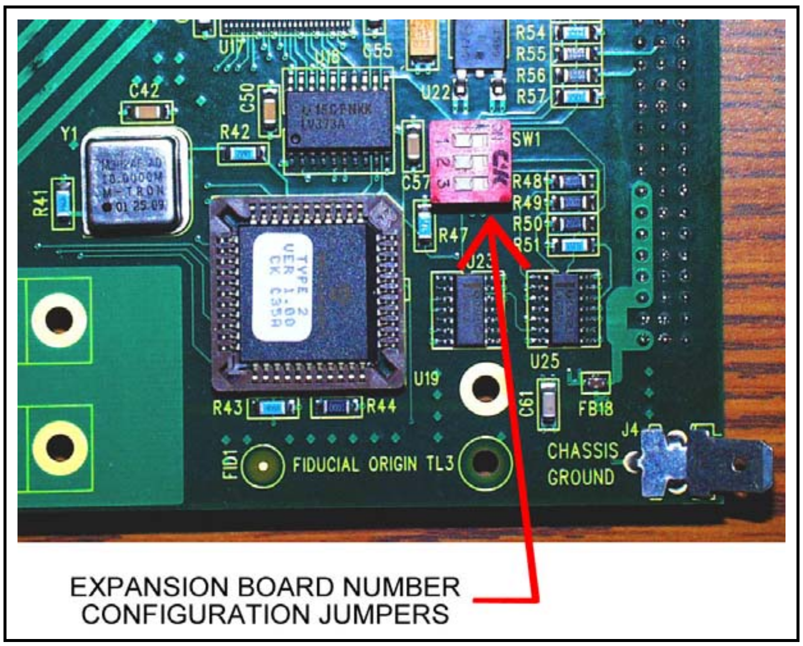


Figure 5-7. Expansion Board Number Configuration Switches, Board P/N 520.5003

The table below shows board number switch settings.

Board Number	Switch 1	Switch 2	Switch 3
1	Off	Off	Off
2	On	Off	Off
3	Off	On	Off
4	On	On	Off
5	Off	Off	On
6	On	Off	On
7	Off	On	On
8	On	On	On

5.5.6 LEDs and Reset Switch

All expansion board assemblies include a “heartbeat” LED. It has a two-second on/off blink cycle when the microprocessor on the expansion board is properly programmed and the program is successfully running.

Each expansion board assembly also has a reset switch. In the unlikely event that the heartbeat LED remains lit without blinking, press the reset button to reboot the expansion board’s microprocessor.

5.5.7 Microprocessor Chip Swapping

The expansion board design does not allow flash upgrade programming. The microprocessor chip must be physically swapped in order to change the expansion board programming. For that reason, the expansion board microprocessor (U19) is mounted in a socket. A special tool is required to properly extract and insert microprocessor chips. Consult your Lufkin Automation representative if you feel that it is necessary to exchange the microprocessor chip.

5.5.8 Loop Power Considerations

The Lufkin Well Manager RPC includes a 13.8-VDC, 40-Watt power supply as standard equipment. Many process transmitters require more than 13.8-VDC loop power to drive full range output into a 250-Ohm termination resistor. Check the performance curves for the transmitter being used to determine if you need to order and install the optional 24-VDC loop power supply in the Lufkin Well Manager RPC.

If the standard 13.8-VDC power supply is used for transmitter loop power, the analog inputs will no longer be isolated from the motherboard. This could cause a problem, particularly if the process transmitter is built into another piece of electronic equipment at the wellhead, such as a variable speed drive with signal outputs for motor current or voltage. To avoid possible conflicts, contact your Lufkin Automation representative with details about the equipment that you want to interface.

5.6 RS-485 Communication Expansion Board

The optional RS-485 communication expansion board (Part No. 520.5012, shown in Figure 5-8) is designed to piggyback mount on two of the I/O expansion boards (Part No. 520.5003 and 520.5023). When you install the RS-485 board on the I/O expansion board, make sure the connectors are configured as follows:

- **JP1** on RS-485 expansion board to **JP2** on I/O expansion board
- **JP2** on RS-485 expansion board to **JP3** on I/O expansion board

The field connection terminal block for the RS-485 communication expansion board should be placed to the left edge and over the terminal block of the I/O expansion board.

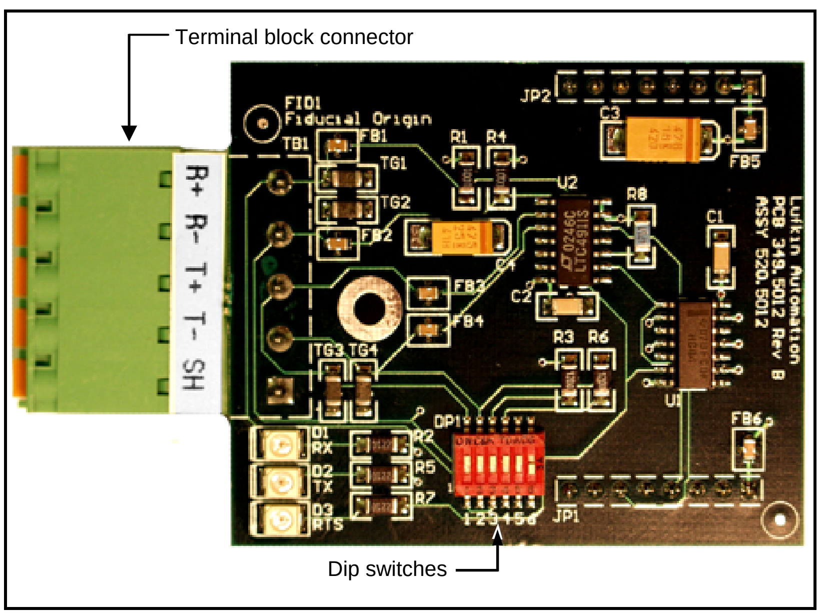


Figure 5-8. RS-485 Communication Expansion Board

The RS-485 communication expansion board provides an interface for the Lufkin Well Manager RPC to the Modbus Master data network.

The 520.505x series of expansion boards have enhanced communication expansion capabilities. Contact your Lufkin Automation representative for a copy of the *Lufkin Expansion Board Type 5 User's Guide*. The details below for the expansion board 520.5012 are not applicable to the Type 5 expansion boards.

5.6.1 Terminal Block Connector

The RS-485 expansion board has a five-position terminal block connector used for the data network wiring. The board is properly installed when the terminal block is on the left edge of the Lufkin Well Manager RPC front panel, with the panel open. The connector is labeled as follows from top to bottom.

Position	Signal	Description
1	R+	Receiver +
2	R–	Receiver –
3	T+	Transmitter +
4	T–	Transmitter –
5	SH	Cable Shield

5.6.2 Baud Rate

The RS-485 expansion board can support data communication rates from 300 to 115,200 baud. The software controls baud rate on a slave-device basis. For information about configuring baud rate, see "Configuring Communication Parameters" in section 9, "Lufkin Parameter Programming."

5.6.3 Biasing Resistors

The RS-485 expansion board comes standard with 1K biasing resistors. To change the value of biasing resistors, remove **R1** and **R4** and replace with new values. See Figure 5-8 for resistor locations.

5.6.4 Termination Resistors

120-Ohm termination resistors are pre-installed at locations **R3** and **R6**. These resistors can be activated in the circuit by setting dipswitches **3** and **4** to the ON position. See Figure 5-8 for resistor locations.

In two-wire mode, only one terminating resistor needs to be active (that is, only set dipswitch **3** or **4** to the ON position). Terminating resistors should only be used on the ends of the RS-485 data line.

5.6.5 Constant Receiver Enable/Disable

The RS-485 expansion board comes standard with the receiver set up for constant receiver mode. It can be set up for receiver disabled during transmission by setting dipswitch **5** to the ON position. See Figure 5-8 for dipswitch locations.

- Constant receive mode should be used for four-wire mode.
- Receiver disabled during transmission should be used for two-wire mode.

For information about how to enable and disable receiver mode, see "Communication Port Configuration" in section 9, "Lufkin Parameter Programming."

5.6.6 Data Line Polarity

The polarity of the two RS-485 lines must be correct. The "+" lines should be connected together, and the "–" lines should be connected together between devices on the network. If a device uses "A" and "B" designation, then you must determine which terminal "A" or "B" is the "+" terminal. When no data is being transmitted, the "–" terminal should be negative with respect to the "+" terminal.

5.6.7 Dipswitch Configuration

Dipswitch assignments for two-wire and four-wire mode are provided in the tables below. See Figure 5-8 for dipswitch locations on the RS-435 expansion board.

Dipswitch Assignments		
Dipswitch 1	OFF	Four-Wire Mode
	ON	Two-Wire Mode — Connects RX+ and TX+
Dipswitch 2	OFF	Four-Wire Mode
	ON	Two-Wire Mode — Connects RX- and TX-
Dipswitch 3	OFF	No Termination for RX
	ON	120 Ohm Termination for RX
Dipswitch 4	OFF	No Termination for TX
	ON	120 Ohm Termination for TX
Dipswitch 5	OFF	Receiver Always Enabled (Four-Wire Mode)
	ON	Receiver Disabled During Transmission (Two-Wire Mode)
Dipswitch 6	NA	Not Used

Two-Wire Mode Configurations

Mode	State	Dipswitch Settings 1	2	3	4	5	6
Constant Receiver Enabled	ON	■	■				
No Terminating Resistors	OFF			■	■	■	■
Receiver Disabled on Transmit	ON	■	■			■	
No Terminating Resistors	OFF			■	■		■
Constant Receiver Enabled	ON	■	■	■			
Terminating Resistors Connected	OFF				■	■	■
Receiver Disabled on Transmit	ON	■	■	■		■	
Terminating Resistors Connected	OFF				■		■

Four-Wire Mode Configurations

Mode	State	Dipswitch Settings 1	2	3	4	5	6
Constant Receiver Enabled	ON						
No Terminating Resistors	OFF	■	■	■	■	■	■
Receiver Disabled on Transmit	ON					■	
No Terminating Resistors	OFF	■	■	■	■		■
Constant Receiver Enabled	ON			■	■		
Terminating Resistors Connected	OFF	■	■			■	■
Receiver Disabled on Transmit	ON			■	■	■	
Terminating Resistors Connected	OFF	■	■			■	■

Note: The setting assigned for dipswitch 6 has no effect on performance.

Section 6

Installing the System

This section describes how to install the various components making up the Lufkin Well Manager RPC system.

Note: For instructions about wiring the system, see section 7, “Wiring the System.

The topics covered in this section include:

6.1 Typical Installation

A typical rod pump controller installation includes the following system components:

- Lufkin Well Manager RPC
- 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.

Note: If a ground rod does not exist adjacent to the motor starter panel, you must install one. For installation information, see “Installing the Mounting Post and Ground Rod” on page 6-4.

Figure 6-1 shows an example of a typical Lufkin Well Manager RPC installation.

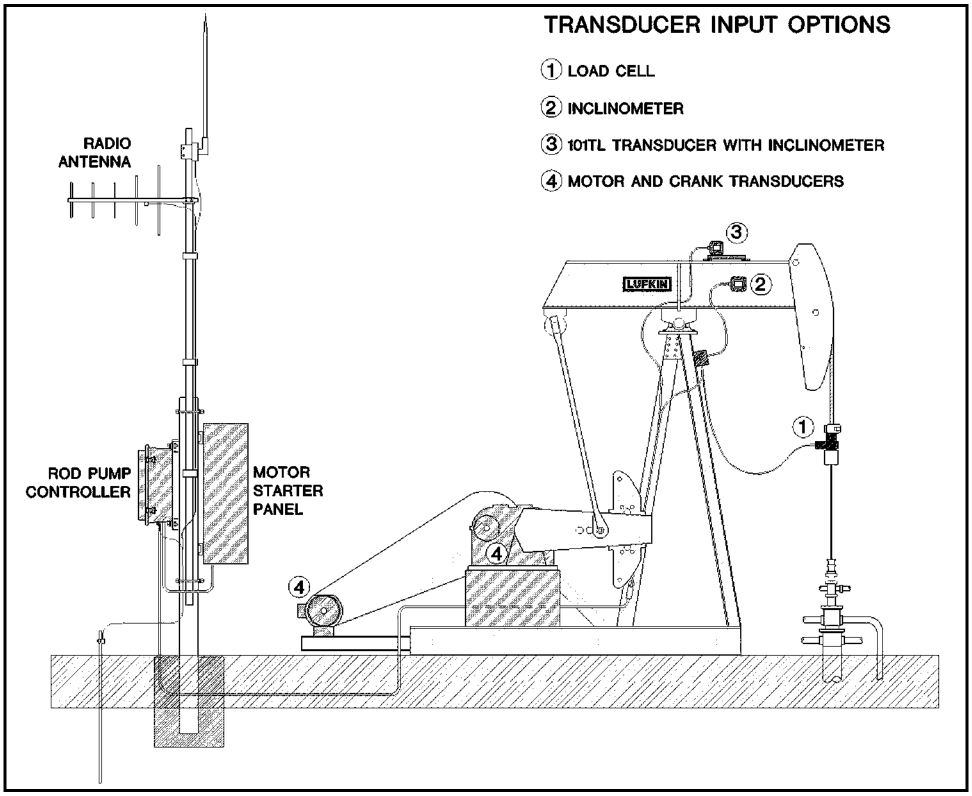


Figure 6-1. Typical Lufkin Well Manager RPC Installation

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

6.2 Site Selection

When you select a site for installing the Lufkin Well Manager RPC, keep the following conditions in mind:

- Mount the Lufkin Well Manager RPC in a location near the pumping unit and motor control panel so that it is easily accessible to 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. If local operational or code requirements dictate that the Lufkin Well Manager RPC be mounted at the edge of the well pad far removed from the pumping unit and/or the motor starter panel, contact your Lufkin Automation representative for design assistance.

- If the Lufkin Well Manager RPC has a radio, keep in mind the radio signal path from the well to the base radio location. The Yagi antenna for the Lufkin Well Manager RPC should not point directly at the pumping unit structure when properly aligned with the base radio location.

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

6.3 Installing the Mounting Post and Ground Rod

DANGER: Be very careful of 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 at least 40 pounds if only the controller will be installed and 75 pounds if a radio and antenna system will be included.

Tools Required

- Shovel or posthole 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 posthole 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 and ready for you to mount to the Lufkin Well Manager RPC on it.

6.4 Installing the Stepdown Transformer

The Lufkin Well Manager RPC requires primary input power in the range of 85 VAC to 264 VAC. Power available at most wellsites is higher voltage; therefore, a stepdown transformer may be required. If a transformer is required, Lufkin Automation suggests that you use one with a secondary voltage of 115 VAC.

Lufkin Automation offers a 75-VA capacity stepdown transformer (Part No. 161.7513). If your installation requires a stepdown transformer, and if you purchased a power transformer from another manufacturer, use that manufacturer's mounting instructions. If you purchased the stepdown transformer from Lufkin Automation, follow the steps below.

Tools Required

- Voltmeter
- Four #8 self-tapping screws
- Drill

Installation Procedure

Follow the steps below to properly install the stepdown transformer.

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 without your knowledge.

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.

6. Use four #8 self-tapping screws to mount the stepdown transformer. Drill holes as necessary.

The stepdown transformer is now installed.

6.5 Installing the Lufkin Well Manager RPC

The Lufkin Well Manager RPC 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 procedure describes how to mount the Lufkin Well Manager RPC with and without a radio communications unit. Figure 6-1 (page 6-3) shows a typical installation with a radio communications unit.

The Lufkin Well Manager RPC can be mounted on the stub pole with the motor control panel or on a separate mounting bracket installed for the controller and radio antenna mast (if one is included in this installation). See Figure 6-2 for the Lufkin Well Manager RPC enclosure dimensions.

If possible, orient the Lufkin Well Manager RPC 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.

Tools Required

- Four 1/4-inch nuts and bolts
- Two wrenches

Installation Procedure

Follow the steps below to properly install the Lufkin Well Manager RPC.

1. Mount the Lufkin Well Manager RPC at a height that allows easy access for you and maintenance personnel
2. Use 1/4-inch nuts and bolts (user supplied) to mount the Lufkin Well Manager RPC to the mounting post or mounting bracket assembly.
3. Use Unistrut C-Channel for flexibility when mounting and positioning the Lufkin Well Manager RPC.

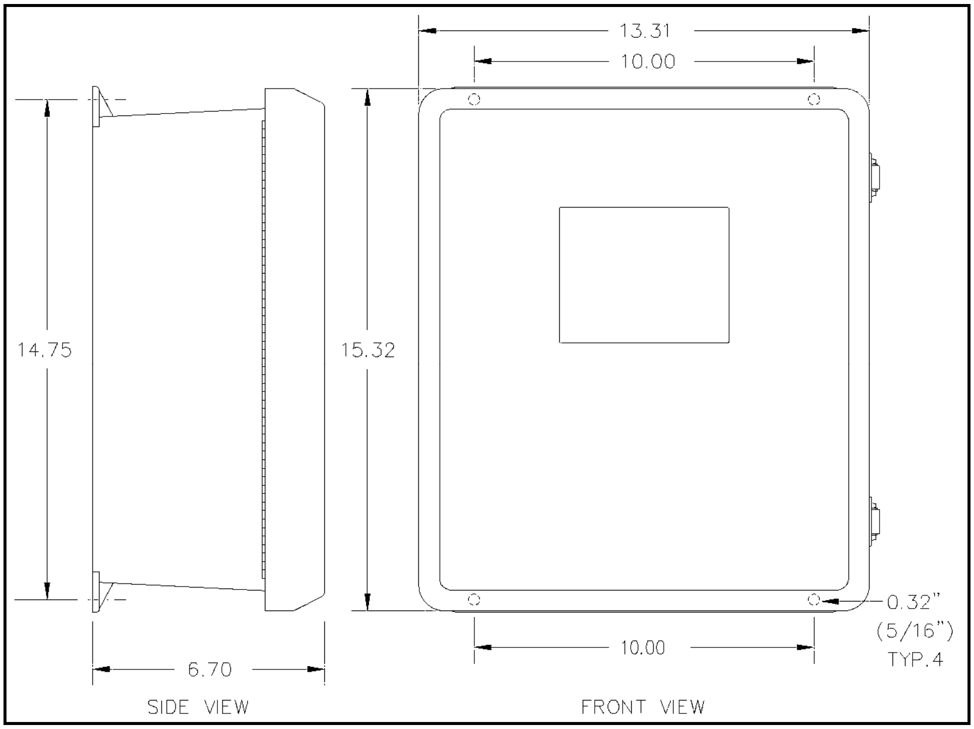


Figure 6-2. Enclosure Dimensions

4. If a radio unit is to be used, install the antenna mast, antenna, and lightning rod (optional) to the mounting post or mounting bracket above the Lufkin Well Manager RPC. 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. 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 Lufkin Well Manager RPC to the wellhead with #2 AWG stranded copper wire with green insulation. See section 6, “Wiring the System,” for more details. Lufkin Automation can provide a copper grounding lug (Part No. 151.0285) for connection at the Lufkin Well Manager RPC. Grounding must meet ANSI/IEEE C37.90.1 Surge Protection Standards. Proper earth grounding of the Lufkin Well Manager RPC 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*.

The Lufkin Well Manager RPC is now installed.

6.6 Installing the Motor Control Relay and the Optional Fault and Start Alert 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 Lufkin Well Manager 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 you select 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 12 VDC nominal and output rated to switch 480 VAC. 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 12 VDC nominal and output rated to switch 660 VAC. 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 12 VDC relay with a panel-mount socket, and voltage transient suppression diode. Output contacts are rated 12 Amp at 240 VAC maximum, and therefore are not suitable if the motor starter control voltage is 480 VAC. 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 12-VDC coil. SPDT output contacts are rated to switch up to 600 VAC. They are suitable for direct connection to the Lufkin Well Manager 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 120-VAC coil. SPDT output contacts are rated to switch up to 600 VAC. 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 Lufkin Well Manager RPC.

Contact your 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

- Voltmeter
- Two #8 screws
- Philips 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 without your knowledge.
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.

6.7 Installing the 101TL Beam Mount Transducer

This subsection describes how to position, mount, and if necessary, remove the 101TL beam mounted transducer.

6.7.1 Positioning on Different Pumping Units

Proper positioning of the 101TL beam mounted transducer on the walking beam is different for conventional units, Mark II units, and air-balanced units. This subsection describes how to position each pumping unit type.

1. Park the walking beam horizontally and set the brake.

2. Turn off all power at the main supply. Use a voltmeter to ensure that no power is present in the motor starter panel.

3. Turn off the Lufkin Well Manager RPC. If the Lufkin Well Manager RPC has an optional battery, it may have the Lufkin Well Manager RPC powered up even though the AC is no longer on.

4. Use the guidelines provided below to position the 101TL on your type of pumping unit.

    - **Conventional Units—228 or larger**
      Position the end of the 101TL with the housing 24 inches forward of the centerline of the Sampson post bearing and directly over the web of the walking beam.

    - **Conventional Units—smaller than 228**
      Position the 101TL six inches forward of the centerline of the Sampson post bearing.

    - **Mark II Units**
      Position the end of the 101TL 24 inches in back of the centerline of the Pitman Bearing and directly over the web of the walking beam.

    - **Large Air Balance Units**
      Position the end of the 101TL with the housing 12 inches forward of the air cylinder centerline and directly over the web of the walking beam.

    - **Small Air Balance Units**
      Position the end of the 101TL six inches behind the air cylinder center line. The distance from the air cylinder to the horsehead prevents the 101TL from being positioned 12 inches forward of the air cylinder center line.

The 101TL beam mounted transducer is now positioned on the pumping unit.

6.7.2 Welding to the Walking Beam

The 101TL welding pads are made of mild steel. Use the appropriate welding rod to assure good penetration into both the walking beam flange and the transducer mounting pad.

Note: The well load does not need to be removed from the walking beam when mounting the 101TL.

Follow the steps below to weld the 101TL beam mounted transducer to the walking beam.

1. Position the 101TL beam mounted transducer as described in the subsection, "Positioning on Different Pumping Units" (page 6-10).

2. Make a small tack weld on the outside end of one of the welding pads.

3. On the opposite end of the 101TL, make a one-inch pass across the end of the welding pad with equal penetration into the pad and the beam. Allow the weld to cool to touch. See Figure 6-3.

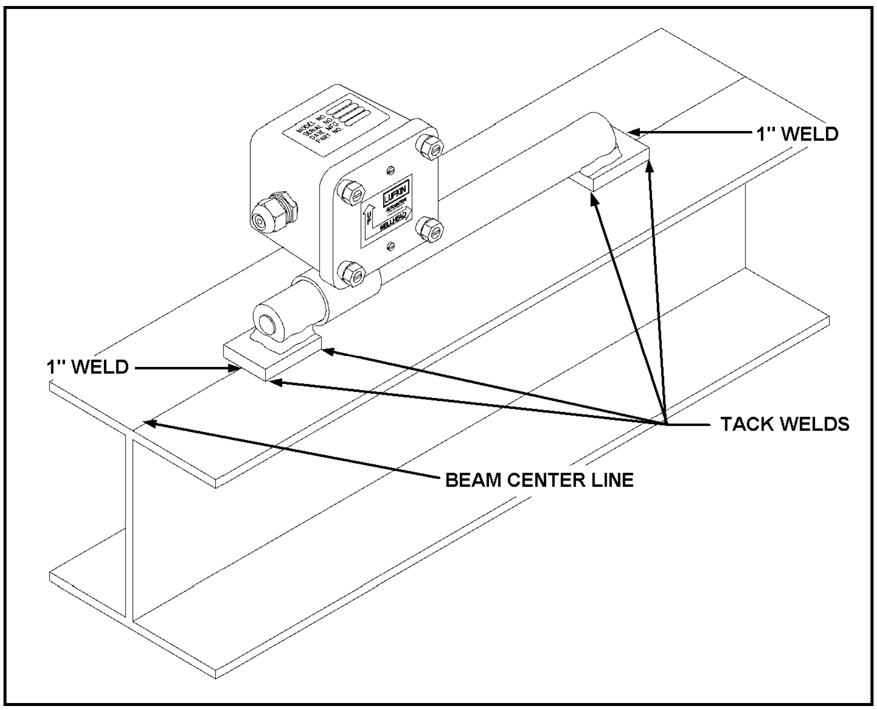


Figure 6-3. 101TL Transducer Welded on the Walking Beam

Note: Before you go to step 4, check the end with the tack weld made in step 2. If the weld is broken and that end is pulled up off of the beam, DO NOT press it back down on the beam. Pressing causes excessive stress on the gauge section of the beam transducer. Fill the gap as you do the weld described in step 4.

4. On the end of the transducer with the first tack weld, make a one-inch pass across the end of the welding pad with equal penetration into the pad and the beam.

Note: Allow the weld to cool to touch. Insufficient cooling between welding operations can cause thermal over-stressing of the transducer. Temperature in the gauge section should not exceed 350° F (177° C). Excessive heat on the gauged section of the transducer can cause damage to the strain gauges or the mounting epoxy.

5. Make small tack welds at the remaining corners on the heels of the welding pads. Keep these tacks on the outside edge of the corner so that they are more accessible to a grinder if the transducer needs to be removed in the future. See Figure 6-3 for weld locations.

The 101TL beam mounted transducer is now properly welded.

6.7.3 Removing the Beam Transducer

If you need to remove the 101TL transducer from the walking beam, use the procedure in this subsection.

Tools Required

- Small flat blade screwdriver
- High-speed abrasive cutoff grinder

Removal Procedure

Note: Do not use a blowtorch to remove the transducer from the beam. Do not beat or pry the transducer body.

1. Park the walking beam horizontally and set the brake.
2. Turn off all power at the main supply. Use a voltmeter to ensure that no power is coming to the motor starter panel.

3. Turn off the Lufkin Well Manager RPC. If the controller has an optional battery, it may have the Lufkin Well Manager RPC powered up even though the AC is no longer on.

4. Remove the load cable by disconnecting it from the terminal block in the condulet.

    a. Unscrew the four cover screws on the junction box and remove the cover.

    b. Use a screwdriver to loosen the small screws on the terminal strip, and remove the signal wires.

5. Cut the welds with a high-speed abrasive cutoff grinder. Cut welds completely; do not pry with a screwdriver to make final break.

The 101TL beam mounted transducer is now removed from the walking beam.

6.8 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 see Figure 6-4. 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

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

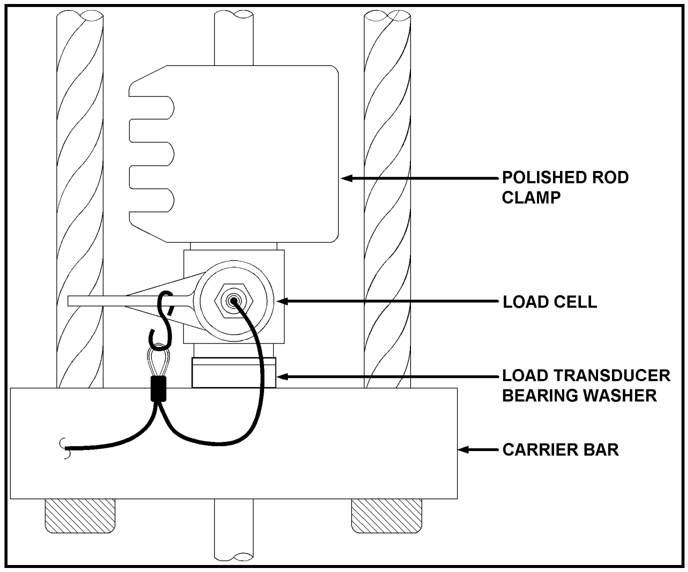


Figure 6-4. Polished Rod Load Cell Installed with a Spherical Leveling Washer Set

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.

DANGER: Keep fingers and hands out of harms 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 Lufkin Well Manager RPC. If it has an optional battery, it may have the Lufkin Well Manager RPC 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, such as

    - 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.

6.9 Installing the Inclinometer

A stand-alone inclinometer is an analog position input device that is not part of another device. It measures the angle of the walking beam and transmits a signal relative to this angle (or incline). It is mounted magnetically to the walking beam.

Installation Procedure

Follow the steps below to properly install the inclinometer.

1. Stop the pumping unit on the downstroke.

2. Turn off all power at the main supply. Use a voltmeter to ensure that no power is coming to the motor starter panel.

3. Turn off the Lufkin Well Manager RPC. If the Lufkin Well Manager RPC has an optional battery, it may have the Lufkin Well Manager RPC powered up even though the AC is no longer on.

4. Clean the surface of the walking beam web so that it is free of grease and rust scale. A clean surface ensures a good magnetic grip.

5. Place the inclinometer on the side of the walking beam web just in front of the saddle bearing. Be careful to position the inclinometer correctly using the “UP” and “WELL HEAD” arrows.

The inclinometer is now installed.

6.10 Installing the Combo Transducer

The 101TL Combo transducer includes both an inclinometer and the 101TL beam load transducer. Figure 6-3 (page 6-11) shows the 101TL Combo transducer mounted on a walking beam in the same manner and location as the 101TL beam transducer. The installation procedure is the same as that for the beam mounted transducer explained under the subsection, “Installing the Beam Mount Transducer,” on page 6-9.

6.11 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 your Lufkin Automation representative if you have problems. 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 6-5.

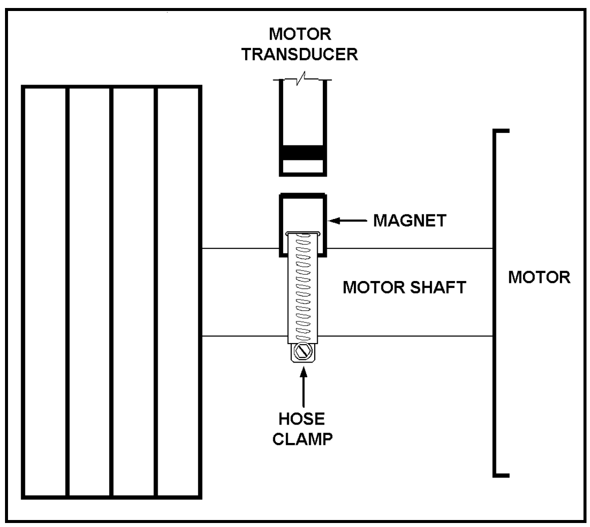


Figure 6-5. Motor Transducer Assembly Diagram Showing T-Bracket Linkage

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 6-6.

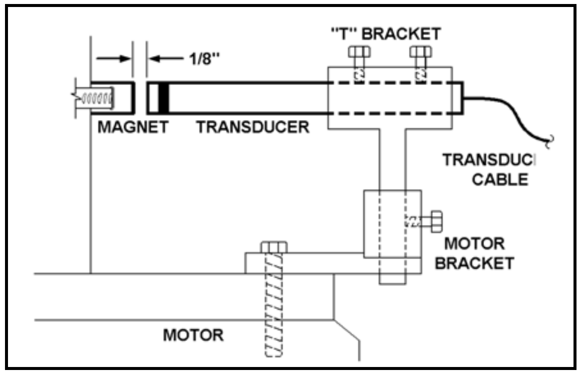


Figure 6-6. Motor Transducer Assembly

6. Tighten all bracket connections.

The RPM Hall-Effect transducer is now installed.

6.12 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. Lufkin Well Manager RPC units with firmware version 5.00 or later can make a firmware phase angle adjustment. If local safety regulations prevent mounting the sensor for bottom of stroke (counter weights up), the sensor can be mounted to sense the crank arm at or near the top of the stroke (counter weights down) and the Lufkin Well Manager RPC configuration can make the phase angle adjustment. For information about how to program the necessary phase angle adjustment, see “Configuring End Device Parameters” in section 8, “RPC Parameter Programming.”

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 bottom-dead-center.

    a. Align the crank and pitman. The centerlines of the pitman and the crank should be in perfect alignment. See Figure 6-7.

    b. Stop the unit near bottom dead-center.

    c. With the motor turned off, release the brake slowly and observe the direction that the cranks rotate.

    d. With this 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.

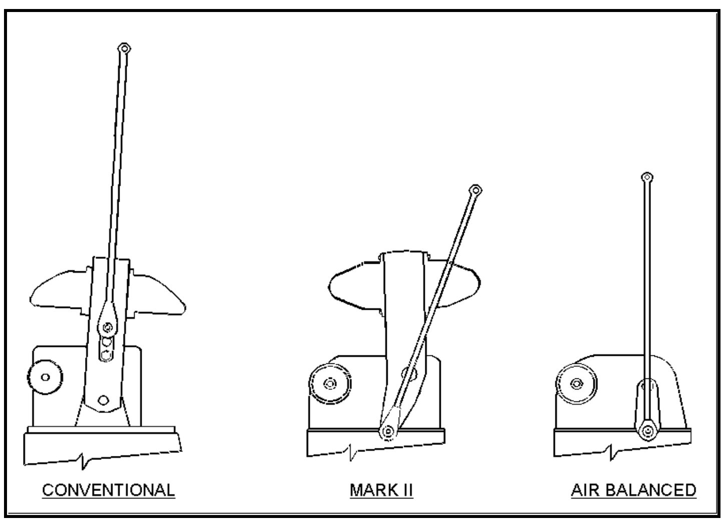


Figure 6-7. Crank/Pitman Alignment at Bottom Dead-Center

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 alignment until you attain perfect alignment.

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 Figures 5- 8 and 5- 9.

5. Use either method described below to mount a magnet.

   - **Bar magnet** (see Figure 6-8) — 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.

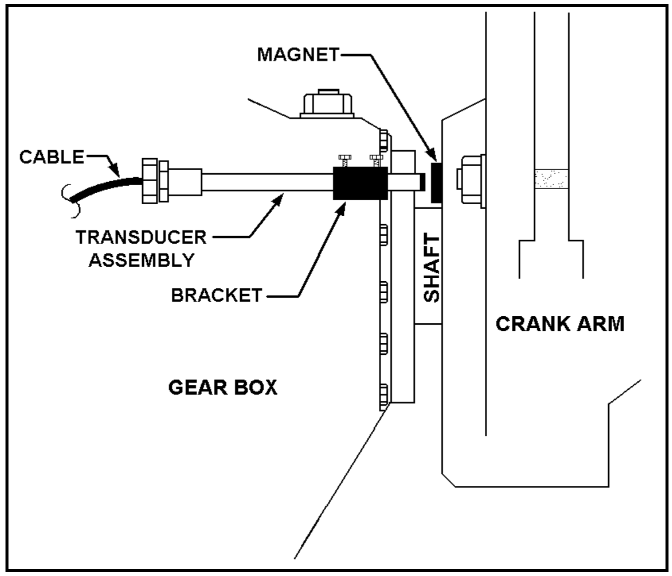


Figure 6-8. Bar Magnet Mounted on Back of Crank Arm

- **Round magnet** (see Figure 6-9) — 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.

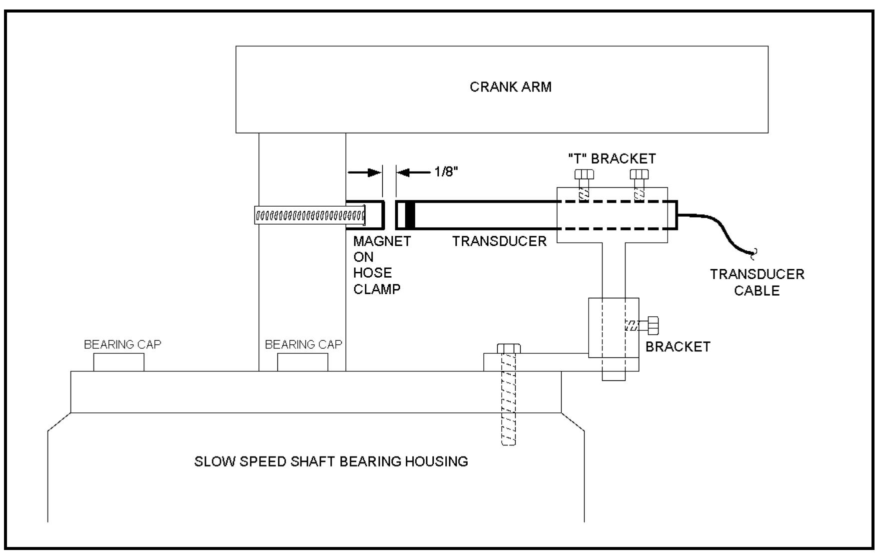


Figure 6-9. Round Magnet Mounted on Low Speed Shaft of Gearbox

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 6-10 for proper magnet alignment.). Tighten all connections securely.

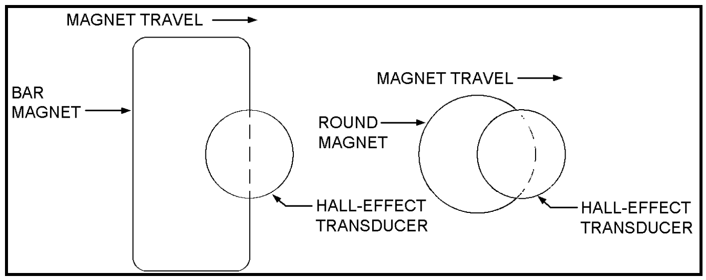


Figure 6-10. Proper Magnet Alignment

The crank arm Hall-Effect transducer is now installed.

Section 7

Wiring the System

This section describes how to wire the various components making up the Lufkin Well Manager RPC system. Following the wiring guidelines for the Lufkin Well Manager RPC and its accompanying devices is crucial for optimum performance.

The first topic in this section covers the recommended wiring specifications to follow for power wiring, system grounding, and shielding. Lists of tools recommended for effectively wiring the system are also provided. The remaining topics cover the wiring procedures for the Lufkin Well Manager RPC and its accompanying devices.

The topics covered in this section include:

Note: If the components you want to wire are not already installed (mounted), see section 5, “Installing the System” for instructions about proper installation.

7.1 Wiring Specifications and Recommended Tools

This subsection covers the recommended wiring specifications to follow for power wiring, system grounding, and shielding the Lufkin Well Manager RPC system. A list of the minimum tools recommended for effectively wiring the system is also provided.

Recommended Wiring Specifications

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

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

Signal Type	Minimum Wire Size	Number of Conductors	Shield	Comments
Power	16 AWG	2	No	Separate from signal wires
Earth Ground	#2 stranded	1	No	Keep short as possible
Analog Inputs	16 AWG	2	Preferred	Twisted pair preferred
Digital Inputs	18 AWG	2	Preferred	Twisted pair preferred

Signal Type	Minimum Wire Size	Number of Conductors	Shield	Comments
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 load cell, inclinometer, and/or Hall Effect transducers. Shields should be terminated only at the hinge mounting screw on the lower right-hand edge of the front panel on which the motherboard is mounted. This point is recognizable by the factory-installed green wire that connects the front panel to the system ground.

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.

Recommended Tools

Note: The terminal strips on the Lufkin Well Manager RPC motherboard for the load and position signal leads and the motor control output wiring are a pressure-clip type. To insert a wire, press the orange tab in with a small screwdriver (or your thumbnail), insert the wire, then release the orange tab. Terminals work better with leads that are not "tinned" with solder. You will probably want to clip off the "tinned" ends of the two Hall-Effect cables and strip back the insulation to expose the stranded wire. Terminal blocks are a plug-in type so that they can be removed for wire insertion and then plugged back in. Observe the "half moon" design that keys the terminal block for proper insertion.

To help make your wiring tasks easier, it is recommended that you have, at the very minimum, the following tools:

- Wire cutters
- Wire strippers
- Small flat-bladed (slotted) screw driver
- Voltage/ohmmeter (VOM)
- Slip joint or water pump pliers

7.2 Grounding the System

DANGER: Be very careful of power cables that are buried around the motor control box. Striking them will cause serious injury or death.

Proper earth grounding of the Lufkin Well Manager RPC is critical to minimize transient voltage that can damage the control system electronics. For the RPC application, Lufkin Automation recommends that you use the wellhead as the system ground electrode. Refer to Figure 7-1 for a visual of the grounding described below.

The ground post on the lower left corner of the Lufkin Well Manager RPC should be connected to the wellhead with an uninterrupted length of stranded #2 AWG green ground wire. Terminate the wire at the Lufkin Well Manager RPC ground post with an approved irreversible crimp connector and at the wellhead with an approved pipe ground clamp rated for #2 wire. Clean down the connection to the wellhead to bare metal before you install the clamp, and sufficiently coat it afterward to prevent any corrosion.

Lufkin Automation strongly recommends that the motor starter panel also be grounded to the wellhead, if it is not already. If you use this grounding method, you will not need to connect a green wire to the **GND** terminal of **TB-1** on the Lufkin Well Manager RPC. This method establishes a connection to earth, and any additional paths to ground could create ground loops. For information about choosing the location of the recommended ground rod, see Figure 7-1 and "Installing the Mounting Post and Ground Rod" in section 6, "Installing the System."

Connect the ground bus in the starter panel to the wellhead with an uninterrupted length of stranded #2 AWG green ground wire. Terminate the wire at the starter panel ground bus with an approved irreversible crimp connector and to the wellhead with an approved pipe ground clamp rated for #2 wire. Clean down the connection to the wellhead to bare metal before you install the clamp, and sufficiently coat it afterward to prevent any corrosion.

If the motor starter panel has a ground bus, connect it "in line" to the ground rod adjacent to the starter panel. If it does not have a ground bus, obtain one and install it according to the manufacturer's instructions. Connect the ground bus to the motor chassis with an uninterrupted length of stranded #2 AWG green ground wire. Use approved irreversible crimp connectors for the terminations at each end. Terminate the primary power service ground lead on the motor starter ground bus.

The system is now grounded.

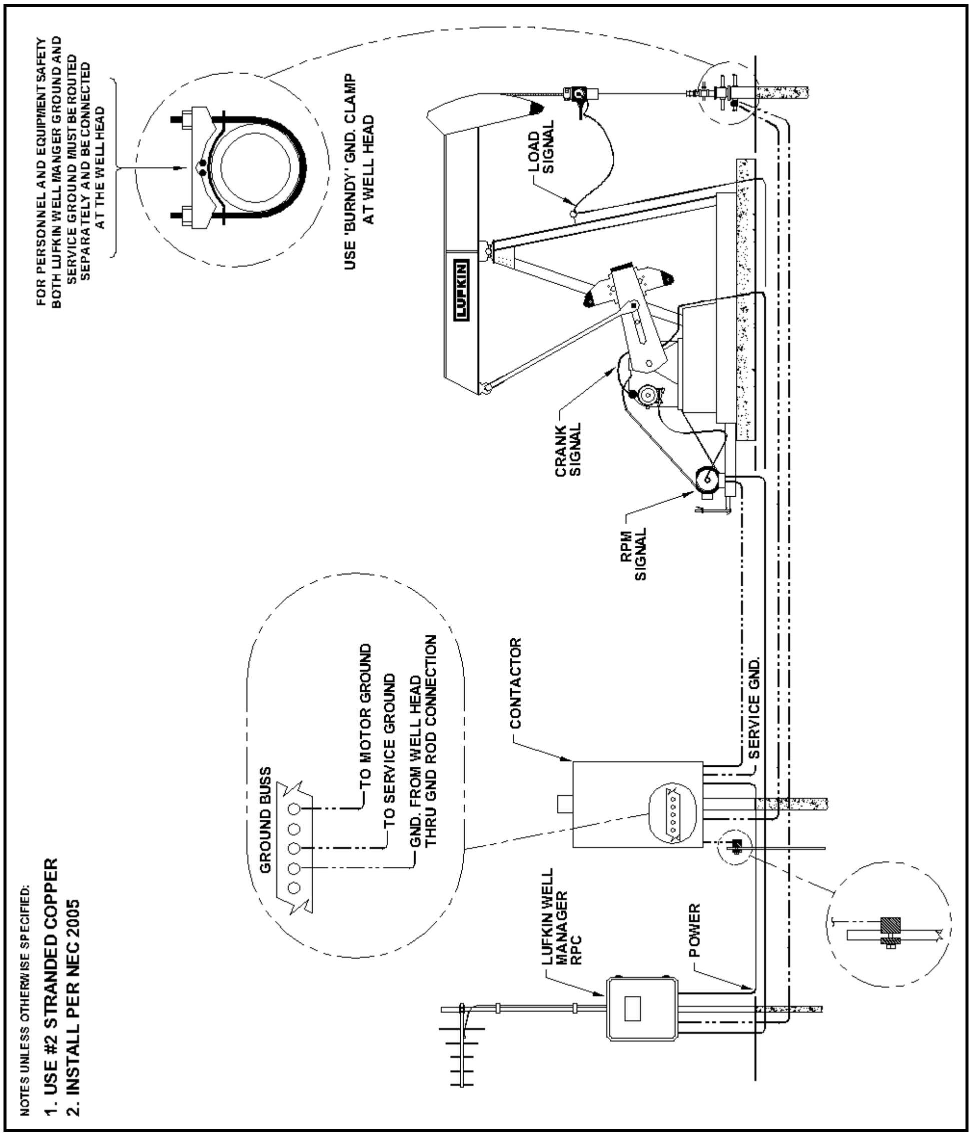


Figure 7-1. Typical Lufkin Well Manager RPC Installation

7.3 Wiring the Stepdown Transformer

The Lufkin Well Manager RPC requires primary power in the range of 85 to 264 VAC. In most cases, a stepdown transformer must be installed in the starter panel to convert 460 VAC to 115 VAC.

Two subsections are devoted to wiring the stepdown transformer to the motor starter panel and the Lufkin Well Manager RPC. Other components, such as the motor control relay (page 7-9) and the optional fault relay (page 7-11) have sections that explain how they are wired to the motor control circuit.

Refer to the suggested control panel wiring diagram in Figure 7-2 when wiring the stepdown transformer. Many types of motor starter panels are used with varied control wiring methods and control voltages. The suggested method in Figure 7-2 will obviously not work in every situation, but the general idea should provide a qualified electrician with enough information to figure out the best way to wire a particular control panel.

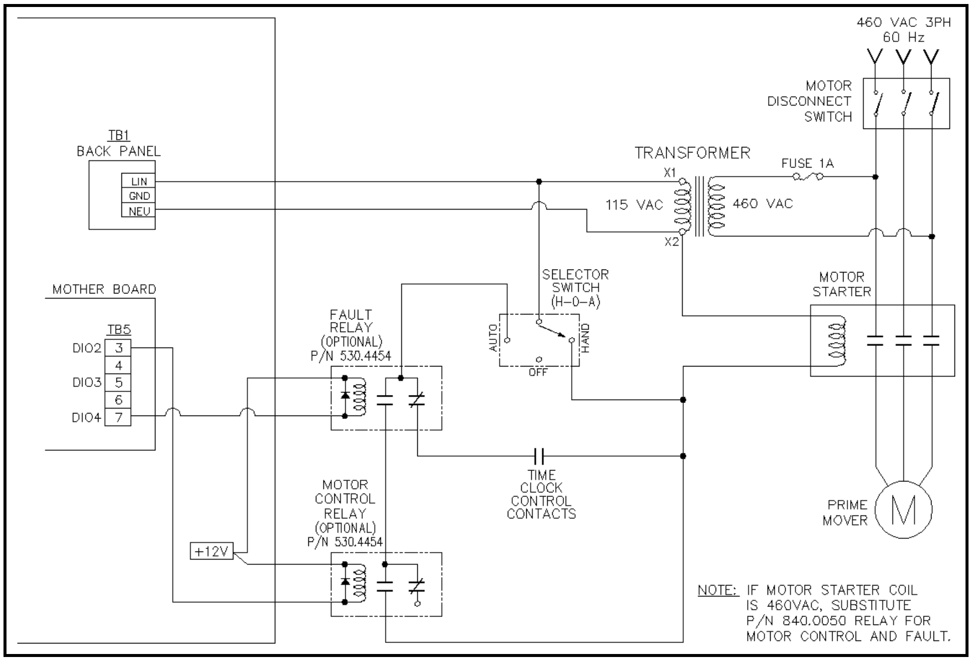


Figure 7-2. Power and Control Relay Wiring Diagram

7.3.1 Wiring the Stepdown Transformer to the Motor Starter Panel

To wire a stepdown transformer to the motor starter panel, follow the steps below:

1. Install the stepdown transformer using the instructions in section 5, “Installing the Stepdown Transformer.”

2. Determine the input side of the transformer by looking at the markings on the ends of the transformer.

3. MAKE SURE THE POWER IS OFF TO THE MOTOR STARTER PANEL. Use a voltmeter to check that no power is coming to the motor starter panel.

4. Cut two lengths of 18 to 12 gauge single-conductor wire that will reach from the transformer to the 460-VAC power source.

Note: A power source of 460 VAC is assumed. Other jumper arrangements on the transformer are available. See the diagram on the transformer.

5. Strip off approximately 1/4 inch of the insulation from the end of the wires and crimp a spade lug on one end of the wire.

6. Loosen a screw on the input side of the transformer and insert the wire under it. Tighten the screw.

7. Route the single conductor wires to the 460-VAC power source and strip off approximately one inch of insulation from the end of the wire.

8. Connect the two wires to the incoming 460-VAC power source at **L1** and **L2**.

Note: Some local codes require you to install fuses. The Lufkin Well Manager RPC has fusing for internal protection, but the 115-VAC power lines and the stepdown transformer are not protected from a short circuit condition. Therefore, Lufkin Automation recommends that you install fuses in the motor starter panel on the ends of the input wires.

The stepdown transformer is now wired to the motor starter panel.

7.3.2 Wiring the Stepdown Transformer to the Lufkin Well Manager RPC

Connect the Lufkin Well Manager RPC to the 115-VAC stepdown transformer located in the motor starter panel. Lufkin Automation recommens that you use, as a minimum, 16 gauge wire.

The wires should be connected to the AC power terminals on the Lufkin Well Manager RPC as follows (see Figure 7-3):

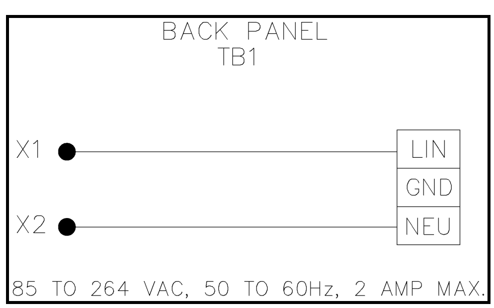


Figure 7-3. Stepdown Transformer to Lufkin Wiring Diagram

- 115 VAC to **Lin** on terminal
- 115 VAC neutral to **Neu** on terminal 3

The Lufkin Well Manager RPC is now wired to the stepdown transformer.

7.4 Wiring the Motor Control Relay

The motor control relay can be either a solid-state relay or an electro-mechanical relay labeled “Motor Control” (as shown in Figure 7-2).

To wire the motor control relay, follow the steps below:

1. Connect the motor control relay input to terminal block **TB5**, terminal 3 on the Lufkin Well Manager RPC logic board. The motor control relay has a set of normally open contacts that are wired in series with the coil circuit of the motor starter. The motor control relay provides a contact closure that energizes the motor starter contactor coil.

2. The Lufkin Well Manager RPC should be wired as follows:

   a. ***For solid-state relay option*** (Figure 7-4):

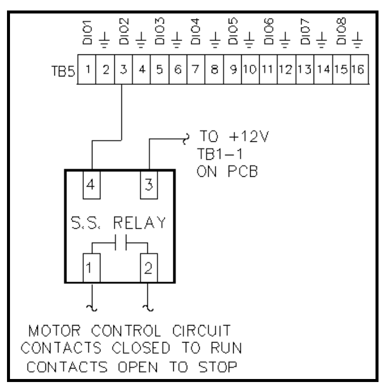


Figure 7-4. Solid-State Motor Control Relay Wiring to Lufkin

- Connect motor control relay terminal 4 to terminal strip **TB5**, terminal 3 on the Lufkin motherboard.
- Connect motor control relay terminal 3 to one of the **+12V** terminals provided on the Lufkin back panel, upper left.

   b. ***For electro-mechanical relay option*** (Figure 7-5):

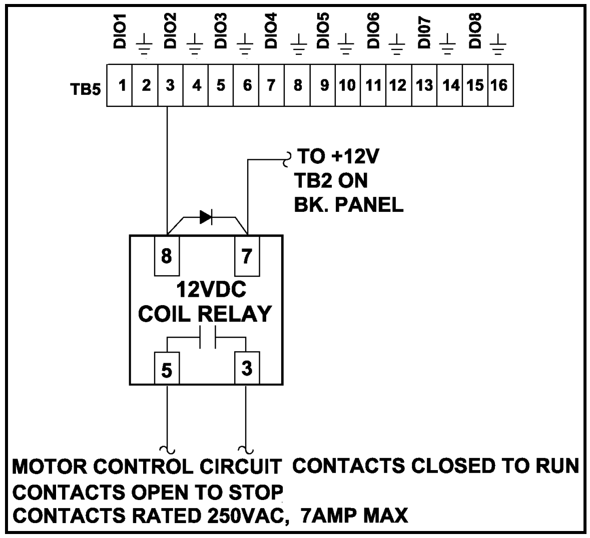


Figure 7-5. Electro-Mechanical Motor Control Relay Wiring to Lufkin

- Connect terminal 8 on the relay socket to terminal strip **TB5**, terminal 3 on the Lufkin Well Manager RPC motherboard.
- Connect terminal 7 of the octal socket to one of the **+12V** terminals provided on the Lufkin Well Manager RPC back panel, upper left.

3. Wire the control relay output contacts in series with the motor starter control circuit. See to Figure 7-2 for a suggested method.

   The motor control contacts can be wired into the motor control circuit in a number of ways. If the starter panel includes a time clock, it is critical that the control circuit avoids a conflict between the clock and the Lufkin Well Manager RPC. If the optional fault relay is not used, a good way to wire these panels is to add a second selector switch wired in to the Auto side of the H-O-A switch. Label it **POC – Clock** and wire the Lufkin Well Manager RPC contacts on the POC side. This approach allows the operator maximum flexibility. You can choose to do one of the following:

   - Pump continuously by switching the H-O-A to **Hand**.
   - Control using the clock by selecting **Auto** then **Clock**.
   - Allow the Lufkin Well Manager RPC to manage the well by selecting **Auto** then **POC**. Figure 7-6 is for this type of motor control approach.

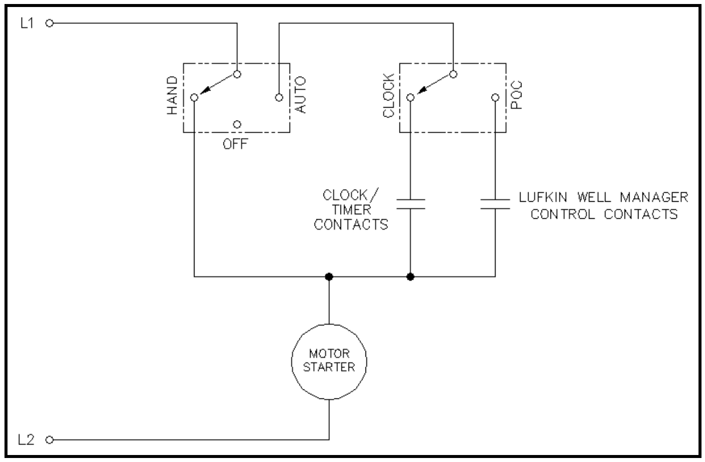


Figure 7-6. Control Circuit Wiring with Clock/POC Switch

The motor control relay is now wired.

7.5 Wiring the Optional Fault Relay

The optional fault relay switches control of the well to the time clock circuit if a microprocessor fault is detected or if 12-VDC power for the Lufkin Well Manager RPC is lost. Since the Lufkin Well Manager RPC normally keeps the fault relay energized, it is necessary to use a set of normally closed contacts that close when the fault relay de-energizes in the event of a fault or power failure. See Figure 7-2 (page 7-7) for a suggested wiring method.

The wiring sequence for wiring a fault relay to the Lufkin Well Manager RPC is as follows:

- Connect the fault relay “negative” terminal-to-terminal strip TB5, terminal 7 on the Lufkin Well Manager RPC motherboard.
- Connect the fault relay “positive” terminal to one of the +**12V** terminals provided on the Lufkin Well Manager RPC back panel, upper left.

Wire the fault relay output contacts as shown in Figure 7-2 (page 7-7).

7.6 Wiring the Start Alert Safety Relay

The optional start alert safety relay is connected to digital output #3, terminal strip TB5, terminal 5. A relay with coil voltage of 12 VDC must be used. Be sure that the relay contacts are sized to handle the voltage and current demands of the selected warning horn/light/siren.

The wiring sequence for wiring a start alert safety relay to the Lufkin Well Manager RPC is as follows:

- Wire the plus terminal of the coil to one of the **+12V** screw terminals on the Lufkin Well Manager RPC back panel.
- Wire the negative coil terminal to **TB5-5** on the motherboard.
- Connect a normally open set of contacts in series with the selected alarm device power circuit.

7.7 Wiring the 101TL Beam Mounted or Combo Transducer

Use the following procedures to route the cable from the 101TL beam mounted transducer to the Lufkin Well Manager RPC. Consult the wiring diagram in Figure 7-7 to wire a 101TL transducer and Figure 7-8 to wire a 101TL Combo transducer.

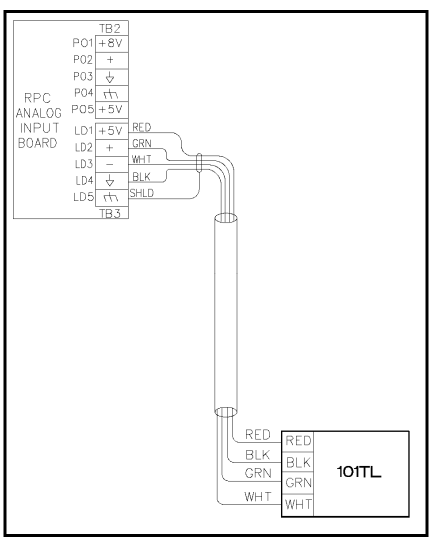


Figure 7-7. 101TL to Lufkin Well Manager RPC Wiring Diagram

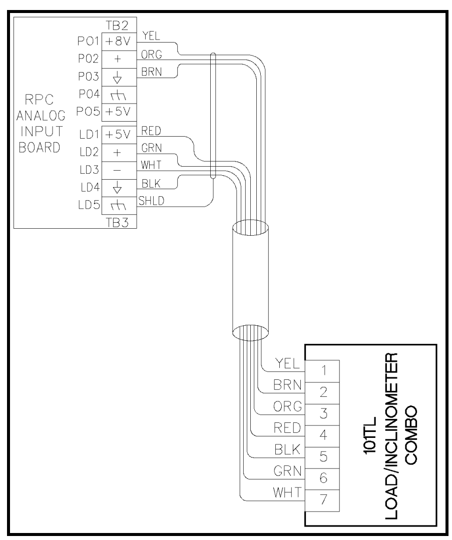


Figure 7-8. 101TL Combo to Lufkin Well Manager RPC Wiring Diagram

7.7.1 Recommended Cable

Lufkin Automation offers a four-conductor (Part No. 509.1301) and seven-conductor (Part No. 509.1700) shielded signal cable for load and position transducer wiring. Separate #18 AWG conductors in conduit is an acceptable alternative. If separate #18 AWG conductors are used, Lufkin Automation recommends that you use wire colors consistent with those shown in Figure 7-7 and Figure 7-8. Consistent color-coding aids in troubleshooting.

7.7.2 Routing the Cable

Follow the steps below to route the signal cable from the 101TL beam mounted transducer to the Lufkin Well Manager RPC.

1. Unscrew the condulet cover.

2. For four-conductor cable (or seven-conductor cable for Combo), install a CGB193 bushing assembly in the condulet, if not present. Standard 101TL assemblies should include a CGB connector.

3. Disassemble the CGB bushing assembly by unscrewing the cap and removing the compression washer and rubber bushing.

4. Place the cap, compression washer, and rubber bushing, in this order, on the cable. Cap threads should face towards the end of the cable. Face the concave side of the compression washer towards the end of the cable. The narrow end of the rubber bushing should face towards the end of the cable.

5. Route the end of the cable through the CGB body, leaving approximately six inches of cable extending out of the top of the condulet.

6. Tighten the CGB cap and bushing assembly part of the way into the body of the condulet. This is done to keep the cable from falling out of the condulet while it is being routed to the Lufkin Well Manager RPC.

7. Use a Hilti gun to shoot 1/4 x 20 Hilti studs into the pumping unit structure.

8. Route the cable to the Lufkin Well Manager RPC using cable clips and 1/4 × 20 nuts to secure the cable to Hilti studs.

Lufkin Automation can provide cable clamps in two sizes:

- Four-conductor cable (Part No. 291.2008)
- Seven-conductor cable (Part No. 291.2009)

Note: When routing the cable from the 101TL to the Lufkin Well Manager RPC, allow enough loose cable at the transition point from the walking beam to the Sampson post to accommodate the walking beam motion.

Alternate methods for securing the cable to the pumping unit are available. For example, if you are using cable in conduit, you could use parallel or par clamps to attach the conduit to the pumping unit. Consult your Lufkin Automation representative to determine the best method for securing the cable to the pumping unit.

7.7.3 Wiring the Cable to the Transducer

Follow the steps below and Figure 7-7 or Figure 7-8 as appropriate to wire the cable to the 101TL beam mounted transducer.

1. If a CGB193 bushing assembly is not already present in the condulet, install one.
2. Strip off six inches of the cable cover extending out of the top of the condulet until it is flush with the inside edge of the condulet. Remove the stress relief material so that only the insulated wire remains.
3. Trim back the wires to four inches in length.
4. Strip back the insulation about 1/4 inch from the end of the signal leads.
5. Access the terminal strip.
   - ***For a Combo unit***, loosen the small screws on the terminal strip mounted on the circuit board plugged in to the inclinometer. You can unplug the board for easier wire insertion, but be careful to note proper orientation since the plug is not keyed. Plugging the connector in backwards will not destroy anything, but the analog position signal will not be correct
   - ***For a 101TL load transducer with no inclinometer***, a barrier type terminal strip is provided. Crimp the spade or ring lugs on to the signal leads for best results.

6. Connect the signal leads to the terminal strip provided in the sequence indicated in the appropriate section of Figure 7-7 and Figure 7-8.

7. Tighten the small screws to firmly attach the wires.

Note: While the cover is off of the inclinometer assembly, check the configuration of the small black shorting jumper on the side of the inclinometer. For proper operation with the Lufkin Well Manager RPC, the jumper must be removed so that both pins projecting from the inclinometer are NOT connected. The jumper can be stored by placing it on one pin only.

---

8. Reinstall the top cover of the condulet, and tighten the retaining screws.

The signal cable is now wired to the 101TL beam mounted transducer, and you are now ready to wire the cable to the Lufkin Well Manager RPC.

7.7.4 Wiring to the Lufkin Well Manager RPC

Follow the steps below Figure 7-7 or Figure 7-8 to wire the 101TL beam mounted transducer or 101TL Combo transducer to the Lufkin Well Manager RPC.

1. Route the wire into the Lufkin Well Manager RPC enclosure through the 7/8-inch hole for the 1/2-inch conduit in the bottom the Lufkin Well Manager RPC enclosure. Use a CGB cable connector to hold the cable and seal it if the cable is not run in conduit.

   If the wiring is in conduit, the 1/2-inch conduit terminates in the 7/8-inch hole in the bottom of the Lufkin Well Manager RPC enclosure.

2. Strip off the outer insulation and remove the stress relief material so that only the insulated wire is remains.

3. Strip back the insulation about 1/4 inches from the end of all wires.

4. Insert the wires in the appropriate terminals in **TB3** or **TB2** on the Load/Position analog input board that is plugged in to the Lufkin Well Manager RPC motherboard as indicated in Figure 7-7 or Figure 7-8.

The 101TL beam mounted transducer (or Combo Transducer) is now wired to the Lufkin Well Manager RPC.

7.8 Wiring the Polished Rod Load Cell

The wiring procedures in this subsection cover the polished rod load cell (PRLC). Use the following procedures to route and wire the cable from the PRLC to the Lufkin Well Manager RPC. Consult the wiring diagram in Figure 7-9.

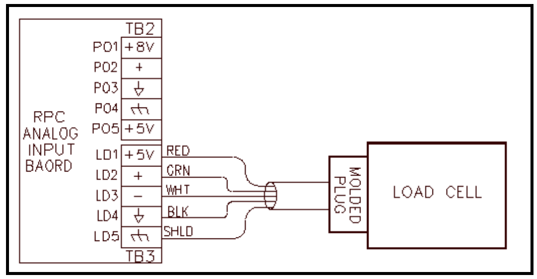


Figure 7-9. PRLC to Lufkin Well Manager RPC Wiring Diagram

7.8.1 Recommended Cable

For the easiest installation, Lufkin Automation provides a load cell cable with a Molex connector that mates with the PRLC. A CGB-type cable connector/seal is included. A 50-foot assembly (Part No. 510.5200) is carried in stock. Other lengths are available.

Alternately, a four-conductor shielded cable (Part No. 509.1301) can be used. To mate with the PRLC, a kit (Part No. 059.0100) is available that includes a Molex connector shell, crimp pins, and a CGB connector. A Molex crimping tool (Part No. 045.0001) is required for crimping the pins to the cable leads. A cable support kit (Part No. 069.0004) is also available that includes hardware to provide physical strain relief for the load cell cable at the Sampson post. A Mark II cable support post (Part No. 291.5000) is also available. Contact your Lufkin Automation representative to order any of these accessories.

Recommended Tools

To help make your wiring procedures easier, you should have the following tools:

- Wire cutters
- Wire strippers
- Crimping tool (optional)
- Slip joint or water pump pliers

7.8.2 Routing the Cable

Follow the steps below to route the cable for the PRLC.

1. Install the Sampson post strain relief beam clamp included in the Cable Support Kit (Part No. 069.0004) and screw the eyebolt in to the clamp. Mount it at a point on the Sampson post that is opposite the PRLC at the mid point of the stroke. If the unit is a Mark II type, an optional cable support post (Part No. 291.5000) can be installed on the front side of the gear box under one of the flange bolts at the gear reducer parting line. This post provides a stable anchor point for the load cell cable. Contact your Lufkin Automation representative for suggestions to route load signal cable.

2. At the PRLC, plug the molded Molex connector into the PRLC socket. Note that the connector is keyed so that it only fits one way. Be sure that the connector is firmly seated. Thread in the CGB cable connector/seal and tighten it with pliers. Connect the S-hook strain relief to the hole in the arm of the PRLC.

3. Determine the amount of working loop for the PRLC cable. With the polished rod at its lowermost point, hold the load cable at the Sampson post strain relief clamp, and pull it towards you until all slack is removed. Add two to three feet to this distance and clamp on the mechanical support thimble at this point. Connect the thimble to the clamp eyebolt using the shackle included in the cable support kit.

You are now ready to wire the signal cable at the Lufkin Well Manager RPC.

7.8.3 Wiring to the Lufkin Well Manager RPC

Follow the steps below and Figure 7-9 to wire the PRLC cable to the Lufkin Well Manager RPC.

1. Route the PRLC cable into the Lufkin Well Manager RPC enclosure through the 7/8-inch hole for the 1/2-inch conduit in the bottom the Lufkin enclosure. Use a CGB cable connector to hold the cable and seal it if the cable is not run in conduit.

2. If the wiring is in conduit, the 1/2-inch conduit terminates in the 7/8-inch hole in the bottom of the Lufkin Well Manager RPC enclosure.

3. Strip off the outer insulation and remove the stress relief material so that only the insulated wire is left.

4. Strip back the insulation about ¼ inch from the end of the red, black, green, and white wires.

5. Insert the wires, including the shield, in the appropriate terminals in **TB3**.

The PRLC is now wired to the Lufkin Well Manager RPC.

7.9 Wiring the Inclinometer

The wiring procedures in this subsection cover the inclinometer. Use the following procedures to route and wire the cable from the inclinometer to the Lufkin Well Manager RPC. Consult the wiring diagram in Figure 7-10.

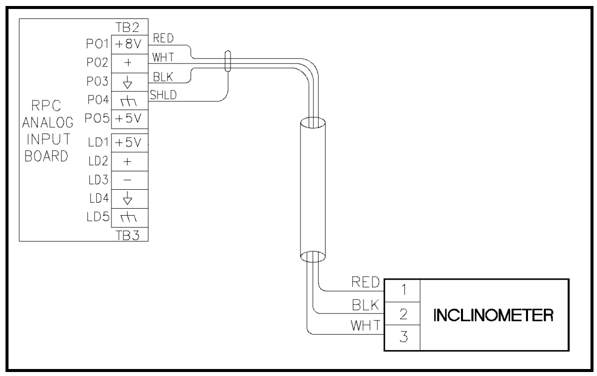


Figure 7-10. Inclinometer to Lufkin Well Manager RPC Wiring Diagram

7.9.1 Recommended Cable

A four-conductor, #20 AWG cable (Part No. 509.1301) is recommended.

7.9.2 Wiring the Cable to the Inclinometer

Lufkin Automation recommends that the signal cable leads be terminated in the inclinometer assembly before mounting the inclinometer in place on the side of the walking beam. Working on the ground is much easier and safer than working up on the pumping unit.

Follow the steps below to wire the cable to the inclinometer.

1. Remove the cover of the inclinometer assembly.

2. If necessary, install a CGB type connector. The standard magnet mount inclinometer assembly should include a connector for the signal cable.

3. Strip off six inches of the outer covering of the signal cable. Remove the stress relief material so that only the insulated wire and the shield wire remains.

4. Run the cable through the CGB connector so that the outer covering is flush with the inside edge of the connector.

5. Tighten the CGB connector.

6. Strip back the insulation about 1/4 inch from the end of the red, black, and white wires. Cut off the shield wire to keep it from accidentally shorting other connections.

7. Loosen the small screws on the terminal strip mounted on the circuit board plugged in to the inclinometer. You can unplug the board for easier wire insertion, but be careful to note proper orientation since the plug is not keyed. Plugging the connector in backwards will not destroy anything, but the analog position signal will not be correct.

8. Insert the red, black, and white wires to the strip in the sequence indicated in Figure 7-10.

9. Tighten the small screws to firmly attach the wires. Plug the terminal board back in to the inclinometer if removed.

Note: While the cover is off of the inclinometer assembly, check the configuration of the small black shorting jumper on the side of the inclinometer. For proper operation with the Lufkin Well Manager RPC, the jumper must be removed so that both pins projecting from the inclinometer are NOT connected. The jumper can be stored by placing it on one pin only.

10. Reinstall the top cover of the condulet. Mount the inclinometer on the side of the walking beam.

The cable is now wired to the inclinometer. You are now ready to route the cable to the Lufkin Well Manager RPC.

7.9.3 Routing the Cable

Follow the steps below to route the cable for the inclinometer.

1. Use a Hilti gun to shoot 1/4 x 20 Hilti studs into the pumping unit structure.

2. Route the cable to the Lufkin Well Manager RPC using cable clips and 1/4 x 20 nuts to secure the cable to Hilti studs.

Note: When routing the cable from inclinometer to the Lufkin Well Manager RPC, allow enough loose cable at the transition point from the walking beam to the Sampson post to accommodate the walking beam motion.

Alternate methods of securing the cable to the pumping unit are available. For example, if using cable in conduit, you could use parallel or par clamps to attach the conduit to the pumping unit. Consult your Lufkin Automation representative to determine the best method of securing the cable to the pumping unit.

7.9.4 Wiring to the Lufkin Well Manager RPC

Follow the steps below and consult Figure 7-10 (page 7-18) to wire the inclinometer cable to the Lufkin Well Manager RPC.

1. Route the wire into the Lufkin Well Manager RPC enclosure through the 7/8-inch hole for the 1/2-inch conduit in the bottom the Lufkin Well Manager RPC enclosure. Use a CGB cable connector to hold the cable and seal it if the cable is not run in conduit.

   If the wiring is in conduit, the 1/2-inch conduit terminates in the 7/8-inch hole in the bottom of the Lufkin Well Manager RPC enclosure.

2. Strip off the outer insulation and remove the stress relief material so that only the insulated wire is left.

3. Strip back the insulation about 1/4 inch from the end of the red, black, and white wires.

4. Insert the wires, including the shield, in the appropriate terminal in **TB2**. Consult Figure 7-10.

The inclinometer is now wired to the Lufkin Well Manager RPC.

7.10 Wiring Hall-Effect Transducers

Hall-Effect transducer cables are a molded assembly pre-wired at the sensor end. The only field wiring necessary is to connect the leads at the Lufkin Well Manager RPC. Use the following procedures to route and wire the cable from the Hall-Effect transducers to the Lufkin Well Manager RPC. Consult the wiring diagram in Figure 7-11.

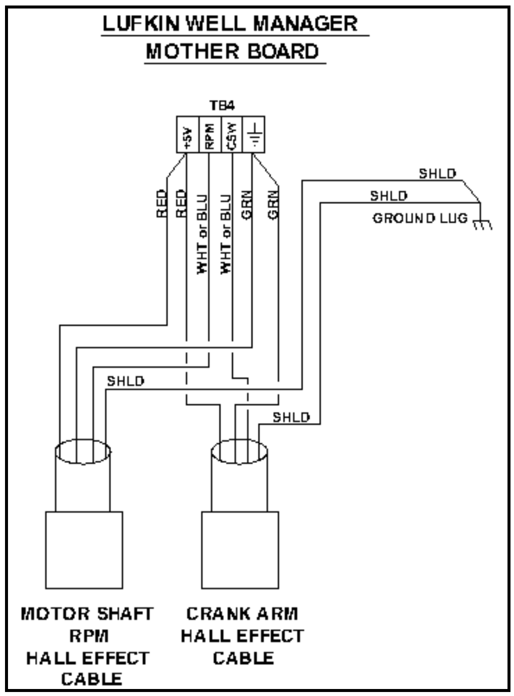


Figure 7-11. Hall-Effect Transducer to Lufkin Well Manager RPC Wiring Diagram

1. Route the two cables into the Lufkin Well Manager RPC enclosure through the 7/8-inch hole for the 1/2-inch conduit in the bottom the Lufkin Well Manager RPC enclosure. Use a CGB cable connector to hold each cable and seal it if the cable is not run in conduit.

2. Strip off the outer insulation and remove the stress relief material so that only the insulated wire is left. Be careful not to strip off the label that identified the cable as either **RPM** or **Crank**.

3. Strip back the insulation about 1/4 inch from the end of the red, and white wires on each cable.

4. Insert the wires in the appropriate terminal in **TB4**. Consult Figure 7-11. Take care that the white lead from the cable marked **RPM** is inserted in terminal 2 (**RPM**), and that the white wire from the cable labeled **Crank** is inserted in terminal 3 (**CSW**).

Note: It is necessary to insert the red wire from both cables into terminal 1 **+5V**, and the green wire from both cables into terminal 4. It will probably be necessary to cut off the "tinned" end of the wires to get both to fit.

5. Terminate the shields at the hinge mounting screw in the lower right corner of the front panel.

The Hall-Effect transducers are now wired.

7.11 Wiring Expansion Boards

Each expansion board (520.5002 and/or 520.5003) is provided with a 1/4-inch quick connect terminal for an earth ground connection (chassis ground). Each expansion board assembly also includes a green ground wire. It is imperative that the ground wire be connected. Figure 7-12 shows typical field wiring for auxiliary/expansion analog and digital inputs and outputs.

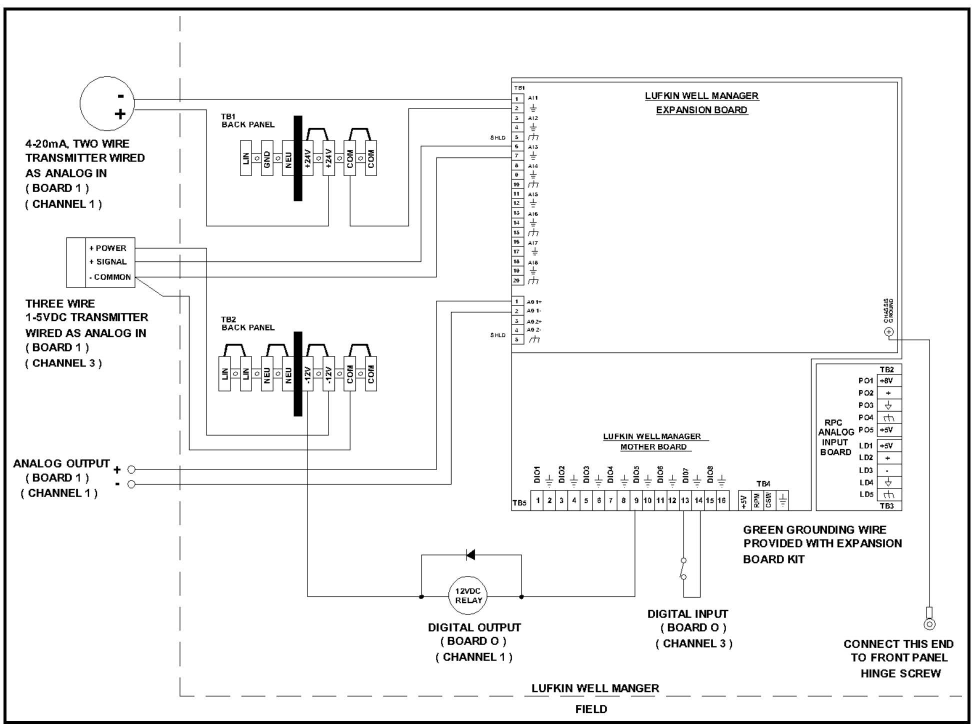


Figure 7-12. Typical Auxiliary Input and Output Field Wiring

7.12 Performing Power-Up Voltage Checks

WARNING: Power-up voltage checks should only be performed by a qualified technician who has experience working with the motor control box and its high-voltage circuits.

Use this procedure to make sure that the Lufkin Well Manager RPC is receiving proper voltage from the motor control box and that the proper voltage is provided to the Lufkin Well Manager RPC.

Tools Required

- AC/DC voltmeter

Power-Up Check Procedure

Follow the steps below to make sure the proper voltage is connected to the Lufkin Well Manager RPC.

1. Do all the following in this order:

   a. Make sure the power switch for the Lufkin Well Manager RPC is turned to OFF.

   b. Turn the HOA switch in the OFF position.

   c. Turn on the main power switch to the motor control panel.

2. Use an AC voltmeter to check for 110-120 VAC between the terminals labeled **LIN** and **NEU** on terminal strip on the lower left corner of the Lufkin Well Manager RPC back panel.

   - If the voltage is correct, go to the next step.

   - If the voltage is not correct, check wiring to the stepdown transformer and the fuses associated with the transformer.

3. Leave the H-O-A switch switched to OFF and the main power switch to the motor switched to ON, and then turn on the Lufkin Well Manager RPC. The power On/Off switch is located on the front cover.

4. Release the unit brake and turn the H-O-A switch to the position wired for control by the Lufkin Well Manager RPC. The unit should start.

5. If Hall-Effect transducers are used as the position input, observe the RPM and CSW lights on the left edge of the Lufkin motherboard. The RPM should be blinking on and off at a rapid rate and the CSW light should blink 0n once a pump cycle as the magnet on the crank arm passes the Hall-Effect sensor.

Wiring is now complete and you are ready to program the Lufkin Well Manager RPC.

Section 8

RPC Parameter Programming

Several parameters need to be defined in the Lufkin Well Manager RPC in order to obtain well control, end device calibration, and downhole calculations. This section describes the programming screens for these parameters and how to access them.

The topics covered in this section include:

8.1 Overview of RPC Parameter Programming

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

- End device parameter configuration
- Pumping unit dimensions
- Rod string data
- Control mode (surface, downhole, VSD downhole, etc.)
- Operation mode (normal, host, or timed)

General RPC 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 you should do the initial programming using the Quick Start feature. Later on, you can revise the control parameters by returning to Quick Start or by accessing the specific programming screens you need. For information about Quick Start, see section 18, "Quick Start Feature."

MENU 2

All programming screens for RPC functions are accessed through the Programming Menu screen (Figure 8-1). To display this screen, select **2. PROGRAMMING** from the Main Menu screen. Use the menu map provided in section 2 to help you navigate to the screen you need. Descriptions about each RPC parameter programming screen (including field descriptions) are described throughout this section.

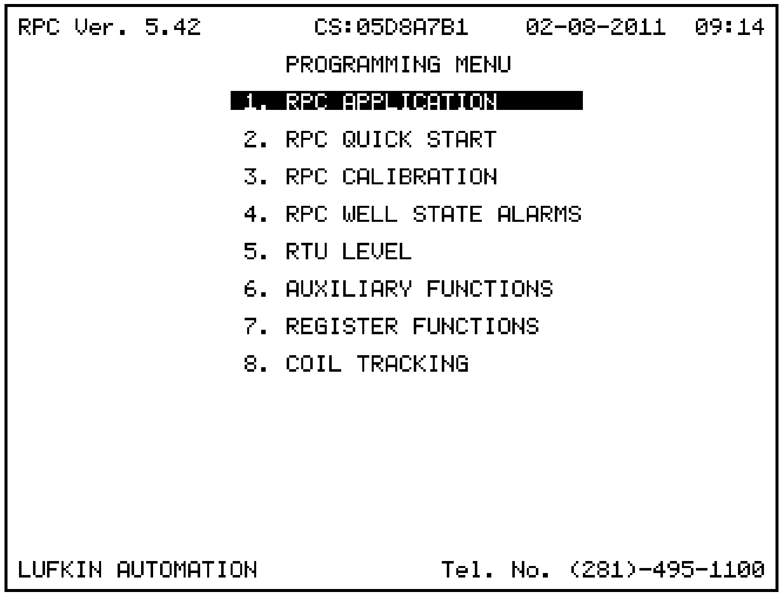


Figure 8-1. Programming Menu Screen

Note: A user password is required to access the Programming Menu screen if password protection is enabled. For information about passwords, see “Changing Passwords” in section 9 “Lufkin Parameter Programming.”

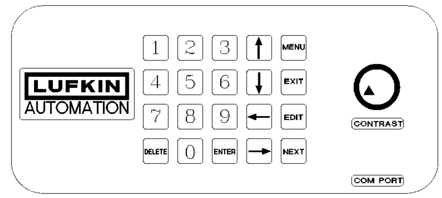
8.1.1 RAM Backup Protection

Many of the parameters programmed for rod pump control are stored in RAM on the Lufkin Well Manager RPC circuit board. This memory is supported during power outages by a lithium battery located near the top of this circuit board. Failure to include the battery will cause the Lufkin Well Manager RPC to loose programming when the power switch is turned off.

Before programming the Lufkin Well Manager RPC, ensure that the shorting jumper is on both pins so that the battery is included in the circuit. Battery disconnect jumper pins are located next to the battery. If the battery is not included, the Lufkin Well Manager RPC will loose programming when the power switch is turned off. The battery jumper configuration can be checked by looking down between the optional expansion board (if installed) and the main board from the top. If the jumper is not on both pins, the expansion board must be temporarily removed to properly place the jumper. For more information about the battery, see “Battery Disconnect Jumper Pins” in section 5, “Hardware Configuration.”

8.1.2 Operator Interface Keypad Programming

All programming parameter values can be entered through the 20-key operator interface keypad mounted in the Lufkin Well Manager RPC enclosure. This operator interface allows you at the wellsite to program and calibrate the Lufkin Well Manager RPC, and access and display current and historical data instead of using the *Dynalink* operator interface program that runs on a laptop computer. For information about the keypad and how to use it, see “Controller Operator Interface” in section 2, “Description of the Lufkin Rod Pump Controller System.”



8.1.3 Parameter Programming Procedure

Most screens use the same procedure to edit (program) control parameters. The procedure involves displaying the screen you need, highlighting the field with the parameter, editing the parameter value, saving it to the Lufkin Well Manager RPC, and then repeating the steps for the next parameter. When a procedure is unique to the screen or additional steps are required, its procedure is provided after the screen description.

The procedure provided below is used for most screens.

1. Display the screen that has the parameters you want to edit.

2. Press <↑> or <↓> to highlight the field you want to edit.

3. Do one of the following:

   - ***To enter numerical values***, press **<EDIT>** and then press the number keys. After you press a key, the next digit to the right highlights. You can press <**←**> to return to a digit to the left to change it. After all numerical values are correct, press **<ENTER>**.

   - ***To select field options***, press **<EDIT>**, press <↑> or <↓>, and then press **<ENTER>**.

   The next field highlights.

4. Repeat step 3 for each field you want to edit.

5. When you are finished editing fields, do either of the following.

   - Press **<EXIT>** to return to the menu screen from where you selected the screen you edited.

   - Press **<MENU>** to return to the Main Menu screen.

Your parameter values are saved to the Lufkin Well Manager RPC.

8.2 RPC Parameter Programming

MENU 2/1

Most parameters required for complete rod pump control functionality are programmed through the RPC Parameters Menu screen (Figure 8-2). To display this menu, select **1. RPC APPLICATION** from the Programming Menu screen.

Note: Additional RPC parameter programming is configured through options available under the RPC Calibration Menu screen (page 8-63).

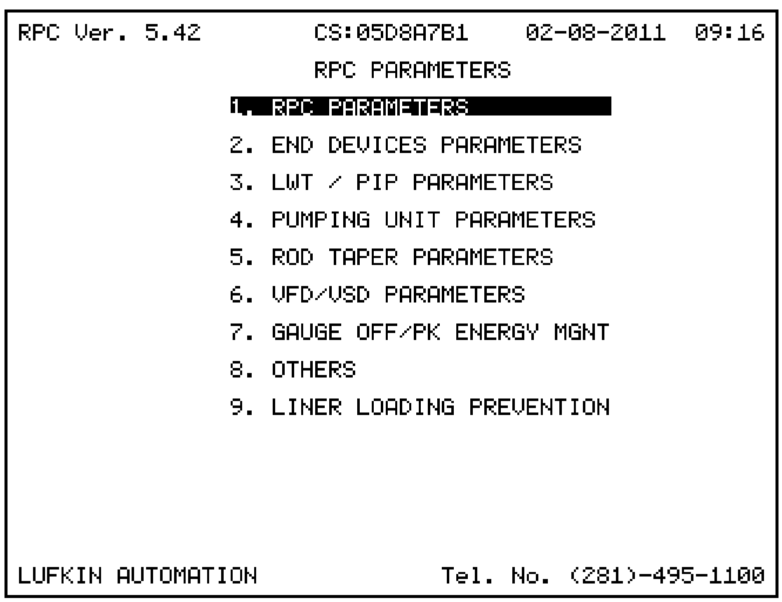


Figure 8-2. RPC Parameters Menu Screen

Note: All parameter units may be displayed in English, Metric, or a combination of units of measurement systems. For information about programming the display units used for the data fields, see “Units of Measurement Configuration” in section 9, “Lufkin Parameter Programming. The RPC parameter programming section is written assuming that American English units are used. If you have selected other units of measurement, the programming screens illustrated below will reflect that choice and you should enter data in the measurement units indicated on your actual screen.

RPC parameter programming includes the following:

- General RPC control parameters
- Type of end devices to be used
- Lufkin Well Test (LWT) and Pump Intake Pressure (PIP) parameters
- Pumping unit dimensions required for Hall-Effect transducer installations
- Rod tapers for downhole control
- Variable speed drive (VSD) control parameters for optional variable speed control systems
- Gauge off time (GOT) and Peak Energy Management parameters

Each of these programming operations is described below.

8.3 General RPC Parameters

MENU 2/1/1

The RPC Parameters menu (Figure 8-3) is used to program general RPC parameters. General RPC parameter programming must be completed for the rod pump control features of the Lufkin Well Manager RPC to function properly.

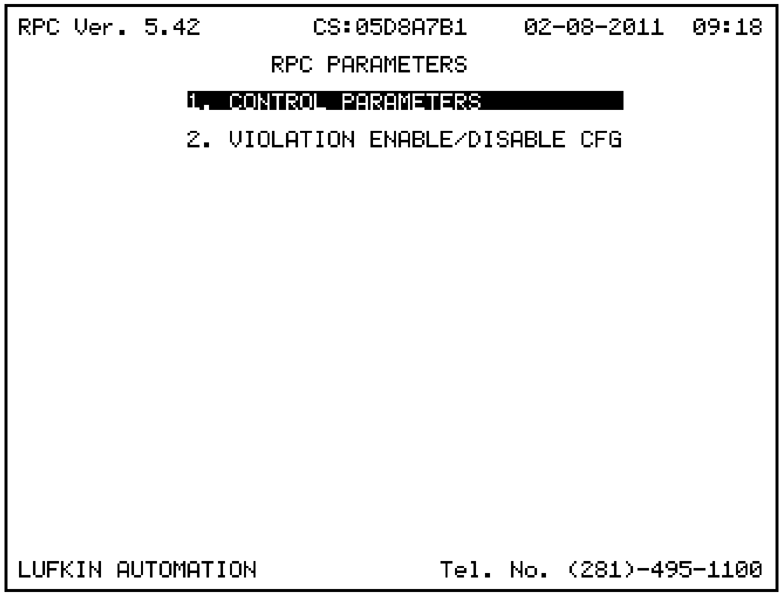


Figure 8-3. General RPC Parameters Menu

If you experience problems with either load or position input data, and the Lufkin Well Manager RPC persists in shutting down the well because of those problems, use the option **2. VIOLATION ENABLE/DISABLE** to disable all or some of the control functions while troubleshooting. For information about this option, see “Enabling/Disabling Control Functions” starting on page 8-14.

8.3.1 Configuring RPC Control Parameters

General RPC parameter programming must be completed regardless of the type of end devices selected. This programming is done through the RPC Control Parameter screen (Figure 8-4).

MENU 2/1/1/1

Data Field Descriptions

Information about each data field is provided below.

Control Mode

- **Surface** — The Lufkin Well Manager RPC controls the well from analysis of surface dynagraph shape using the Pump off setpoint.
- **Downhole** — The Lufkin Well Manager RPC controls from analysis of the calculated downhole dynagraph using the Pump Fillage setpoint

- **VFD-DH** — When an optional analog output circuit board is added, the Lufkin Well Manager RPC adjusts the speed of a variable speed drive unit to maintain a desired downhole pump fillage.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  09:20
                RPC CONTROL PARAMETER
                 Control Mode  DOWNHOLE
               Operation Mode  NORMAL
         Minimum Pump Strokes     003
                Downtime Mode  Manual
       Manual Downtime(hh:mm)  000:05
          Power ON Delay(sec)   00010
       Start Alert Delay(sec)   00010
    POff/LowFL Strokes Allowed     02
   Malfunction Strokes Allowed     02
                   E/D     Allowed    Consec    Start
 Malfunctions     State     Limit    Allowed    Delay
    Peak Load      E        50000      005       ***
     Min Load      E            0      005       ***
Low Motor RPM      D         1050      003      0003
Malf Setpoint      E        *****      004       ***
 Low Fluid Ld      E            0      003       ***

[UP/DWN] to navigate             [EDIT] to modify item
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 8-4. RPC Control Parameter Screen

- **VFD-SURF** — When an optional analog output circuit board is added, the Lufkin Well Manager RPC adjusts the speed of a variable speed drive based on the surface dynagraph shape utilizing the Pump Off setpoint.
- **Motor Power** — The Lufkin Well Manager RPC controls the well using a motor power number calculated from an electric motor speed/torque curve. This number is indicative of the work being done by the prime mover in the early part of the down stroke. This number will decrease as the well pumps off. The Lufkin Well Manager RPC can be programmed to automatically revert to the Motor Power Control mode when a load transducer/cable failure occurs.

Note: If the control mode is changed, either manually or automatically, certain default control functions are automatically enabled.

Operation Mode

- **Normal** — The Lufkin Well Manager RPC performs all of the enabled safety and control functions. This mode takes full advantage of the Lufkin Well Manager RPC capabilities.

- **Host** — The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC units on the radio network to place them in the Downtime-Host Mode well state. The Lufkin Well Manager RPC controls would stop the wells and keep them down until receiving a command to re-start.
- **Timed —** The Lufkin Well Manager RPC can be programmed to cycle on/off for user set times. Limited control functions by the Lufkin Well Manager 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 Lufkin Well Manager RPC will not perform any dynagraph analysis for this number of initial strokes. Peak and minimum load protection is provided during Minimum Pump Strokes.

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 Lufkin Well Manager RPC control has very limited capabilities during Minimum Pump Strokes.

The allowed range is 0 to 999, and the default is 3.

Downtime Mode

Downtime mode choices are **Manual** or **Automatic**. Select **Manual** initially until the well has pumped a few days to stabilize and the cycle run time stability has been observed. For information about the automatic downtime operation, see appendix A, “Automatic Downtime.”

Manual Downtime (HH:MM)

A user-programmed idle time or downtime after a stop for pumpoff (surface setpoint or downhole pump fillage) or pumping equipment malfunction can be specified. The Lufkin Well Manager RPC automatically restarts the unit when the specified downtime elapses. 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 5 minutes.

Power On Delay

When power is applied to the Lufkin Well Manager RPC, the initial control state is Downtime Power On Delay. The Lufkin Well Manager RPC delays starting the pumping unit for this number of seconds specified. This feature is included to allow an 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.

Start Alert Delay

Digital output 3 on the Lufkin Well Manager RPC motherboard is dedicated for 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 Lufkin Well Manager RPC delays starting the unit until the Start Alert Delay time has elapsed.

Pumpoff Strokes Allowed

This parameter sets the number of consecutive strokes that the pumpoff control parameter (either Surface setpoint or Downhole Pump Fillage) must be violated before the Lufkin Well Manager RPC makes the decision to shut down the pumping unit. Use larger numbers for gassy wells or wells with trash interference with pumping action. The default value is 2 strokes.

Malfunction Strokes Allowed

The number of consecutive strokes that the surface malfunction setpoint must be violated before the Lufkin Well Manager RPC decides to shut down the pumping unit for one of the consecutive malfunctions allowed. The default value is 2 strokes.

The lower part of this programming screen contains parameters that configure the secondary control functions of the Lufkin Well Manager RPC. Data presented in the columns include:

- **Malfunctions** — identifies the control function.
- **E/D State** — displays whether the function is presently enabled or disabled. See “Programming Violation Enable/Disable”on page 8-14 for more information.
- **Allowed Limit —** programmable fields for control parameters including:

Allowed Limit — Low RPM

The lowest motor RPM at which the Lufkin Well Manager RPC will continue to run the pumping unit. If the prime mover RPM dips below this limit, the Lufkin Well Manager RPC shuts down the unit almost instantly. No adjustable delay for this action is allowed during the pumping state. An adjustable start delay, in seconds, can be programmed in the right-hand column of this screen. For large pumping units with slower acceleration rates or for variable speed applications, longer startup delays may be necessary. This feature is only available when the Hall-Effect position input option is used.

Peak Load

The maximum allowed value for load input. If the load exceeds this limit, the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC instantly shuts down the pumping unit with no consecutive stroke delay. The default value is zero.

Peak Torque

The maximum allowed torque value in thousands of inch-pounds. If the Lufkin Well Manager RPC calculates a torque value greater than this limit at the completion of a stroke, the pumping unit shuts down early in the next upstroke.

- **Consec Allowed** — The Lufkin Well Manager RPC allows for re-tries for all of the malfunction-type of control actions. For example, if the maximum allowed peak load is violated, the Lufkin Well Manager RPC counts that as a peak load violation and initially shuts down the pumping unit in a downtime state. After the programmed downtime elapses, the Lufkin Well Manager RPC tries to re-start the pumping unit. If the peak load violation is repeated before a normal pumpoff cycle occurs, the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC 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.

- **Start Delay —** Two entries (**No RPM** and **Low RPM**) are time delays, in seconds, to allow the pumping unit time to accelerate up to operating speed. When the unit starts up, the Lufkin Well Manager RPC waits this number of seconds before checking for No RPM and Low RPM violations.

Low Fluid Ld

The Lufkin Well Manager RPC 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

This field is not available for all Control modes.

Start Up Rev

The number of motor revolutions on startup that the Lufkin Well Manager RPC counts before initiating any type of control function other than No RPM. The default value is 50. No operator adjustment is typically required.

Reference Rev

A number must be programmed in this field to allow the Lufkin Well Manager RPC to get started, After the Lufkin Well Manager RPC reaches a Pumping - Normal mode well state, note the Motor Rev/Stroke value on the RPC Status screen and enter that value in this field. The default value is 0, but 155 is suggested as an initial setting. If the pumping speed is changed because the drive belt sheave sizes are changed, the Reference Rev value must be re-programmed so that the reference revolution is consistent with the new motor rev/stroke. The Quick-Start routine includes a screen you can use to automatically test and set this value. The reference revolution can also be set using the Reference Revolution Calibration screen (**MENU: 2/3/3**).

Belt Slip Limit

When in the Pumping Normal mode well state, the Lufkin Well Manager RPC 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 Slip Limit percentage, the Lufkin Well Manager RPC sets an alarm flag to indicate possible belt slippage. No other control action is taken. The default value is 5%.

Cutoff Power Configuration Mode

This value is the control point for the Motor Power mode of control. The modes available are **Manual** or **Automatic**.

- In **Manual** mode, the operator must select and program the reference cutoff power. For help deciding an appropriate cutoff value, go to the **Average Downstroke Motor Power** field in RPC Status Screen #2. This value is calculated each stroke. For more information about this field, see “RPC Status Screen 2” in section 10, “Status Screens.”

- In **Automatic** mode, the Lufkin Well Manager RPC automatically selects a nominal reference cutoff power when the dynagraph card analysis indicates pump off, and the Lufkin Well Manager RPC shuts down the pumping unit.

The default is Manual.

Reference Cutoff Power

When in Motor Power Control mode, the Lufkin Well Manager RPC compares the calculated average downstroke pseudo motor power to this reference cutoff power for each stroke. If the calculated power number falls below the reference cutoff power for the number of consecutive pumpoff strokes allowed, the Lufkin Well Manager RPC shuts down the pumping unit.

8.3.2 Enabling/Disabling Control Functions

MENU 2/1/1/2

All Lufkin Well Manager RPC control functions can be disabled or enabled individually, or they all can be enabled/disabled simultaneously using the Violation Enable/Disable CFG screen (Figure 8-5). To display this screen, select **2. VIOLATION ENABLE/DISABLE CFG** from the RPC Parameters Menu screen.

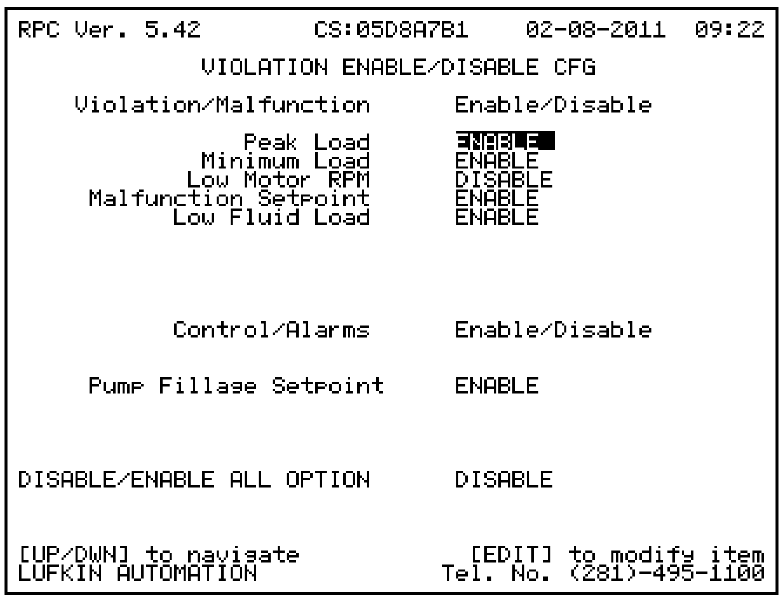


Figure 8-5. Violation Enable/Disable CFG Screen

Below are the procedures for enabling/disabling a single function or all simultaneously.

- ***To enable/disable each field separately***, press **<EDIT>**, press <↑> and<↓> to toggle between **Enable** and **Disable**, and then press **<ENTER>** when the desired option displays. The next field highlights. Repeat this process for each field you want to change.

- ***To enable/disable all fields at once***, select the **DISABLE/ENABLE ALL OPTION** field at the bottom of the list, press **<EDIT>**, press <↑> and<↓> to toggle between **Enable** and **Disable**, and then press **<ENTER>** when the desired option displays.

For troubleshooting load and position inputs, it may be helpful to disable all control functions until the problem is resolved. Be aware that when you use **Disable/Enable All Option**, all control functions are set to the action specified in this field, regardless that some are in the enabled state and others are disabled. You must remember however to return to this screen and enable the control functions you need.

Note: If the control mode is changed, either manually or automatically, certain default control functions are automatically enabled.

8.3.3 Configuring End Device Parameters

MENU 2/1/2

You must specify the types of end devices used for load and position inputs. End device type configuration is done using an End Devices Parameters screen. Figure 8-6 is an example. To display this screen, select **2. END DEVICES PARAMETERS** from the RPC Parameters Menu screen.

Note: The exact fields displayed on this screen depend on the end devices selected in the **Load Transducer Type** and **Position Transducer Type** fields.

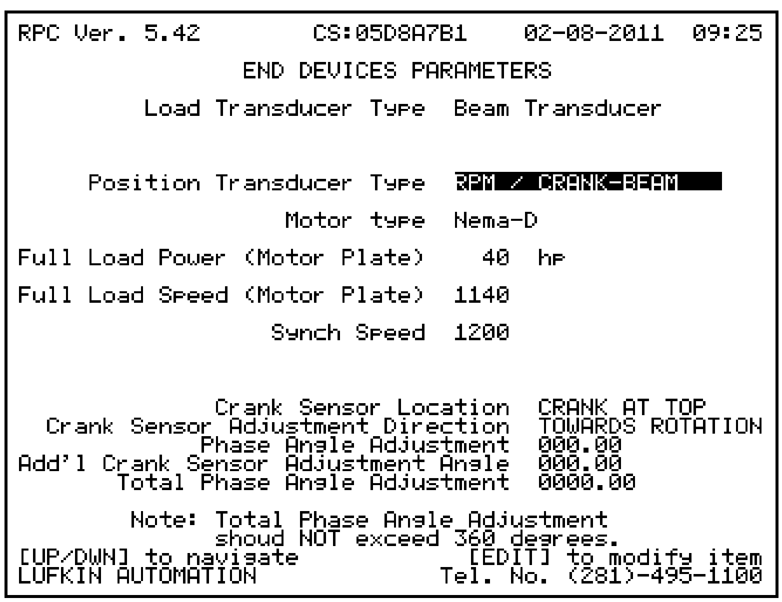


Figure 8-6. End Devices Parameters Screen

Data Field Descriptions

Information about each data field is provided below.

Load Transducer Type

Options available are:

- Non-Calibrated (101TL beam transducer)
- Calibrated 50,000 (50K PRLC)
- Calibrated 30,000 (30K PRLC)
- Horse shoe — for 40K, 2MV/V, temporary load cell
- Other — You must specify the full-scale rating and MV/V output at the RTU Level/Load Position Input programming screen (**MENU: 2/5/6**). For information, see “Configuring Load and Position Inputs” in section 9, “Lufkin Parameter Programming.”

Position Transducer Type

Options available are:

- Analog (Inclinometer)
- One Digital — Beam
- One Digital — Linear
- RPM/Crank — Beam
- RPM/Crank — Linear

The type of position determines which additional fields are displayed below it.

Motor type

This field only appears on this screen when RPM/Crank is the position transducer type selected. The options available are:

- NEMA D
- UHS (ultra high slip)

Full Load HP

Specify the horsepower of the prime mover. This information should be available on the prime mover nameplate.

Full Load Speed

Specify the full load RPM rating of the prime mover. This information should be available on the prime mover nameplate.

Sync Speed

Specify the no-load speed of the motor. This information should be available on the prime mover nameplate.

Note: A no-load speed of 1200 RPM is assumed by the Lufkin Well Manager RPC. When special motors are used (50 Hz, for example), edit the **Sync Speed** field to enter the correct value. An incorrect sync or no-load speed will invalidate the Lufkin Well Manager RPC torque calculations.

Crank Sensor Location

The Lufkin Well Manager RPC needs to sense a digital input at the exact dead bottom of the stroke. This means that the counter weights will be at the exact top of their travel; i.e. in the **Crank at Top** location. If local safety regulations make it prohibitive to climb on the pumping unit with the counter weights in the up position, the crank arm Hall-Effect can be mounted so that the probe passes in front of the magnet at the top of the stroke where the counter weights are at the bottom of their travel. In that event select the **Crank at Bottom** option for this field. Note that the **Phase Angle Adjustment** field below will automatically enter an adjustment of approximately 180 degrees based on the type of pumping unit being used

Crank Sensor Adjustment Direction

If the crank arm Hall-Effect sensor cannot be mounted to sense the magnet at exactly the bottom/top of the stroke, a firmware correction can be made in the **Add'l Crank Sensor Adjustment Angle** field below. If the crank is past the magnet at exact bottom/top, select the **Against Rotation** option and the **Add'l Crank Sensor Adjustment Angle** will be subtracted from the total **Phase Angle Adjustment** value below. If the crank arm has not quite reached the magnet at the exact bottom/top of the stroke, then select the **Towards Rotation** option to add the **Add'l Crank Sensor Adjustment Angle** field to the **Total Phase Angle Adjustment**.

Phase Angle Adjustment

The Lufkin Well Manager RPC automatically inserts a value based on the option selected in the **Crank Sensor Location** field and the type of pumping unit. This field cannot be edited.

Add'l Crank Sensor Adjustment Angle

This value is the angular displacement of the crank arm sensor from the crank arm magnet at the exact bottom/top of the stroke. Keep in mind that a full pump stroke is 360 degrees of movement of the crank arm and make a best estimate of the number of degrees the sensor is forward or back of the crank arm when the unit is stopped at exact dead bottom/top of the stroke. If the downhole pump card leans to the left or right, adjust the crank sensor adjustment angle value to obtain a better looking pump card.

Total Phase Angle Adjustment

This value is the total of the **Phase Angle Adjustment** and **Add'l Crank Sensor Adjustment Angle** fields. This total must not exceed 360 degrees. This field cannot be edited.

8.3.4 Configuring LWT/PIP Parameters

MENU
2/1/3

All Lufkin Well Manager RPCs operating with RPC Application firmware version 4.66 or higher use a patented algorithm that can determine the pump fluid load by analyzing a downhole pump card. The fluid load value is used along with user-defined parameter values for casing and tubing pressures, pump plunger diameter, and pressure/volume/temperature (PVT) properties for the produced fluid to calculate pump intake pressure (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.

Firmware version 4.66 or higher also includes a Lufkin Well Test (LWT) feature, which is an improvement over the inferred production algorithm (IPA) feature. The LWT algorithm provides automated fluid volume adjustments for pump slippage, fluid shrinkage, and tubing movement.

For information about the PIP, LWT, and IPA theories and features, see appendix E, "Pump Intake Pressure and Lufkin Well Test Theory."

Three programming screens are used to configure LWT and PIP. To display the first screen, select **3. LWT/PIP PARAMETERS** from the RPC Parameters Menu screen. To move to the next screen, press **<NEXT>**. To move to the previous screen, press **<EXIT>**.

LWT/PIP Screen 1/3 Data Field Descriptions

Figure 8-7 is an example of the first screen displayed. Information about each data field is provided below.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  09:27
                LWT / PIP Parameters 1/3
     Surface Stroke Length   100.00   in
             Pump Diameter   01.00    in
           Pump Depth(TVD)    5280    ft
      Tubing Head Pressure         30psig
           Tubing Gradient   000.40   psi/ft
      Casing Head Pressure   000000.0psig
             LWT Water Cut   20.00    %
          LWT Pump Leakage   000.0    b/d
        LWT Cutoff Control   DISABLE
      Fluid Load Detection   ADVANCED
     Fluid Load Adjustment   00000.0 lbs
     Consider Shallow Well    NO
Consider Unanchored Tubing    NO
               Tubing Size   2 3/8    in
[NEXT] - Next Cfg Screen
```

Figure 8-7. LWT/PIP Parameters 1/3 Screen

Surface Stroke Length

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

Specify the diameter of the pump plunger in inches.

Pump Depth

Specify the true vertical depth from the surface to the pump intake, in feet. This data is used in the Valve Check leakage rate calculation. For information about this calculation, see appendix B, “Valve Checks, Counter Balance Effect, and Residual Friction.”

Tubing Head Pressure

Specify the gauge pressure at the well head tubing in PSI.

Tubing Gradient

Specify the gradient for the fluid in the tubing in psi/foot.

Casing Head Pressure

Specify the pressure in PSI gauge of the casing at the surface.

LWT Water Cut

Specify the percentage of the produced fluid that is water.

LWT Pump Leakage

Specify the amount of leakage around the pump plunger in barrels per day. The Valve Check feature of the Lufkin Well control described in appendix B, “Valve Checks, Counter Balance Effect, and Residual Friction,” can be used to check for quantified pump leakage.

LWT Cutoff Control

When this feature is enabled, the pumping unit will shut down for the day when a programmed daily production volume is reached and remains shut down until the next gauge off time, at which time normal operation resumes.

When you enable this field, a data field appears to the right of the **Enable/Disable** option field for you to specify a daily production cutoff value in barrels.

```
LWT Cutoff Control   ENABLED 1000.0 bbls
```

Fluid Load Detection

Options available are **Basic** and **Advanced**.

- ***If* Basic *is selected***, the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC uses one of the techniques described in the PIP calculation theory described in appendix E, “Pump Intake Pressure and Lufkin Well Test Theory.”

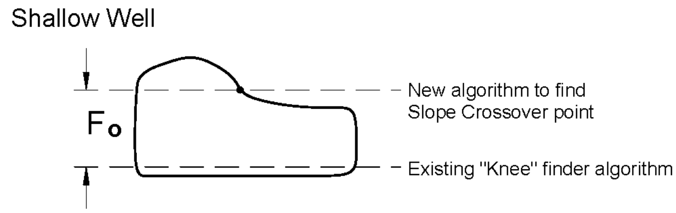
Fluid Load Adjustment

The fluid load that the Lufkin Well Manager RPC calculates by either the Basic or Advanced fluid load detection method can be adjusted by using this field. When **<EDIT>** is pressed a **+/-** selection field is displayed as part of the pounds figure.

Consider Shallow Well

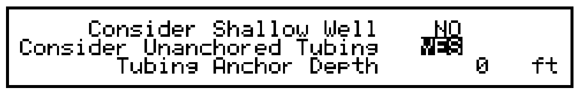
Specify **YES** or **NO**. No generally accepted exact definition of a “shallow well” exists. As a general rule, a shallow well is a well with a pump depth of less than 3,000 feet or a deeper well with a large diameter pump. The primary indicator is the shape of the downhole pump card.

If the pump card has the general shape as illustrated in the example below, specify **YES**.



Consider Unanchored Tubing

Specify **YES** or **NO**. 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**. When **YES** is selected, the **Tubing Anchor Depth** and **Tubing Size** fields appear.



– **Tubing Anchor Depth** — 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 Size** — Specify the API tubing size by selecting it from the available options.

LWT/PIP Screen 2/3 Data Field Descriptions

After you press **<NEXT>**, the second LWT/PIP Parameters screen (Figure 8-8) appears.

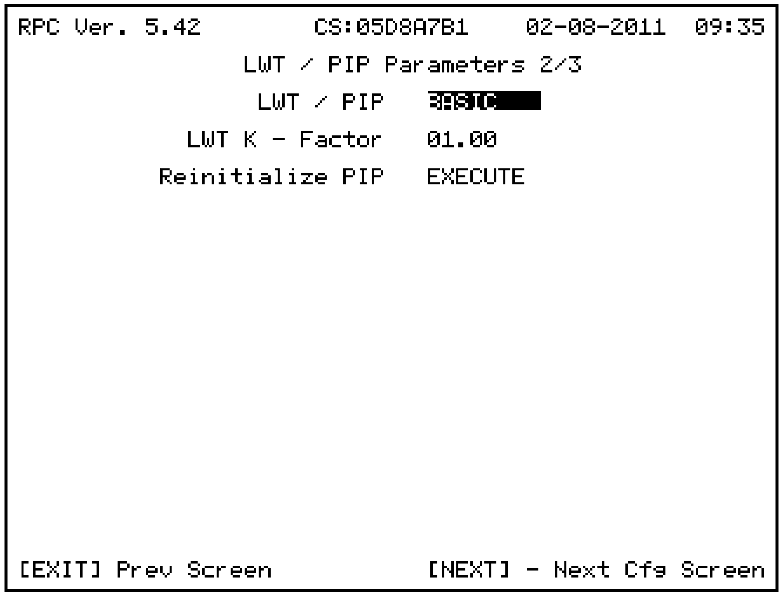


Figure 8-8. LWT/PIP Parameters 2/3 Screen

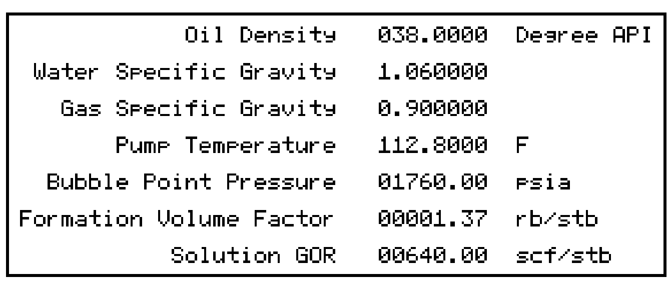
Information about each data field is provided below.

LWT/PIP

This field selects the method to be used for both LWT and PIP. The options available are **BASIC** and **ADVANCED**.

- ***If* BASIC *is selected***, the Lufkin Well Manager RPC reverts to the older IPA algorithm (as explained in appendix E, "Pump Intake Pressure and Lufkin Well Test Theory") with an added correction for pump leakage. 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.

- ***If* ADVANCED *is selected***, several more data fields appear.



– **Oil Density** — Oil density expressed in the selected units of degrees API, kg/liter, or kg/cubic meter.

- **Water Specific Gravity** — The specific gravity of the produced water.

- **Gas Specific Gravity** — The specific gravity of the produced gas.

- **Pump Temperature** — The fluid temperature at the pump intake

- **Bubble Point Pressure** — 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.

- **Formation Volume Factor** — 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.

- **Solution GOR** — 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.

The Lufkin Well Manager RPC will automatically pick or calculate values for **Pump Temperature**, **Bubble Point Pressure**, **Formation Volume Factor**, and **Solution GOR** based on user-entered values for **Pump Depth**, **Oil API**, **Water Specific Gravity**, and **Gas Specific Gravity**. You can override these automatic selections if better data is available. Contact your Lufkin Automation representative if you have questions.

LWT K – Factor

A calibration factor to correct for slippage and shrinkage. For a more-detailed explanation, see appendix F, “Pump Intake Pressure and Lufkin Well Test Theory.”

Reinitialize PIP

This is simply a command field to tell the Lufkin Well Manager RPC to reinitialize the PIP calculation. It is best practice to execute this field any time that any of the parameters on these two programming screens are changed. To execute this command, highlight the field and press **<ENTER>**.

LWT/PIP Screen 3/3 Data Field Descriptions

After you press **<NEXT>**, the third LWT/PIP Parameters screen (Figure 8-9).

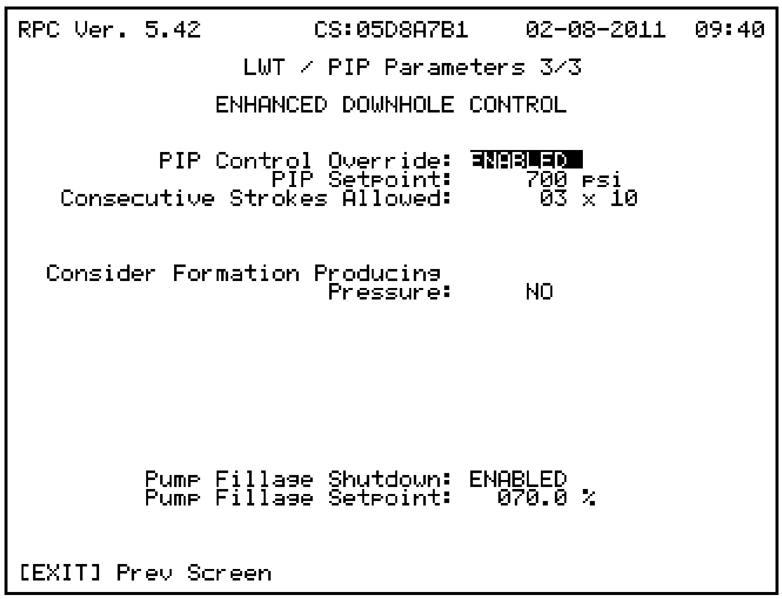


Figure 8-9. LWT/PIP Parameters 3/3 Screen

PIP Control Override

The Lufkin Well Manager 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 choices are **ENABLED** and **DISABLED**.

Note: The remaining fields displayed on this screen are only available when **ENABLED** is specified in the **PIP Control Override** field.

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.

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.

Consider Formation Producing Pressure

Specify whether you want to use the Consider Formation Pressure? query feature. You will only want to consider selecting **YES** if the pump is set above "mid-perfs." For more information about this feature see "Consider Formation Pressure? Query Feature" in appendix E, "Pump Intake Pressure and Lufkin Well Test Theory."

Note: If you select **YES**, the **Formation Dept** field appears along with the message shown below it.

```
              Formation Depth:      0  ft


   Pumping uphole may cause gas interference.  It
is suggested that Pump Fillage Shutdown be DISABLED
in this case.
```

– **Formation Depth** — Specify the depth of the topmost perforations in feet.

Pump Fillage Shutdown

Specify whether pump fillage is to be used as a shutdown parameter.

- ***If* ENABLED *is selected***, the calculated pump fillage will be the primary control parameter and the PIP setpoint will serve as an override backup.

- ***If* DISABLED *is selected***, the PIP setpoint becomes the primary control parameter for cycling the well.

Pump Fillage Setpoint

Specify the value to be used as a pump fillage control 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.

This field only displays when **ENABLED** is specified in the **Pump Fillage Setpoint** field.

8.4 Pumping Unit Parameter Configuration

MENU 2/1/4

When one of the RPM/Crank options for a position transducer is selected, the Lufkin Well Manager RPC requires pumping unit dimension data to calculate the polished rod position and display a surface dynagraph card. The data required includes:

- Pumping unit type
- Direction of rotation
- Six key API dimensions

Early versions of the Lufkin Well Manager RPC application firmware allowed you to manually program dimensional data through a single programming screen. The required data was usually available for newer pumping units, so this approach worked well for many installation sites. Frequently however, the “K” dimension would have to be calculated from available “G”, “H”, and “I” dimensions. Also, at many well sites with older pumping units, dimensional data was difficult, if not impossible, to obtain. Figure 8-20 (page 8-38) illustrates the dimensions required for a conventional pumping unit. For more information, refer to *API Specification 11E*, “Specification for Pumping Units.”

The newest Lufkin Well Manager RPC firmware contains the pumping unit database from the Lufkin Automation *SROD* design software to help overcome those types of problems. A new user interface allows a user to select a pumping unit from that database to provide the required dimensional data. The database presently contains dimensional data for 1,570 pumping units.

The type of position transducer specified in the **Position Transducer Type** field in the End Devices Parameters screen (**MENU: 2/1/2**) determines whether fields display to configure beam or linear pumping unit dimension data.

- To enter beam pumping unit dimension data, see 8-27
- To enter linear pumping unit dimension data, see appendix F, “Linear Pumping Unit Application.”

Procedures are also provided under each topic about how to configure this data manually or by obtaining its values from the Lufkin Well Manager RPC database.

8.4.1 Configuring Beam Pumping Unit Data

MENU 2/1/4

Beam pumping unit data can be entered manually or by retrieving the necessary data from the Lufkin Well Manager RPC database. Both configuration methods begin using a Pumping Unit Parameters screen similar to Figure 8-10. To display this screen, select **4. PUMPING UNIT PARAMETERS** from the RPC Parameters Menu screen.

- To enter beam pumping unit data manually, see 8-28
- To enter beam pumping unit data using the database, see 8-29

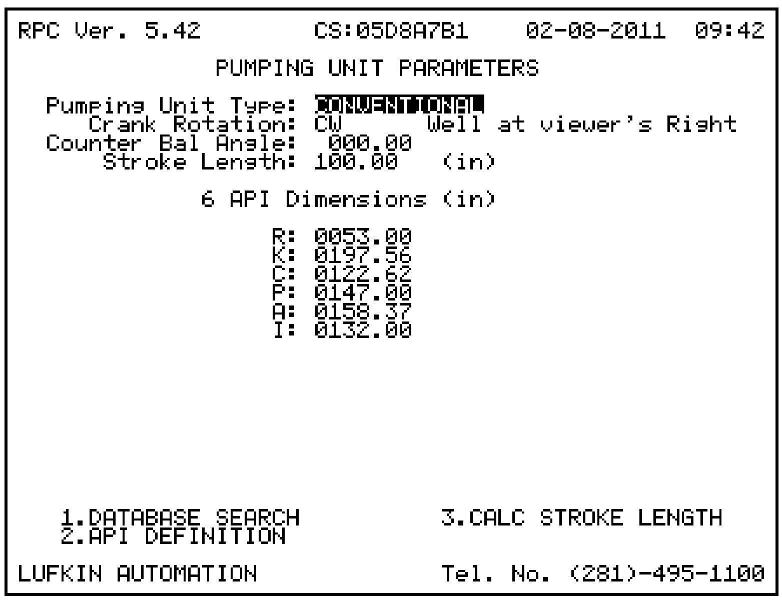


Figure 8-10. Pumping Unit Parameters Screen for RPM/Crank-Beam Units

Note: This programming screen is also included in the Quick-Start feature described in section 18, "Quick-Start Feature."

Data Field Descriptions

Information about each data field is provided below.

Pumping Unit Type

The choices available are:

- Conventional
- Air Balanced
- Mark II

Crank Rotation

To determine the crank rotation direction, stand facing the side of the pumping unit with the wellhead to your right. Observe the motion of the crank arm as clockwise (CW) or counter clockwise (CCW). Enter the appropriate selection.

API Dimensions

Specify each of the dimensions described on this screen.

Entering Beam Pumping Unit Data Manually

If the six API dimensions are known, using them is the fastest way to enter the required data.

Follow the steps below to enter the data manually.

1. Display the Pumping Unit Parameters screen (**MENU: 2/1/4**).
2. Enter the appropriated data in each field.
3. When all data fields read as desired, select **3. CALC STROKE LENGTH** to have the Lufkin Well Manager RPC calculate the theoretical stroke length from the dimensions just entered.
4. If the calculated theoretical stroke length differs from the measured stroke length, it may be necessary to adjust the values for dimensions A and C.

Entering Beam Pumping Unit Data Using the Lufkin Well Manager RPC Database

The Lufkin Well Manager RPC database presently contains dimensional data for approximately 1,570 pumping units.

Follow the steps below to enter data using the database.

1. Display the Pumping Unit Parameters screen (**MENU: 2/1/4**) and then select **1. DATABASE SEARCH** to display the Database Search Options Menu screen (Figure 8-11).

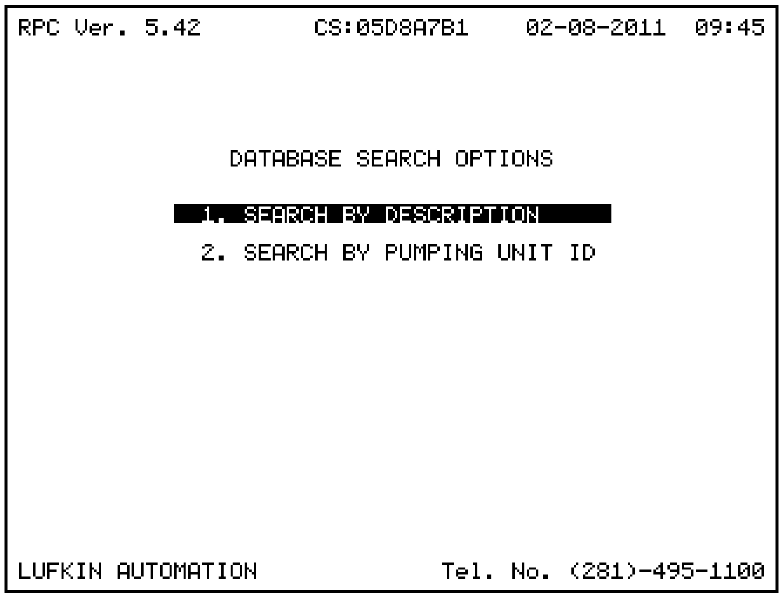


Figure 8-11. Database Search Options Menu Screen

2. Select one of the two options offered to enter the pumping unit data:

   - ***If you know the database ID number for a pumping unit***, search for it by pumping unit ID. This method is the fastest way to complete the database selection process. It is also the fastest way when several Lufkin Well Manager RPCs are being used on a small variety of pumping units, and you have become familiar with the database ID numbers for those pumping units.

     a. Select **2. SEARCH BY PUMPING UNIT ID** to display a Search by Pumping Unit ID screen similar to Figure 8-12 (page 8-30) to enter the ID number.

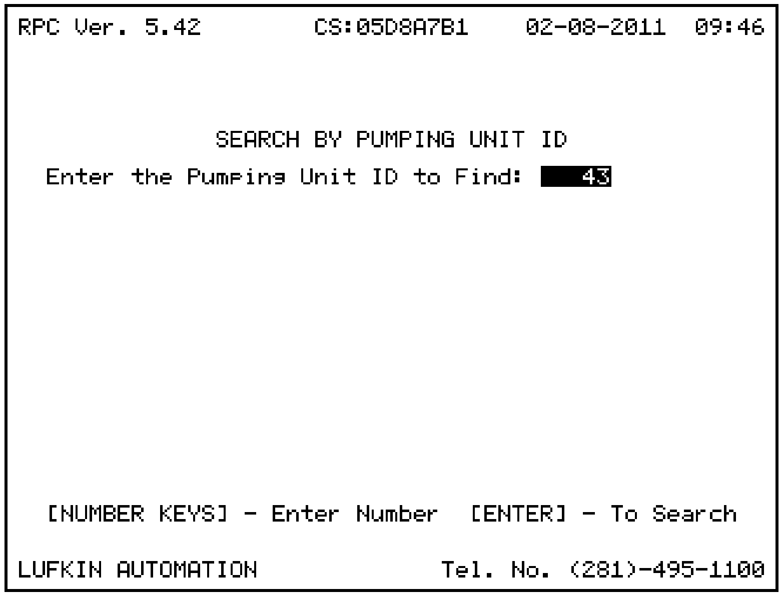


Figure 8-12. Search by Pumping Unit ID Screen

b. Press **<EDIT>** and then use the number keys to enter the desired unit ID number.

c. Press **<ENTER>** to select the unit ID.

A Crank Hole selection screen similar to Figure 8-18 (page 8-35) displays.

d. Go to step 3 on page 8-35 and follow the instructions from that point to complete the pumping unit data entry task.

- ***If you do not know the database ID number for a pumping unit***, search for the pumping unit by its pumping unit description.

a. Select **1. SEARCH BY DESCRIPTION** to display a Pumping Unit Data Base Utility Menu screen similar to Figure 8-13.

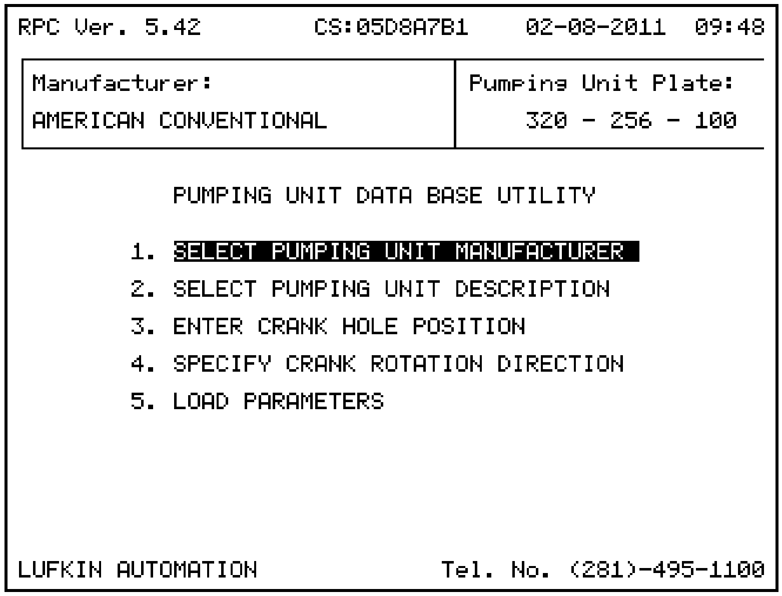


Figure 8-13. Pumping Unit Data Base Utility Menu

Each menu option must be used in sequence to complete the pumping unit data programming. You do not need to return to the menu between steps because the program will automatically move to the next step as you finish each step.

b. Select **1. SELECT PUMPING UNIT MANUFACTURER** to start the database selection. A screen similar to Figure 8-14 displays.

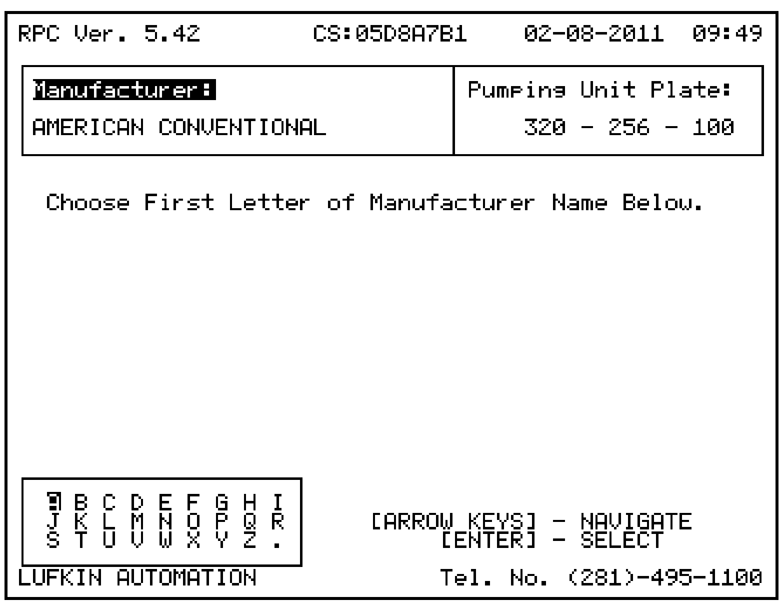


Figure 8-14. First Step of the Manufacturer Selection Process

c. Using the box in the lower left corner, highlight the first letter of the desired pumping unit manufacturer name. Use the arrow keys to move the small cursor until the first letter of the pumping unit manufacturer name is highlighted, and then press <**ENTER**>.

   The Lufkin Well Manager RPC searches the database for all manufacturer names starting with that letter and then displays a screen similar to Figure 8-15 listing all of the matches found. For example, in Figure 8-14 the letter “L” is highlighted so the database is searched for all manufacturer names beginning with the letter “L,” and then a list of the results of that search is displayed on a screen similar to Figure 8-15.

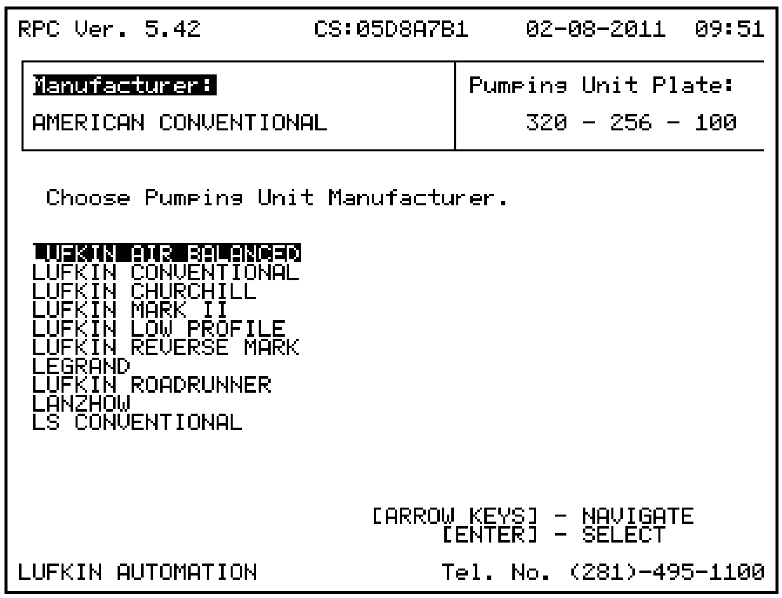


Figure 8-15. Second Step of the Manufacturer Selection Process

d. Press <↑> and <↓> to highlight the desired choice and then press <**ENTER**> to select that choice and continue with the database selection process.

   A screen similar to Figure 8-16 displays asking for a pumping unit description.

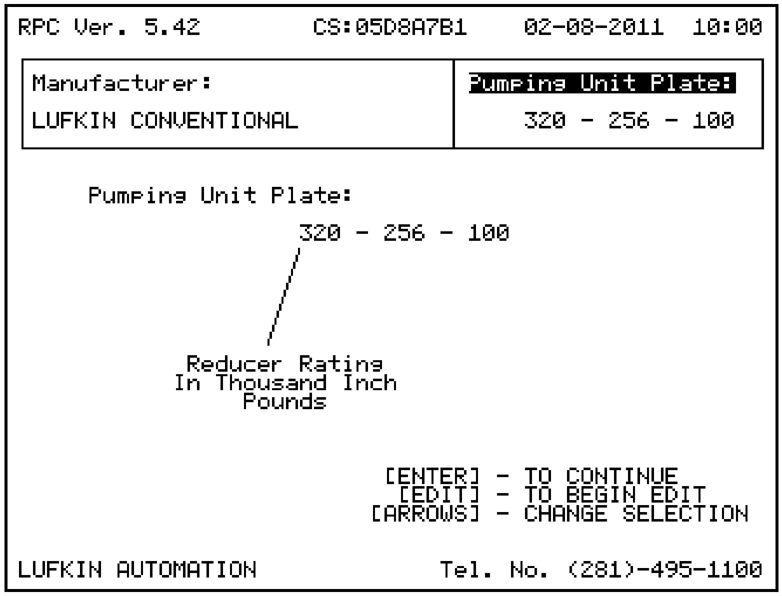


Figure 8-16. Pumping Unit Nameplate Data Screen

This screen includes three data entry fields representing the API convention for pumping unit marking.

- The left field is the torque rating of the gearbox in thousands of inch-pounds.
- The center field is the structural rating of the pumping unit in hundreds of pounds.
- The right field is the maximum stroke length for the pumping unit in inches.

e. Press <←> and <→> to move the cursor between data entry fields. A “pointer” and a description about the field presently selected appears. For example, in Figure 8-16, **Reducer Rating in Thousand Inch Pounds** describes the field highlighted.

f. To program data in a highlighted field, press <**EDIT**>, use the number keys to enter the desired data, and then press <**ENTER**> to complete the edit process for that field.

If all three fields are programmed as “blank” (displayed as “xxx”), the Lufkin Well Manager RPC searches for and displays a list of all pumping units available in the database for the selected manufacturer. To blank a field, highlight the field, press <**EDIT**>, and then press <**ENTER**>.

g. After the pumping unit plate data is entered as desired, press <**ENTER**> to start searching the Lufkin Well Manager RPC database. A screen similar to Figure 8-17 displays listing all matches for the manufacturer and description entered.

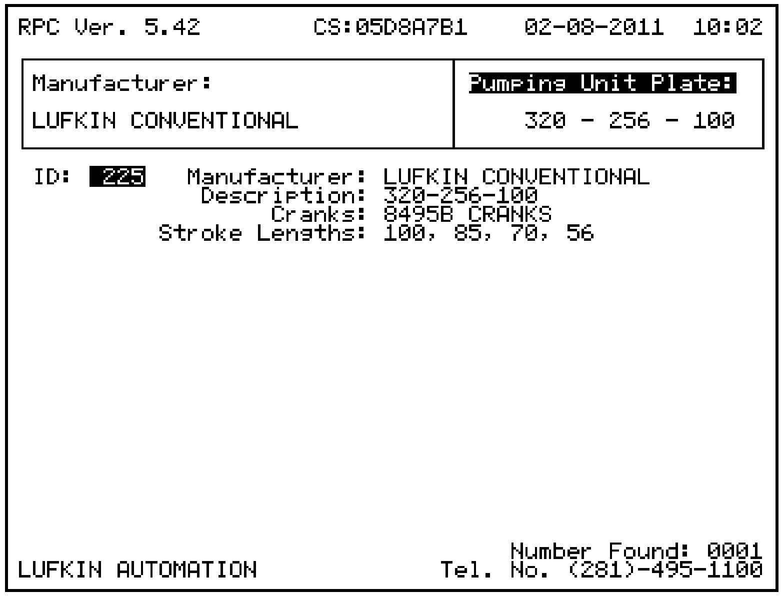


Figure 8-17. Results of the Database Search

Note: The ID number shown in Figure 8-17 is the number used in the Search by Pumping Unit ID option available on the Database Search Options menu (Figure 8-11) shown on page 8-29.

h. Do one of the following:

- If no match is found, a **Number Found: 0000** notice displays in the lower right corner of the screen. Return to the Pumping Unit Nameplate Data screen (Figure 8-16) and program for a less restrictive search by blanking out all three data fields. The new search lists all units by that manufacturer in the database. If no match is found again, the manufacturer is not included in the database. Contact the manufacturer to obtain the required dimensional data or make field measurements of the unit. See "On-Site Manual Measuring of Pumping Unit Dimensions" on page 8-37 for information about making field measurements.

- If more than one match is found and displayed, press<↑> and <↓> to highlight the **ID** field for the unit desired.

Note: The database selection process can be shortened at this point if the default values for crank hole and direction of rotation are suitable. The default values are:

Crank Hole 1: Longest stroke length

Direction of Rotation: Clockwise for conventional unit
Counterclockwise for MKII unit

To use the shortcut, press **<EXIT>** to return to the Pumping Unit Data Base Utility menu (Figure 8-13 on page 8-31), and then select **5. LOAD PARAMETERS**. The Pumping Unit Parameters screen (Figure 8-10 on page 8-27) displays with a popup box briefly notifying you that the database search is completed.

i. To continue with the pumping unit data entry process, press **<ENTER>**.

A Crank Hole Position screen similar to Figure 8-18 appears.

```
RPC Ver. 5.42         CS:05D8A7B1    02-08-2011  10:04

 Manufacturer:                       Pumping Unit Plate:
 LUFKIN CONVENTIONAL                   320 - 256 - 100

  Choose the crank hole position      Stroke Length
               Crank Hole 1:              100.7
               Crank Hole 2:              85.5
               Crank Hole 3:              70.7
               Crank Hole 4:              56.2

     NOTE: A crank hole position of 1 denotes the
           the pumping unit will have its longest
           stroke length.

  [ARROW KEYS] - CHANGE OPTION        [ENTER] - ACCEPT
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 8-18. Crank Hole Position Screen

3. Press <↑> and <↓> to highlight the crank hole you want used and then press <**ENTER**> to select that crank location and continue with the selection process.

A screen similar to Figure 8-19 displays prompting you to select the proper direction of rotation.

Note: This screen automatically displays after the information in the Enter Crank Hole Position option is entered and **<ENTER>** is pressed.

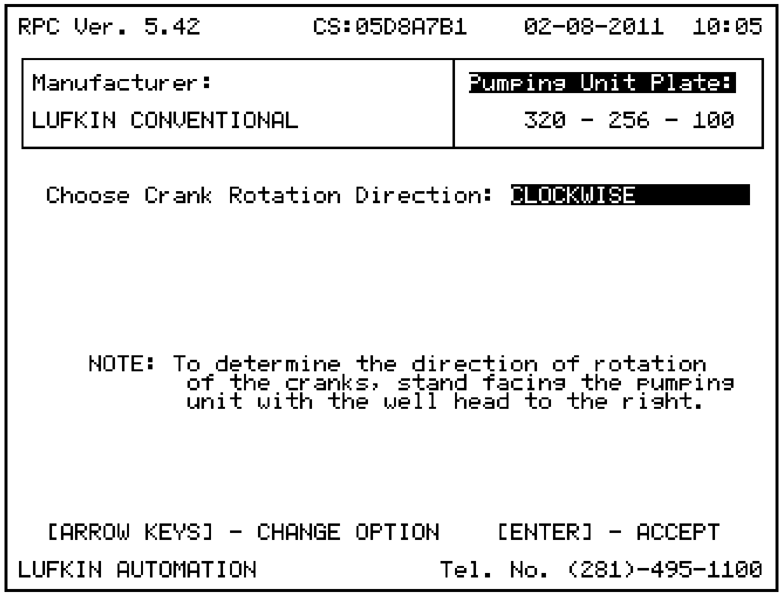


Figure 8-19. Select Direction of Rotation Screen

4. Do both of the following:

   a. Press <**EDIT**> and then press <↑> and <↓> to toggle between the **CLOCKWISE** and **COUNTERCLOCKWISE** options.

      To determine the crank rotation, stand facing the side of the pumping unit with the wellhead to your right. Observe the motion of the crank arm as clockwise or counterclockwise.

   b. Select the appropriate option and then press <**ENTER**>.

   The Pumping Unit Parameters screen (Figure 8-10) displays with a popup box briefly notifying you that the database search is completed.

5. Select **3. CALC STROKE LENGTH**.

   The Lufkin Well Manager RPC calculates the theoretical stroke length from the dimensions in the database.

6. Compare the calculated stroke length with the measured stroke length.

If there is a variance, the probable cause is that the actual “A” and “C” dimension for the pumping unit installation are not the same as the manufacturers recommended dimensions. Check both dimensions and manually enter revised values. See Figure 8-20 on page 8-38 to identify the A and C dimensions.

7. Select **3. CALC STROKE LENGTH** again to re-calculate theoretical stroke length after revised “A” and “C” dimensions are entered.

8. If satisfied with data displayed, use one of the actions below to complete the data base selection process.

   - If the pumping unit selection was made as part of the Quick-Start feature, press **<NEXT>** to complete the pumping unit data entry and continue with Quick-Start.

   - If the pumping unit data entry was directly accessed using **MENU: 2/1/4**, press **<EXIT>** to complete the unit data entry process and return to the RPC Parameters menu (Figure 7-5).

8.4.2 Manually Measuring Pumping Unit Dimensions On-Site

If the pumping unit is not included in the Lufkin Well Manager RPC database, and if you are not able to obtain dimensions from the pumping unit manufacturer, you can make on-sight measurements of the pumping unit to gather the required dimensional data.

Note: Observe all safety precautions when climbing on the pumping unit to make these measurements.

Figure 8-20 illustrates the dimensions required for a conventional pumping unit.

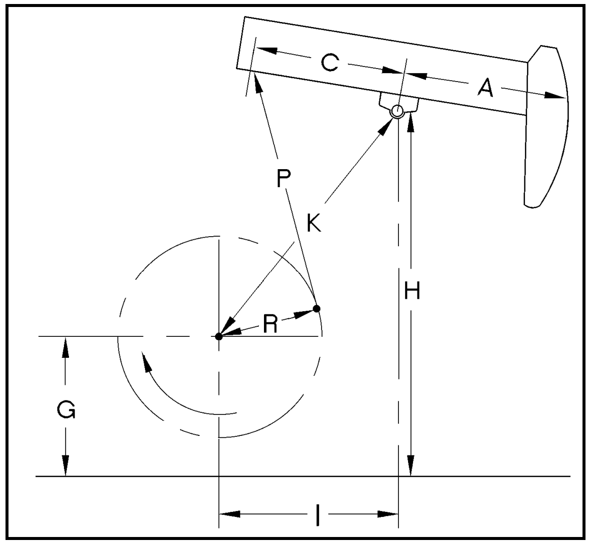


Figure 8-20. API Dimensions for Conventional Pumping Unit

Figure 8-21 illustrates the dimensions required for Mark II and air-balanced units.

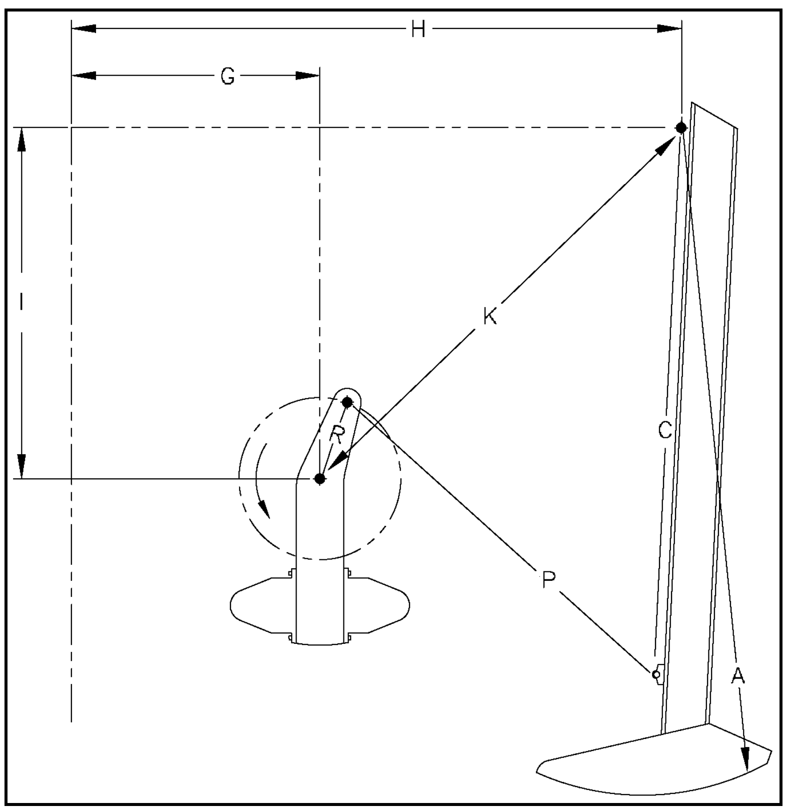


Figure 8-21. Dimensions for Mark II and Air Balanced Units

Generally, it will be necessary to calculate the "K" dimension using the formula provided below.

$$K = \sqrt{I^2 + (H - G)^2}$$

8.5 Configuring Rod Tapers for Downhole Control

MENU 2/1/5

The Down Hole Rod Taper Parameter screen (Figure 8-22) is required only if **Downhole** is the control mode selected in the RPC Control Parameter programming screen (**MENU: 2/1/1/1**). The Lufkin Well Manager RPC must have rod string and pump diameter data to calculate the downhole pump card for each stroke. Pump diameter data is entered as part of IPA programming explained on page 8-18.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  10:06
              DOWN HOLE ROD TAPER PARAMETER
 Number of Rod Taper ( Max of 6 ): 3
 Taper   Type Interval Diameter Weight  Modulus
   #            (ft)     (in)   (lbs/ft)(MMPSI)
   1      S     2220    00.875  02.224  0030.5
   2      S     2850    00.750  01.634  0030.5
   3      S      210    01.500  06.000  0030.5




   Legend for Type: S for Steel   F for Fiberglass
   Note: Taper # 1 is the first rod from the surface.
        Damping Factor .............  00.08
 Stuffing Box Friction .............    100  lbs
  Tubing Head Pressure .............     30  psig
       Tubing Gradient .............  00.40  psi/ft
LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 8-22. Down Hole Rod Taper Parameter Screen

Default values are provided and will cover many applications, but the discerning user may use these parameters to obtain better results on difficult wells.

One or more **Taper #** rows will be presented based on the number entered in the **Number of Rod Taper** field. **Taper #1** is the top most portion of the rod string. Enter the interval and diameter data for each taper. You should confirm that the Lufkin Well Manager RPC has entered the correct rod weight and modulus.

Data Field Descriptions

Information about each data field is provided below.

Type

- S for steel
- F for fiberglass

Interval

Enter the number of feet for this size rod in this taper.

Diameter

Enter the rod diameter of this taper. If a standard API rod diameter is entered, the Lufkin Well Manager RPC will enter the correct weight in pounds per foot in air in the adjacent column to the right. If a special rod diameter is entered, such as Corod diameters in 1/16-inch increments, you need to enter the correct weight in that column.

Weight

The Lufkin Well Manager RPC will automatically enter the correct weight (pounds per foot in air) if the rod diameter is API standard. If it is not API standard, specify the correct data for the diameter of this taper. Be sure that this field has a number in it before moving ahead with the programming. Zeros in this field due to entry error in the **Diameter** field will cause the downhole dynagraph card calculation feature to not work.

Modulus

The Lufkin Well Manager RPC has preset modulus data in millions of PSI for each of the two types of rod supported. For steel, the Lufkin Well Manager RPC will enter a modulus of 30.5. For fiberglass, the Lufkin Well Manager RPC will enter a modulus value of 7.2. For special rod materials, you may need to enter a correct value for Modulus.

Damping Factor

This factor is available to allow the Lufkin Well Manager RPC to handle any forces that would tend to dampen rod string oscillation. Damping could be due to mechanical rod/tubing friction, paraffin or rod/fluid hydraulic effects, or a combination of these wellbore conditions. If downhole card shapes do not appear to be correct, and you think that there may be a significant amount of damping, consider using the Lufkin Automation predictive/design program SROD™ to help arrive at a good value for this damping factor.

Stuffing Box Friction

This factor is used to compensate for surface friction due to tight stuffing box seals. Enter in pounds.

Tubing Head Pressure

Since flow line backpressure directly impacts the load on the pump plunger, it is necessary to enter the correct wellhead tubing pressure in PSI.

Tubing Gradient

The gradient of the produced fluid must be entered in this field. Gradient is the pressure in PSI exerted per foot of fluid column head. The gradient for fresh water is 0.434 PSI per foot.

8.6 Configuring VFD/VSD Parameters

MENU 2/1/6

When the Lufkin Well Manager RPC is equipped with an optional I/O expansion board that provides an analog output, it can control the speed of a variable speed drive (VSD) that will accept an external voltage for speed control. VSD parameters operate in conjunction with the existing standard safety violation parameters. This conjunction provides a complete solution for control of a pumping unit system that uses a generic VSD.

Note: Lufkin Automation offers a Lufkin VSD controller package that combines the RPC controller function in the same cabinet as a variable speed drive. This user manual does not address the Lufkin RPC Controller/VSD combo product. For information about the combo product, refer to the *Lufkin Well Manager ™— Variable Speed Drive Rod Pump Control User Manual* (Part No. 099.5035)

For the generic VSD application, only one VFD/VSD Parameters screen (similar to Figure 8-23) is used to configure VSD parameters and operating speed ranges. To display this screen, select **6. VFD/VSD PARAMETERS** from the RPC Parameters Menu screen.

Note: This screen will not display and the message **NOT REQUIRED** appears when a VSD is not specified as the RPC control mode. To specify a VFD, go the RPC Control Parameter screen (**MENU: 2/1/1/1**) and select one of the VSD options available in the **Control Mode** field. For more information about this screen see "Configuring RPC Control Parameters" on page 8-7.

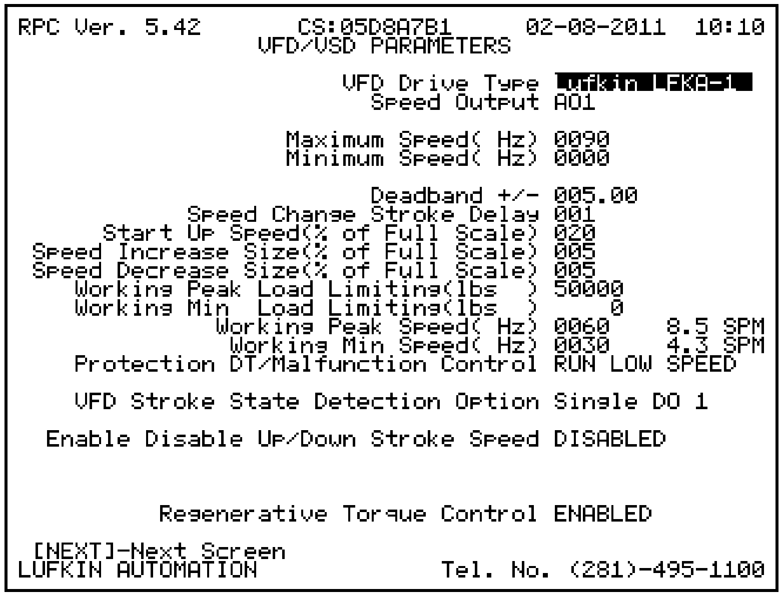


Figure 8-23. VFD/VSD Parameters Screen

Data Field Descriptions

Information about each data field is provided below.

VFD Drive Type

Select the type of variable speed drive being used. The options available are:

- **Lufkin LFKA-1** — Select when using a Lufkin variable speed drive. Refer to the *Lufkin Well Manager™— Variable Speed Drive Rod Pump Control User Manual* (Part No. 099.5035).
- **Others** — Select when using a generic inverter drive. This is the only option supported by the user manual you are reading.

Speed Output

This parameter is for selecting the analog output channel to be used on the auxiliary analog expansion board. The Lufkin Well Manager RPC analog outputs are logical or virtual outputs. The selected analog output must therefore be configured so that the Lufkin Well Manager RPC knows which physical hardware point to control. For information about analog output configuration, see “Configuring Analog Outputs” in section 9, “Lufkin Parameter Programming.”

Alternatively, a constant value can be specified to force the drive to operate at a fixed speed. The available options are **AO 01**, **AO 02**, and **CONST**. The default is **AO 01**. If **CONST** is selected, an additional field is provided to enter a value. The units for this value correspond to the **Scaling Unit** parameter described next.

Scaling Unit

This parameter allows you to select the engineering units to be associated with the display of the analog output value to the drive. It is easiest to match this with the units being used in the drive (for example, Hz). The available options are **%** (default), **V**, **mA**, **SPM**, **RPM**, and **Hz**.

Maximum Speed

This parameter associates the engineering value of maximum speed with the maximum hardware analog output (10 VDC or 5 VDC, depending on the header block selected). This value should be selected to match the engineering unit maximum in the drive. For example, if the drive scales the analog speed reference so that 0 to 10 VDC input corresponds to 0 to 90 Hz, the maximum speed in the Lufkin Well Manager RPC should be set at 90 Hz.

Minimum Speed

This parameter associates the engineering value of the minimum speed with the minimum hardware analog output (0 VDC). This value should be selected to match the engineering unit minimum in the drive. For example, if the drive scales the analog speed reference so that 0 to 10 VDC input corresponds to 0 to 90 Hz, the minimum speed in the Lufkin Well Manager RPC should be set at 0 Hz.

Deadband

This parameter is used in the decision making process to determine whether the Lufkin Well Manager RPC should speed up or slow down the pumping unit. The units for this parameter are dependent on whether the VFD-DH or VFD-SURF control is selected. The default is ±5 percent (VFD-DH) or ±5 inches (VFD-SURF). Speed changes only occur during the Pumping—Normal Mode well state.

VFD-DH

At the end of each stroke of the pumping unit, the Lufkin Well Manager RPC calculates the current pump fillage. In VFD downhole control, the algorithm determines if the current pump fillage falls outside the pump fillage setpoint plus-or-minus deadband. In this case, the deadband is a percentage, related to the percent pump fillage. This is shown in Figure 8-24. For example, if the deadband is ±5 percent, and the Pump Fillage setpoint is 60%, the algorithm will speed up the pumping unit if the Current Pump Fillage is greater than 65 percent, as shown in the figure. It will not change the speed if the current pump fillage is from 55 percent to 65 percent, since it falls inside the deadband. If the current pump fillage is less than 55 percent, the controller will consider that the well is pumped off and will slow down the pumping unit.

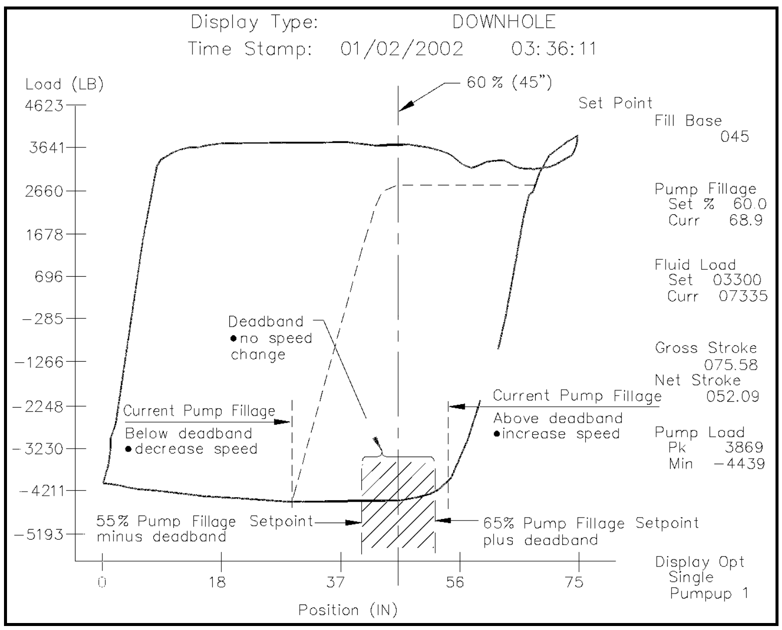


Figure 8-24. Pump Card Illustrating Use of the Deadband Parameter

VFD-SURF

If the control mode is programmed as VFD-SURF, the deadband is in units of inches.

At the end of each pump stroke, the Lufkin Well Manager RPC calculates and analyzes a surface dynagraph card. The speed control decision is dependent on the location of the POC setpoint (see "Surface Realtime Dynagraph" in section 12, "Dynagraph Cards"). To illustrate the speed control decision, see Figure 8-25.

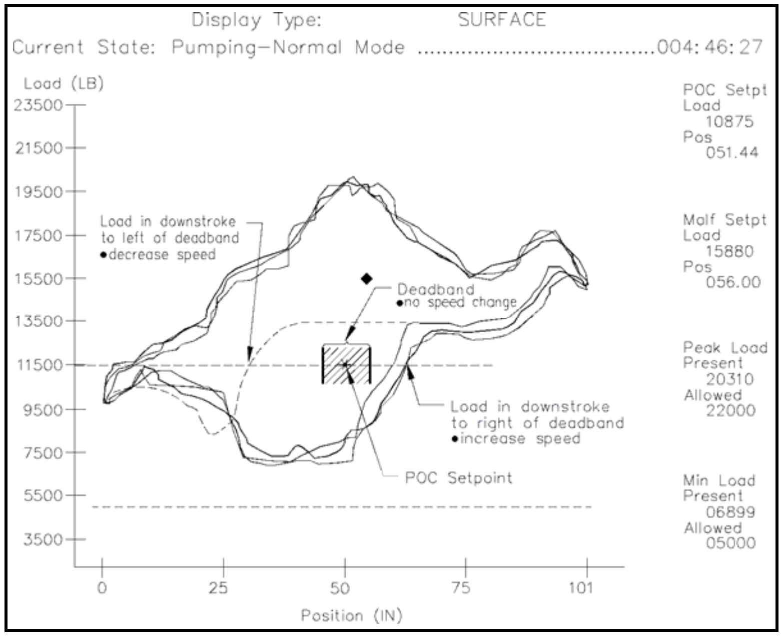


Figure 8-25. Surface Card Illustrating use of the Deadband Parameter

If a horizontal line is drawn through the POC setpoint, this line will intersect the early part of the downstroke load trace. If the load trace falls more than deadband inches to the right of the POC setpoint when crossing that line (as shown in Figure 8-25), the algorithm will speed up the pumping unit. If the load trace falls more than deadband inches to the left of the load trace, the algorithm considers that the well is pumped off and slows down the pumping unit. If the load trace falls within the deadband, the speed is not changed.

Speed Change Stroke Delay

This parameter has a default value of 1, which indicates that the algorithm will make a decision to speed up, slow down, or make no speed change every stroke. A value of 2 indicates that the decision to change speed will be made every second stroke. Valid values are 1 to 999.

Start Up Speed

This parameter tells the Lufkin Well Manager RPC at what initial speed to start the pumping unit. In general it is best to start at a slow speed, unless the well conditions warrant starting at a faster speed. The units for this parameter are consistent with the **Scaling Unit** parameter. The default value is 0%.

Speed Increase Size

When the Lufkin Well Manager RPC decides that it should increase pumping unit speed, it will add the **Speed Increase Size** value to the current speed output, and change the speed output accordingly thereby speeding up the pumping unit. The default value is 5%, and the units for this parameter are consistent with the **Scaling Unit** parameter. In this manner, the algorithm changes speed in small steps until the pump fillage is within the deadband setting. Smaller values result in a longer response time to changing well conditions.

Speed Decrease Size

When the Lufkin Well Manager RPC decides that it should decrease pumping unit speed, it will subtract the **Speed Decrease Size** value from the current **Speed Output** value and change the analog output accordingly thereby slowing the pumping unit. The default value is 5%, and the units for this parameter are consistent with the **Scaling Unit** parameter. Smaller values will result in a longer response time to changing well conditions.

Working Peak Load Limit

Setting this parameter to a value below the Peak Load Allowed Limit activates this safety feature. The units for this parameter are in pounds, with a default value of 50,000 lbs.

If the peak load observed during a pumping unit cycle exceeds the Working Peak Load Limit value, the Lufkin Well Manager RPC makes a decision to slow the pumping unit by one step, reducing the current speed output by the **Speed Decrease Size** value. If the Working Peak Load Limit is again exceeded on the following stroke, the unit will be slowed again. In this fashion the speed will be adjusted slower until the Working Peak Load Limit is no longer violated. Working Peak Load violations override the pump fillage control decision. When this limit is not violated, the algorithm returns to the normal speed change decision process based on fillage.

Working Minimum Load Limit

Setting this parameter to a value above the Minimum Load Allowed activates this safety feature. The units for this parameter are in pounds, and the default is 0 lbs.

If the minimum load observed during a pumping unit cycle falls below the Working Minimum Load Limit, the Lufkin Well Manager RPC makes a decision to slow the pumping unit by one step. If the Working Minimum Load Limit is again exceeded on the following stroke, the unit will be slowed again. In this fashion the speed will be adjusted slower until the Working Minimum Load Limit is no longer violated. When this limit is not violated, the algorithm returns to the normal speed change decision process based on fillage.

Working Peak Speed

This parameter allows you to limit the maximum analog output from the Lufkin Well Manager RPC to a value less than the full output voltage (10 or 5 VDC, depending on configuration header selection). The units for this parameter are consistent with the Scaling Unit parameter.

Working Minimum Speed

This parameter allows you to set the minimum analog output from the Lufkin Well Manager RPC to a value greater than the minimum output voltage (0 VDC). The units for this parameter are consistent with the **Scaling Unit** parameter. Figure 8-26 illustrates the speed limits.

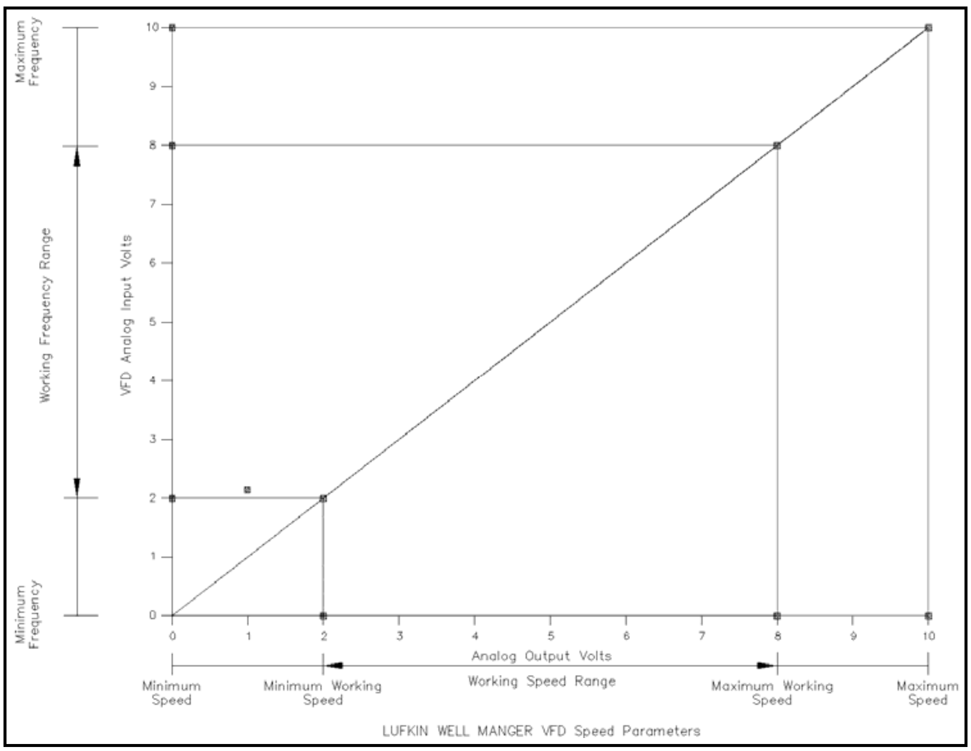


Figure 8-26. Speed Range Scaling

Protection DT/Malfunction Control

This parameter allows you to select whether the pumping unit is to be turned off in the event of a safety violation (such as Peak Load or Malfunction setpoint) or switched to the programmed Working Minimum Speed and continue running. Available choices are **VFD/VSD OFF** and **RUN LOW SPEED**.

- If **VFD/VSD OFF** is chosen and a safety violation occurs, the controller turns off the drive and goes through its programmed downtime. After the downtime elapses, the controller again attempts to operate the well by turning on in its usual fashion and adjusting speed as necessary. If the same safety violation occurs again, the well continues in its downtime/retry routine until the Consecutive Allowed Limit is exceeded for that safety violation. When the Consecutive Allowed Limit is exceeded, the controller goes to a Malfunction state, and user intervention is needed to reset the malfunction after isolating and fixing the pumping equipment problem that caused the shutdown.

- **If RUN LOW SPEED** is chosen and a safety violation occurs, the controller runs at the Working Minimum Speed and starts the downtime timer. After the downtime elapses, the controller again attempts to operate the well normally by going through the normal startup sequence (starting unit, minimum pump strokes, followed by pumping normal) and adjust speed as necessary. If the same safety violation occurs again, the well will continue in its RUN LOW SPEED downtime/retry routine until the Consecutive Allowed Limit is exceeded for that safety violation, after which the controller goes to a Malfunction state. In the Malfunction state, the unit will run at minimum speed until user intervention corrects the problem and resets the malfunction. After the malfunction is reset, the unit will resume normal operation and speed up again.

VFD Stroke State Detection Option

The Lufkin Well Manager RPC can be programmed to provide digital outputs to the VFD to tell the VFD if the pumping unit is in the upstroke or downstroke portion of the pumping cycle.

- The **Single DO** option turns on digital output DI/O 5 (terminal 9 of terminal strip TB5 on the motherboard) at the bottom of the stroke and holds it On for the upstroke period.

- The **Double DO** option momentarily closes digital output DI/O 5 at the bottom of the stroke and momentarily turns on digital output DI/O 6 at the top of the stroke.

The digital output configuration is presently hardcoded in the Lufkin Well Manager RPC firmware when one of the two available Stroke Detection options is selected. It is not necessary to perform separate steps to configure these two auxiliary digital points. The Stroke Detection output feature can be disabled by selecting that option.

Refer to the VFD documentation to determine if your drive can take advantage of knowing if the unit is in the upstroke or downstroke. You may need to use an interposing control relay between the Lufkin Well Manager RPC and the inverter drive.

Enable Disable Up/Down Stroke Speed

When this option is enabled, two additional parameter fields are added to the programming screen. These fields allow you to program the Lufkin Well Manager RPC to switch to a pre-set lower speed at the top of the stroke, plus or minus a programmed percentage of full stroke.

```
  VFD Stroke State Detection Option  Single DO

Enable Disable Up/Down Stroke Speed  ENABLED
  DownStroke Speed Change( % of SL )  010.00
                 Percent Speed Change  10.0
```

The **DownStroke Speed Change** parameter is programmed in percentage of surface stroke length. This parameter can be a negative or a positive number.

- A negative number switches the drive to low speed before the top of stroke.
- A positive number switches the drive to low speed after the top of the stroke.

The **Percent Speed Change** parameter programs the desired downstroke speed. This value is entered as a percent of the Maximum Speed in line four of the VFD/VSD Parameters screen (Figure 8-23). This parameter can be either “+” (plus) to increase downstroke speed or “-” (minus) to decrease downstroke speed. Neither sign on the display screen indicates a “+”, or speed increase, action.

8.7 Configuring Gauge Off Time and Peak Energy Management

MENU
2/1/7

Gauge off time (GOT) is the time of day that the Lufkin Well Manager RPC updates all of the 60-day historical data buffers. This time is typically set for early in the morning shortly before operator personnel report for work so that the Lufkin Well Manager RPC can display valid and fresh data from the previous day for analysis.

Oil producers may have contracts with their electric power provider to minimize power consumption during peak demand times of the day in return for a more economical rate. The Lufkin Well Manager RPC has a Peak Energy Management feature that has the controller shut down the pump during peak times, go into a Downtime Peak Energy Management state, and suspend all normal operation. You can program the period of day and which days this function is to take affect. Normal operation resumes at the end of the programmed period.

The Gauge Off Time/Peak Energy Management screen (Figure 8-27) is used to specify GOT and Peak Energy Management times. To display this screen, select **7. GAUGE OFF/PEAK ENERGY MGNT** from the RPC Parameters Menu screen.

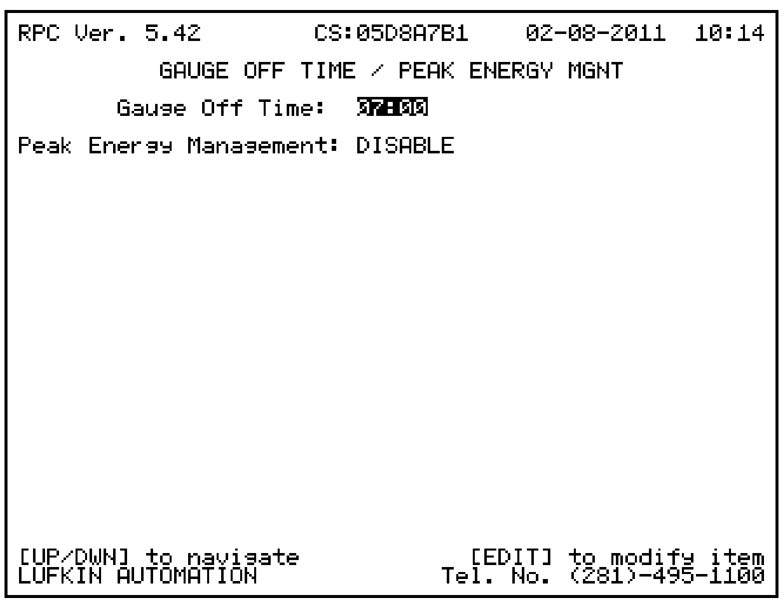


Figure 8-27. Gauge Off Time/Peak Energy Mgnt Screen

Data Field Descriptions

Information about each data field is provided below.

Gauge Off Time

Specify the time of day that the Lufkin Well Manager RPC updates all of the 60-day historical data buffers. Time is specified using the 24-hour clock format of HH:MM:SS.

Peak Energy Management

Specify whether you want the Peak Energy Management function to take affect.

- ***To disable it***, select **DISABLE**. This feature can be useful when times are specified for its use, but you want it cancelled temporarily, such as when you are servicing or testing the equipment. Disabled is the default state.

- ***To enable it***, select **ENABLE**. After you select this option, additional fields display for you to specify the days and times this feature is to take affect.

```
Peak Energy Management: ENABLE

               Period: 10:00 - 14:00
       Days Applicable: Monday          DISABLE
                        Tuesday         DISABLE
                        Wednesday       DISABLE
                        Thursday        DISABLE
                        Friday          DISABLE
                        Saturday        DISABLE
                        Sunday          DISABLE
                        Whole Week      DISABLE
```

– **Period** — Specify the start time for the desired shutdown period, and then the end time. End time must be later in the day than the start time. The period *may not* include a rollover to the next day. For example, a start time of 22:00 and a stop time of 03:00 are not allowed.

– **Days Applicable** — Specify which days this feature is to take affect by selecting between **ENABLE** and **DISABLE**. The same time period applies to each day of the week that is enabled.

Procedure

Follow the steps below to program GOT and peak energy management.

1. From the **Main Menu** screen, select **2. PROGRAMMING**, and then to display the **3. RPC APPLICATION** to display the RPC Parameters Menu screen.

Note: If another screen is displayed, press <**MENU**> to instantly return to the Main Menu screen.

2. Select 7**. GAUGE OFF TIME/PEAK ENERGY MGNT** to display the Gauge Off Time/Peak Energy Mgmt screen with the **Gauge Off Time** field highlighted.

3. Press **<EDIT>**, use the number keys to specify the gauge off time, and then press **<ENTER>**. Be sure to use the 24-hour clock format of HH:MM.

4. To enable Energy Peak Management, press <↓> to highlight the **Peak Energy Management** field.

5. Press **<EDIT>** and then press <↑> or <↓> to scroll to **ENABLE**, and then press **<ENTER>**.

6. Fields for **Period** and **Days Applicable** display.

7. Do the following to specify the start and stop times for Peak Energy Management:

   a. Press **<EDIT>** and then press the numerical keys to specify the start time. After you press a number key for the digit that is highlighted, the next digit to the right highlights. You can press <←> to return to a digit to the left.

   b. After the time is specified for the start time, press **<ENTER>**.

   c. Press <↓> or <→> to highlight the field for specifying the stop time.

   d. Repeat steps a and b to specify the numerical values in this field.

   e. Press<↓>.

   The time field for **Monday** highlights.

8. Press **<EDIT>** and then press <↑> or <↓> to scroll between **ENABLE** and **DISABLE**, and then press **<ENTER>**.

   The field for the next day highlights.

9. Press<↓>.

10. Repeat steps 8 and 9 for each day.

11. When finished editing fields, do either of the following:

- Press **<EXIT>** to return to the RPC Parameters Menu screen.
- Press **<MENU>** to return to the Main Menu screen.

The times for GOT and Peak Energy Management are saved.

8.8 Configuring Miscellaneous RPC Parameters (Others)

MENU 2/1/8

Use the Others screen (Figure 8-28) to specify parameters for an assortment of RPC operations, including pump-O-meter and rod-o-meter stroke counts, H-O-A switch position determination, and enable lockout restart. To display this screen, select **8. OTHERS** from the RPC Parameters Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  10:16
                          OTHERS
             Pump-O-Meter  0000000000
              Rod-O-Meter  0000000000

       Reference PRP (hp)  0000.0  [01-01-1970 00:00]
           Peak PRP Limit  0100.0  hp

       Crank Start Detect  0300 Rev
             Start Window  0000 seconds
         No Crank Timeout  090  seconds

   Load Failure Threshold  00100 Raw

             H-O-A Switch  DISABLE


      External Reset Malf  DI 00 [0=Disable]
     External Clear Alarm  DI 00 [0=Disable]

      Active Alarm Action  NONE


          Lockout Feature  DISABLE
LUFKIN AUTOMATION               Tel. No. (281)-495-1100
```

Figure 8-28. Others Screen

Data Field Descriptions

Information about each data field is provided below.

Pump-O-Meter and **Rod-O-Meter**

Use these fields to clear the counters for rod pump and stroke activity. The Lufkin Well Manager RPC counts and accumulates the number of strokes since the last time rod string work and/or pump work was performed. These counts give operators a tool to measure rod and pump life. These counters can be viewed on Status Screen 2 (**MENU: 1**).

To reset a counter, highlight the desired field, press **<EDIT>**, press **<0>** to display all zeros, and the press **<ENTER>**. To verify that they are cleared, go to Status Screen 2.

Reference PRHP

Specify a reference number for future use by the well operator. You should enter this number immediately after a chemical or hot oil treatment for paraffin is completed to establish a point of reference to check against for a future need for an additional treatment.

Peak PRHP Limit

Specify a value at which the Lufkin Well Manager RPC will set an alert flag to advise the operator that a paraffin treatment may be required. This value is a high limit.

Crank Start Detect

Specify the number of motor revolutions that the Lufkin Well Manager RPC 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 Lufkin Well manager 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.

Start Window

Specify an additional delay time, in seconds, after the well start output is energized before the Lufkin Well Manager RPC 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 motor prime movers do not need an additional delay.

Load Failure Threshold

This value is the low limit for the accumulative number of raw count change of the load input during the Starting Unit load signal checking. This number should only be adjusted by a qualified Lufkin Automation technician.

H-O-A Switch

An extra contact block on the unit Hand-Off-Auto switch can be wired to discrete inputs on the Lufkin Well Manager RPC to give an operator at the host computer a definitive indication of the position of that H-O-A Switch. The contacts must be wired so that one discrete input is connected to signal common when the switch is in the Auto position. A second discrete input is connected to 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 signal common.

When you select **ENABLE**, the well states "Pumping/HOA in Hand" and "DT/HOA in Off" are activated. Two additional fields appear that prompt you designate the digital input to be used for the HOA switch contacts. You must use the AUX Digital Input Configuration screen (**MENU: 2/6/1/3**) to define these digital inputs. For information about configuring them, see "Configuring Auxiliary Digital Inputs and Outputs" in section 9, "Lufkin Parameter Programming."

```
H-O-A Switch  ENABLE
  H-O-A Hand  DI 00
  H-O-A Auto  DI 00
```

External Reset Malf and External Clear Alarm

Use these features to designate defined discrete inputs to be used for performing reset and clear operations using a pushbutton mounted on a cabinet door when security or other operational considerations prevent access to the operator interface keypad. When you push the button, the designated input is momentarily connected to signal common to execute the desired reset/clear action.

You must use the AUX Digital Input Configuration screen (**MENU: 2/6/1/3**) to define these digital input channels. For information about configuring them, see "Configuring Auxiliary Digital Inputs and Outputs" in section 9, "Lufkin Parameter Programming."

Active Alarm Action

Use this feature to specify discrete digital outputs to be used for dynamic and latched alarms. When you select **DIGITAL OUTPUT** to enable this feature, two additional fields appear for you to select the digital output to be used for the dynamic and latched alarms. After you select an output, the alarm will display **Enabled**.

```
Active Alarm Action   DIGITAL OUTPUT
      Dynamic Alarm  DO 00 [0=Disabled]
      Latched Alarm  DO 00 [0=Disabled]
```

You must use the AUX Digital Input Configuration screen (**MENU: 2/6/1/3**) to define these digital output channels. For information about configuring them, see “Configuring Auxiliary Digital Inputs and Outputs” in section 9, “Lufkin Parameter Programming.”

Lockout Feature

Use this feature to have the pumping unit restart in the Malf/Lockout well state when a specified time period due to a power outage has been surpassed. This feature is useful in areas that have high humidity or sea fog conditions that can cause moisture condensation on the windings of open drip-proof motors. Historically motor damage has occurred when motors were restarted after a long power outage before being dried with forced air. In order to return the pumping unit to normal operation, the operator must dry the motor windings and reset the Malfunction condition.

When **ENABLE** is selected, the **Lockout Period** field appears for you to specify the length of a power outage that if exceeded will automatically activate this feature.

```
      Lockout Feature  ENABLE
Lockout Period(hh:mm)  04:00
```

8.9 Configuring Liner Loading Prevention

MENU 2/1/9

For wells that have a fluid liner loading condition, you can configure the Lufkin Well Manager RPC to stop pumping and shut in the casing when gas production from the casing is detected below a specified rate. The Lufkin Well Manager RPC then goes through a user-specified casing shut-in time and downtime long enough to allow casing gas pressure to build and push fluid that has been drawn up the annular space between the tubing and casing back down the annular space to the pump intake. After downtime, the pumping unit resumes pumping as long as enough fluid is available to fill the pump each stroke. After the shut-in time expires, the casing is reopened to allow the gas to flow freely up the casing.

All liner loading configuration is done using the Liner Loading Prevention screen (Figure 8-29). To display this screen, select **9. LINER LOADING PREVENTION** from the RPC Parameters Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  10:17
                 LINER LOADING PREVENTION
Liner Loading State:Exception: LWM Not Operational

             Liner Loading Option   INPUT : AI
         Valve Control DO Channel   00

                 Input AI Channel   00
                    Current Value   000.00
                        Threshold   00000
                            Delay   00000  secs

Last Liner Loading Prevention 00/00/2048  00:00:00





LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 8-29. Liner Loading Prevention Screen

Data Field Descriptions

Information about each data field is provided below.

Liner Loading State

The following liner loading states possible:

- Liner Loading Period – POC Disabled
- Liner Loading Idle – DT Pumpoff
- Liner Loading Idle – Well Run
- Transitional State
- Exception: Malf State
- Exception: Not Normal Oper
- Exception: Calibration State
- Exception: Pumpoff Ctrl Disabled
- Exception: Lufkin Not Operational
- Exception: Liner Loading Disabled
- Exception: Downtime Violation

Liner Loading Period–POC Disabled means liner loading prevention is in operation and therefore normal pump-off control is disabled.

Liner Loading Period – POC Disabled and **Liner Loading Idle – DT Pumpoff** mean liner loading prevention is not in operation but allowed to switch to operation if the liner loading prevention criteria is satisfied.

The remaining states are exception states wherein liner loading prevention will not switch into operation.

Liner Loading Option

Specify whether you want the liner loading feature to be in effect and which method you want used to control it. The choices are:

- **DISABLED** — Liner loading prevention is not in effect.

Note: Wh en **DISABLED** is selected, no other fields display.

- **Timer** — Liner loading prevention is based on a user-specified time period. The following fields appear when this option is selected.

```
                        Timer Interval   00001  hrs
   Liner Loading Prevention Period   00001  mins

Last Liner Loading Prevention 00/00/2048  00:00:00
Next Liner Loading Prevention 04/13/2008  05:43:26
```

– **Time Interval** — Specify how far apart, in hours, that the liner loader prevention operations are to occur.

– **Liner Loading Prevention Period** — Specify the number of minutes that liner loading prevention is to be in operation.

– **Last Liner Loading Prevention** — States the date and time the last liner loading prevention was in operation. This field is read-only.

– **Next Liner Loading Prevention** — States the date and time of the next scheduled liner loading prevention operation should occur. This field is read-only.

- **Input AI** — Liner loading prevention is based on a user-defined analog input threshold value. If the analog input value is less than the threshold, liner loading prevention is invoked and stays in operation until the value goes higher than the threshold. The following fields appear when this option is selected.

```
                         Current Value   000.00
                             Threshold   00000
                                 Delay   00000  secs

Last Liner Loading Prevention 00/00/2048  00:00:00
```

– **Valve Control DO Channel** – Designates the digital output to be used to close/open the casing valve. The auxiliary digital output must be configured. For information about configuring it, see “Configuring Auxiliary Digital Inputs and Outputs” in section 9, “Lufkin Parameter Programming.”

– **Input AI Channel** – Designates the defined analog input that is to be used as the control parameter for Liner Loading. The auxiliary analog input must be configured. For information about configuring it, see “Configuring Auxiliary Analog Inputs” in section 9, “Lufkin Parameter Programming.”

– **Current Value** — States the present AI value. This field is read-only.

– **Threshold** — Specify the AI value limit that is to set liner loading prevention into operation.

– **Delay** — Specify the delay, in seconds, before the threshold limit violation is to be acknowledged.

– **Last Liner Loading Prevention** — States the date and time the last liner loading prevention operation occurred. This field is read-only.

Procedure

Follow the steps below to configure liner loading prevention using the Timer or AI Input option.

1. From the **Main Menu** screen, select **2. PROGRAM** to display the Programming Menu screen.

Note: If you have another screen displayed, press **<MENU>** to instantly return to the Main Menu screen.

2. Select **1. RPC APPLICATION** to display the RPC Parameters Menu screen.

3. Select **9. LINER LOADING PREVENTION** to display the Liner Loading Prevention configuration screen.

   The **Liner Loading Option** field highlights.

4. Press **<EDIT>** and then press <↑> and <↓> to select the prevention method you need. Choices are **DISABLED**, **TIMER**, and **INPUT: AI**.

Note: **DISABLED** turns off liner loading prevention. Go to step 7.

   For **TIMER** and **INPUT: AI**, additional fields display.

5. Press <↑> and <↓> to select the field you want to configure and then do the following:

   a. Press **<EDIT>**.

   b. Press the number keys to enter the value you need.

   c. When the values are correct, press **<ENTER>**.

6. Repeat step 4 for each field you need to configure.

7. When finished, select **<MENU>** to exit the Liner Loading Prevention configuration screen and return to the Main Menu screen.

   If you selected **TIMER** or **INPUT: AI 1**, you need to configure the analog input channel and the digital output channel to be used.

8. Display the AUX Digital I/O Configuration screen (**MENU: 2/6/1/3**) to define the digital output channel and then do the following:

Note: For information about the AUX Digital I/O Configuration screen, see "Configuring Auxiliary Digital Inputs and Outputs" in section 9, "Lufkin Parameter Programming."

---

   a. Press <←>, <→>, <↑>, and <↓> to highlight the digital channel you specified in the **Valve Control DO Channel** field in the Liner Loading Prevention configuration screen and then press <**ENTER**>. The **Board #** field highlights in the **Setup** portion of this screen.

   b. In the **Board #** field, press **<EDIT>** enter the physical board number as set by the jumpers on the board, and then press **<ENTER>**. The motherboard is always designated as Board #0. The **Channel #** field highlights.

   c. Press **<EDIT>**, enter the board digital channel where the valve actuator is connected, and then press **<ENTER>**.

Note: Channel # 1 on Lufkin board is D05 on the board.

---

   d. Press <↓> to highlight the **Input/Output** field, press **<EDIT>**, press <↑>, and <↓> to highlight **OUTPUT**, and then press **<ENTER>**.

9. When finished, do one of the following:

   - ***If you specified liner loading option*** **TIMER**, press **<MENU>** to return to the Main Menu screen. The liner loading prevention feature is now in effect.

   - ***If you specified liner loading option ANALOG***: AI, press **<EXIT>** to return to the AUX IO Configuration Menu screen, and then go to the next step to specify the analog input channel.

10. Select **1. AUX ANALOG INPUT CONFIGURATION** to display the AUX Analog Input Configuration screen. The **AI 1** field highlights.

11. Do all of the following:

    a. Press <←>, <→>, <↑>, and <↓> to highlight the same analog input channel configured in the **Input AI Channel** field of the Liner Loading Prevention configuration screen, and then press **<ENTER>**. The **Board #** field highlights in the **Setup** portion of this screen.

    b. In the **Board #** field, press **<EDIT>** enter the physical board number as set by the jumpers on the board, and then press **<ENTER>**. The motherboard is always designated as Board #0. The **Channel #** field highlights.

    c. Press **<EDIT>**, and enter the channel number that corresponds to the Lufkin expansion board AI channel where the casing pressure sensor is connected, and then press **<ENTER>**.

    d. In the **Units** field, press **<EDIT>**, press <↑> or <↓> to highlight **PSI**, and then press **<ENTER>**.

    e. In the **Range** field, press **<EDIT>**, press <↑> or <↓> to scroll through the available options for pressure transmitter inputs. When the appropriate transmitter range is selected, press **<ENTER>**.

    f. In the **Max** field, press **<EDIT>**, enter the engineering units for maximum output level from the transmitter, and then press **<ENTER>**.

    g. In the **Min** field, press **<EDIT>**, enter the engineering units for the minimum output level from the transmitter, and then press **<ENTER>**.

12. When finished editing fields, do either of the following:

    - Press **<EXIT>** to return to the RPC Parameters Menu screen.

    - Press **<MENU>** to return to the Main Menu screen.

The liner loading prevention operation is now in effect.

8.10 RPC Calibration

MENU 2/3

In order to obtain accurate dynagraph data, three key rod pump control parameters must be accurately calibrated:

- Beam transducer (if this type of load transducer is configured)
- Bottom of stroke
- Reference revolution

Each calibration feature is a separate option available under the RPC Calibration Menu screen (Figure 8-30). To display this menu, select **3. RPC APPLICATION** from the RPC Calibration Menu screen.

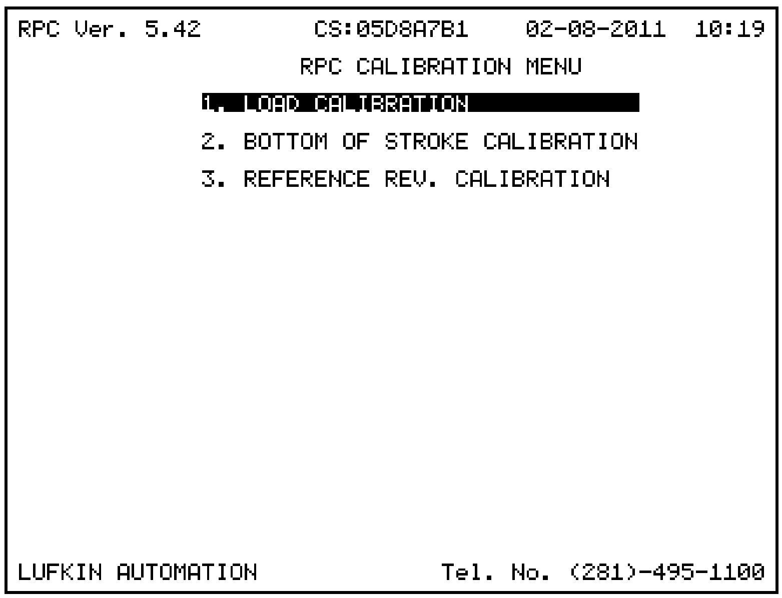


Figure 8-30. RPC Calibration Menu Screen

8.10.1 Configuring Load Calibration

MENU 2/3/1

If the load transducer type being used is a non-calibrated beam transducer, it is necessary to field-calibrate the Lufkin Well Manager RPC for correct loads. You will need the values for peak and minimum load to enter as part of this load calibration. Those values may be from actual well data gathered with a dynamometer system, or they may be predicted values from a *SROD* design software run.

Procedure

Follow the steps below to calibrate loads.

1. From the **Main Menu** screen, select **2. PROGRAM CONTROLLER** to display the Programming Menu screen.

Note: If you have another screen displayed, press **<MENU>** to instantly return to the MAIN Menu screen.

---

2. Select **3. RPC APPLICATION** to display the RPC Calibration Menu screen and then select **1. LOAD CALIBRATION** to display a Load Calibration Setup screen similar to Figure 8-31.

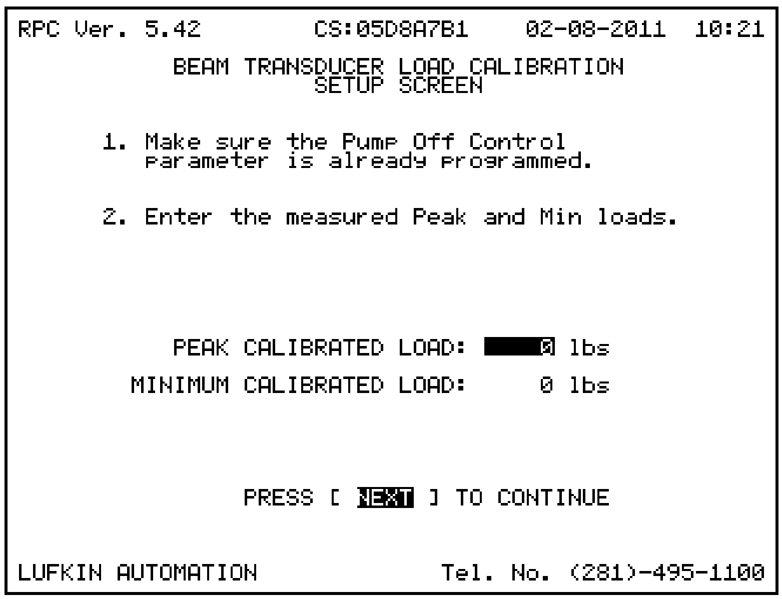


Figure 8-31. Load Calibration Setup Screen

3. As prompted, enter the peak and minimum load values that you want used for calibration. This is done by highlighting the appropriate data field, pressing **<EDIT>**, using the number keys to enter the value, and then pressing **<ENTER>** to accept that value and exit the Edit mode for that field.

4. When both **Peak** and **Minimum** fields read as desired, press <**NEXT**> to continue with the load calibration process.

The Lufkin Well Manager RPC will present a dynagraph screen similar to Figure 8-32 with horizontal dotted lines representing the peak and minimum calibration loads just entered in the previous screen. A notice of **INITIALIZING** displays, and after one or two strokes of the pumping unit, a **Strokes Remaining** countdown from 3 displays.

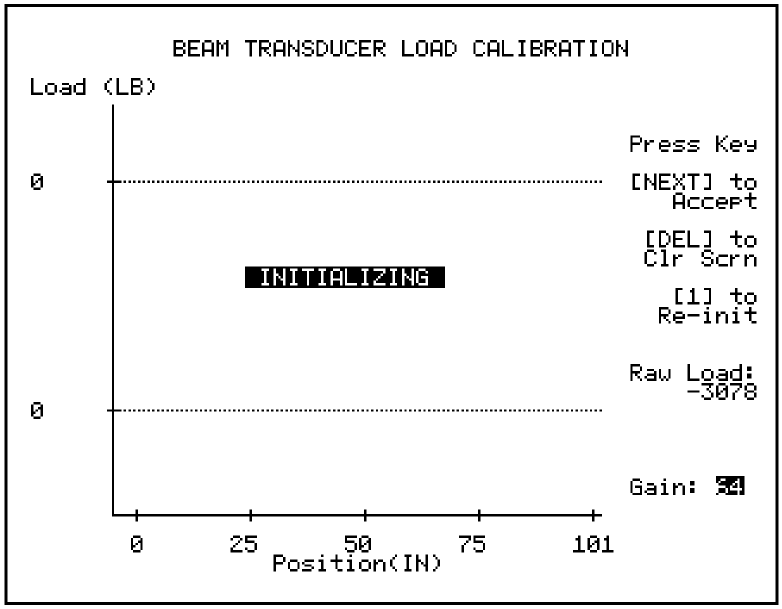


Figure 8-32. Load Calibration Screen

After the three-stroke countdown completes, a realtime dynagraph trace starts between the dotted calibration load lines. Within a few strokes, the card trace should automatically scale to just touch the Peak load line and the Min load line.

5. When you are satisfied that the card shape is touching both calibration load lines, press **<NEXT>** to accept and complete the load calibration procedure.

6. When finished editing fields, do either of the following:

   - Press **<EXIT>** to return to the RPC Calibration Menu screen.

   - Press **<MENU>** to return to the Main Menu screen.

If the pumping unit does not start when you begin the load calibration process, look at **Well State** on the RPC Status screen (**MENU: 1**). It may be necessary in some cases to temporarily disable all control functions until load calibration is completed. Use the **Start/Stop,** or the **Reset Malfunctions** option on the Main Menu screen to return the Lufkin Well Manager RPC to a pumping state. This remedy should allow you to complete the load calibration.

If the load traces as a flat line at the top of the calibration screen and the unit is not able to calibrate, it may be necessary to program a lower value for the load gain. See the table for load gain in “Load Signal Input” in section 20, “Troubleshooting.”

8.10.2 Configuring Bottom of Stroke Calibration

MENU
2/3/2

Normally, if two field personnel are available to set the crank arm sensor at the exact dead bottom of the stroke, one person can observe the CSW light on the left hand edge of the Lufkin Well Manager motherboard as the other person adjusts the magnet location. However, if only one person is available, the Bottom of Stroke Calibration screen (Figure 8-33) and the Start Alert output on the Lufkin Well Manager RPC can be used to assist the person to set the crank switch sensor to activate at exact dead bottom of the stroke. To display this screen, select **2. BOTTOM OF STROKE CALIBRATION** from the RPC Calibration Menu screen.

Watch the CSAW light or with a beeper device connected follow the prompts on the screen to precisely set the crank arm magnet

Note: If a Start Alert beeper is not installed, one can be temporarily connected to **DO 3** on the Lufkin Well Manager RPC motherboard. Terminal **6** on terminal strip TB4 is the terminal designated for a Start Alert output. If you need a Start Alert output, contact your Lufkin Automation representative for information about the Sonalert Kit (Part No. 530.4453) that is available.

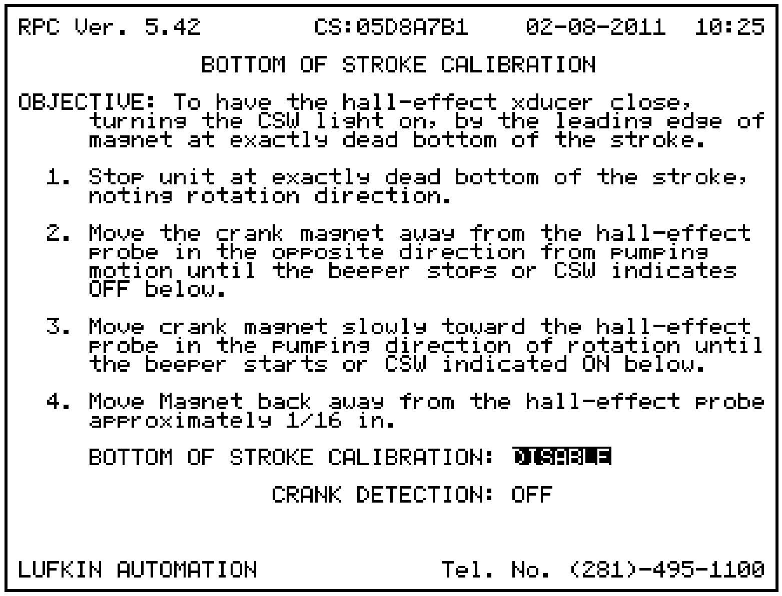


Figure 8-33. Bottom of Stroke Calibration Screen

When the operation is completed, press **<EXIT>** to return to the RPC Calibration Menu screen (Figure 8-30) or press **<MENU>** to return to the Main Menu screen.

8.10.3 Configuring Reference Revolution Calibration

MENU 2/3/3

In order for some control features to work properly, the Lufkin Well Manager 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, and it is therefore necessary to recalibrate this reference revolution (Ref Rev) parameter. Reference revolution can be recalibrated using the Reference Revolution Calibration screen (Figure 8-34). To display this screen, select **3. REFERENCE REV CALIBRATION** from the RPC Calibration Menu screen.

Note: The Quick-Start routine includes a step to perform this calibration during initial commissioning of a controller.

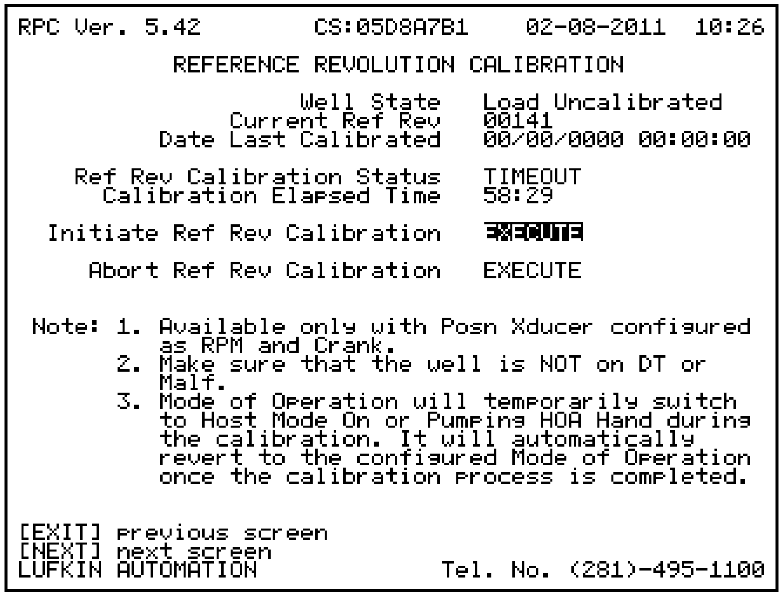


Figure 8-34. Reference Revolution Calibration Screen

When this screen appears, the **Initiate Ref Rev Calibration** field is highlighted. 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**. Press **<EXIT>** to return to the RPC Calibration Menu screen (Figure 8-30) or press **<MENU>** to return to the Main Menu screen.

Note: No other screen is available after you click **<NEXT>**. This is an incorrect prompt that has not been removed from present firmware.

Section 9

Lufkin Parameter Programming

Parameter values controlling basic operations of the Lufkin Well Manager RPC must be properly programmed in order for any effective well management and control to occur. This section describes the programming screens necessary to configure these parameters and how to access them.

The topics covered in this section include:

9.1 Overview of Lufkin Parameter Programming

In addition to the parameters required for routine RPC operations, several other parameters need to be configured (programmed) that control basic daily routine operations and other operations that the Lufkin Well Manager RPC can perform. Some include:

- Date, time, and user passwords
- Communication parameters
- Auxiliary Analog, digital, and accumulator inputs
- Logic expression commands
- AGA-3 and NX-19 parameters

- Register logs and calculations
- Alarms

MENU 2

Lufkin parameter values are found under the Programming Menu screen (Figure 9-1). To access this screen, first select **2. PROGRAM** from the Main Menu screen. Use the menu map provided in section 2 to help you navigate to the screen you need. Descriptions about each RPC parameter programming screen (including field descriptions) are described throughout this section.

Note: Options 1. RPC APPLICATION and 3. RTU CALIBRATION are used for configuring RPC parameters and are explained in section 8, “RPC Parameter Programming.” Option 2. RPC Quick Start is explained in section 18, “Quick Start Feature.”

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  09:14
                   PROGRAMMING MENU
                 1. RPC APPLICATION
                 2. RPC QUICK START
                 3. RPC CALIBRATION
                 4. RPC WELL STATE ALARMS
                 5. RTU LEVEL
                 6. AUXILIARY FUNCTIONS
                 7. REGISTER FUNCTIONS
                 8. COIL TRACKING

LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 9-1. Programming Menu Screen

Note: A user password is required to access the Programming Menu screen if password protection is enabled. For information about passwords, see “Changing Passwords” on page 9-34.

Note: Lufkin Automation recommends that initial programming should be done using the Quick Start feature. Later on, you can revise the control parameters by returning to Quick Start or by accessing the specific programming screen you need. For information about Quick Start, see section 18, “Quick Start Feature.”

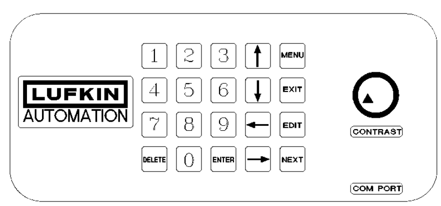
9.1.1 RAM Backup Protection

Many of the parameters programmed for rod pump control are stored in RAM on the Lufkin Well Manager RPC circuit board. This memory is supported during power outages by a lithium battery located near the top of this circuit board. Failure to include the battery will cause the Lufkin Well Manager RPC to loose programming when the power switch is turned off.

Before programming the Lufkin Well Manager RPC, ensure that the shorting jumper is on both pins so that the battery is included in the circuit. Battery disconnect jumper pins are located next to the battery. If the battery is not included, the Lufkin Well Manager RPC will loose programming when the power switch is turned off. The battery jumper configuration can be checked by looking down between the optional expansion board, if installed, and the main board from the top. If the jumper is not on both pins, the expansion board must be temporarily removed to properly place the jumper. For more information about the battery, see “Battery Disconnect Jumper Pins” in section 5, “Hardware Configuration.”

9.1.2 Operator Interface Keypad Programming

All programming parameter values can be entered through the 20-key operator interface keypad mounted in the Lufkin Well Manager RPC enclosure. This operator interface allows you at the wellsite to program and calibrate the Lufkin Well Manager RPC, and access and display current and historical data instead of using the *Dynalink* operator interface program that runs on a laptop computer. For information about the keypad and how to use it, see “Controller Operator Interface” in section 2, “Description of the Lufkin Rod Pump Controller System.”



9.1.3 Parameter Programming Procedure

Most screens use the same procedure to edit (program) control parameters. The procedure involves displaying the screen you need, highlighting the field with the parameter, editing the parameter value, saving it to the Lufkin Well Manager RPC, and then repeating the steps for the next parameter. When a procedure is unique to the screen or additional steps are required, its procedure is provided after the screen description.

The procedure provided below is used for most screens.

1. Display the screen that has the parameters you want to edit.
2. Press <↑> or <↓> to highlight the field you want to edit.
3. Do one of the following:
   - ***To enter numerical values***, press **<EDIT>** and then press the number keys. After you press a key, the next digit to the right highlights. You can press <←> to return to a digit to the left to change it. After all numerical values are correct, press **<ENTER>**.
   - ***To select field options***, press **<EDIT>**, press <↑> or <↓>, and then press **<ENTER>**.

   The next field highlights.
4. Repeat step 3 for each field you want to edit.
5. When you are finished editing fields, do either of the following.
   - Press **<EXIT>** to return to the menu screen from where you selected the screen you edited.
   - Press **<MENU>** to return to the Main Menu screen.

Your parameter values are saved to the Lufkin Well Manager RPC.

9.2 RPC Well State Alarms Configuration

MENU 2/4

Any well state listed in appendix C can be configured to set an alarm flag. Up to thirty-two well state alarms can be configured. Whenever the Lufkin Well Manager RPC is in a configured well state, a dynamic alarm is flagged. The first time that a programmed well state dynamic alarm flag is set, the corresponding latched alarm is also set. Dynamic alarms automatically clear when the well state changes, but the operator must clear latched alarms. For information about clearing these alarms, see section 16, “Alarm Clearing.”

Well state alarms are configured with a Well State Alarm Config screen similar to Figure 9-2. To display this screen, select **4. RPC WELL STATE ALARMS** from the Programming Menu screen.

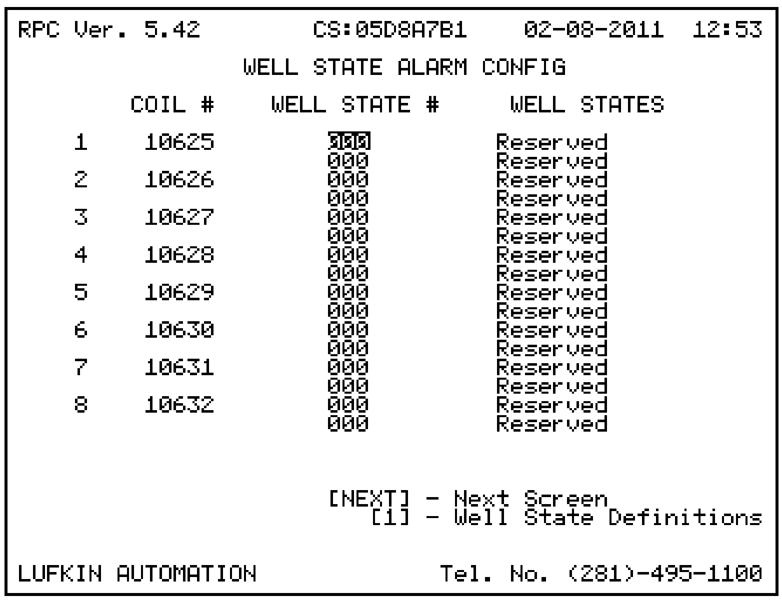


Figure 9-2. Well State Alarm Config Screen

Data Field Descriptions

Information about each data field is provided below.

INDEX

This reference field shows which coil is being configured. This field cannot be edited.

COIL #

This reference field displays the register number in the Lufkin Well Manager RPC memory that will store the well state alarm. Contact your Lufkin Automation representative to obtain the latest Lufkin RPC register map. This field cannot be edited.

WELL STATE

Specify the code number of the well state to set the alarm. Press **<1>** to display a list of the well states with the corresponding code number.

WELL STATES

This field displays an "un-coded" description of the well state code entered in the **Well State** column. Read this description to confirm your code number entry.

Procedure

Follow the steps below to configure well state alarms.

1. From the **Main Menu** screen, select **2. PROGRAM**, and then select **4. RPC WELL STATE ALARMS** to display the Well State Alarm Config screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

The **Well State #** field for **INDEX 1** highlights.

2. Do the following for each coil you want to configure.

   a. If you want to select a specific **Well State #** field, press <↑> or <↓>, to highlight it.

   b. When the field is highlighted, press **<EDIT>**.

   c. Press the numerical keys to enter numerical values. After you press a number key for the digit that is highlighted, the next digit to the right highlights. You can press <←> to return to a digit to the left.

   d. After all numerical values for the field are correct, press **<ENTER>**. The next field highlights.

   e. Repeat steps a through d for each **Well State #** field you want to configure.

3. When you are finished configuring well states, do either of the following:
    - To return to the Program Menu screen, press **<EXIT>**.
    - To return to the Main Menu screen, press **<MENU>**.

9.3 RTU Level Menu

MENU 2/5

Several fundamental operating parameters within the Lufkin Well Manager RPC need to be configured. Usually these parameters only need to be configured once, or at the most, on very rare occasions. The parameters include:

- Date and time, which is required for recording and plotting historical data
- Communication parameters, such as establishing baud rates, handshake protocol, and key up and key down times
- User and supervisor passwords to restrict unauthorized access to the configuration screens
- Restoration of factory-default parameters values
- Mainboard I/O diagnostics for troubleshooting purposes

These configuration operations are performed using the options available under the RTU Level Menu screen (Figure 9-3). To display this menu, select **5. RTU LEVEL** from the Program Menu screen.

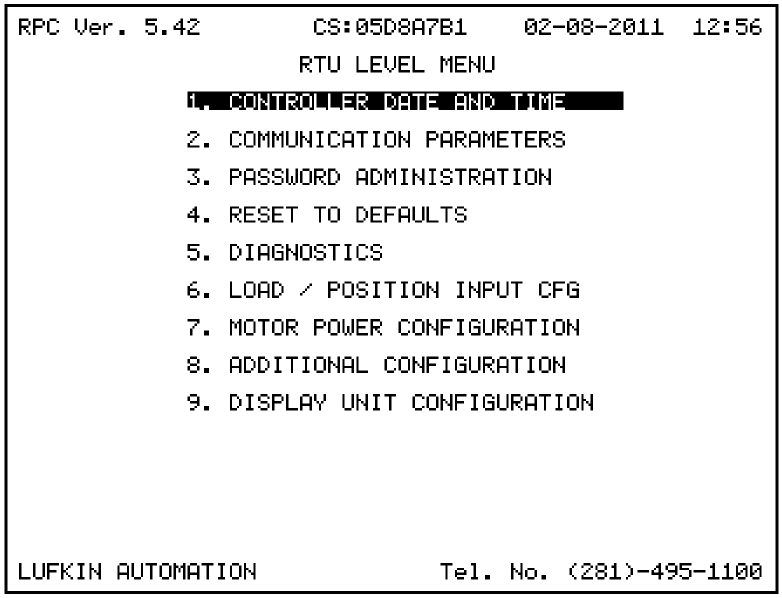


Figure 9-3. RTU Level Menu Screen

Note: Option 5. DIAGNOSTICS (**MENU: 2/5/5**) contains diagnostic tools for troubleshooting RPC control system installations. Its features are discussed in section 17, "System Diagnostics Tools."

9.4 Setting the Controller Date and Time

MENU 2/5/1

In order for historical data to be accurate, the date and time in the Lufkin Well Manager RPC must be programmed to agree with local time.

The Lufkin Well Manager RPC can automatically adjust the time setting for daylight saving time (DST). If your area does not recognize DST, disable the DST feature at this time. The North American — United States dates are used to define the beginning and end of the DST period.

Date and time are set using the Clock Calendar Configuration screen (Figure 9-4). To display this screen, select **1. CONTROLLER DATE AND TIME** from the RTU Level Menu screen.

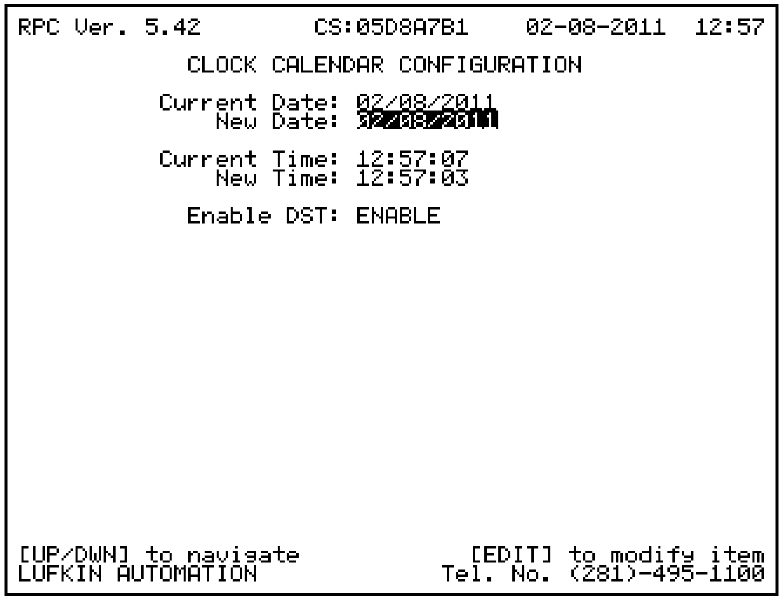


Figure 9-4. Clock Calendar Configuration Screen

Procedure

Follow the steps below to set the date and time.

1. From the **Main Menu** screen, select **2. PROGRAM** to display the Programming Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

2. Select **5. RTU LEVEL**, and then select **1. CONTROLLER DATE AND TIME** to display the Clock Calendar Configuration screen.

   The **New Date** field highlights.

3. Press **<EDIT>** and use the number keys to enter the present month/date/year, and then press **<ENTER>**. Be sure to use the date format shown of MM/DD/YYYY.

4. Press <↓> until the **New Time** field highlights.

5. Press **<EDIT>** and use the number keys to enter the present local time, and then press **<ENTER>**. Be sure to use the 24-hour clock format of HH:MM:SS.

6. If you want to use daylight saving time, make sure the **Enable DST** field reads "ENABLE." If it does not, press <↓> to highlight this field, press **<EDIT>**, press <↑> or <↓> to toggle to **ENABLE**, and then press **<ENTER>**.

7. When finished editing fields, do one of the following:

   - To return to the RTU Level Menu screen, press **<EXIT>**.

   - To return to the Main Menu screen, press **<MENU>**.

The Lufkin Well Manager RPC now resumes operations based on the new date and time you programmed.

9.5 Communication Parameters Configuration

MENU 2/5/2

If the Lufkin Well Manager RPC has data telemetry equipment (radio, cell phone, etc.) connected to it, you must program the communication parameters. Default parameter values are preset with factory-default values that you may need to edit.

Communication parameters are programmed using the options available under the Communication Parameters Menu screen (Figure 9-5). To display this menu, select **2. COMMUNICATION PARAMETERS** from the RTU Level Menu screen.

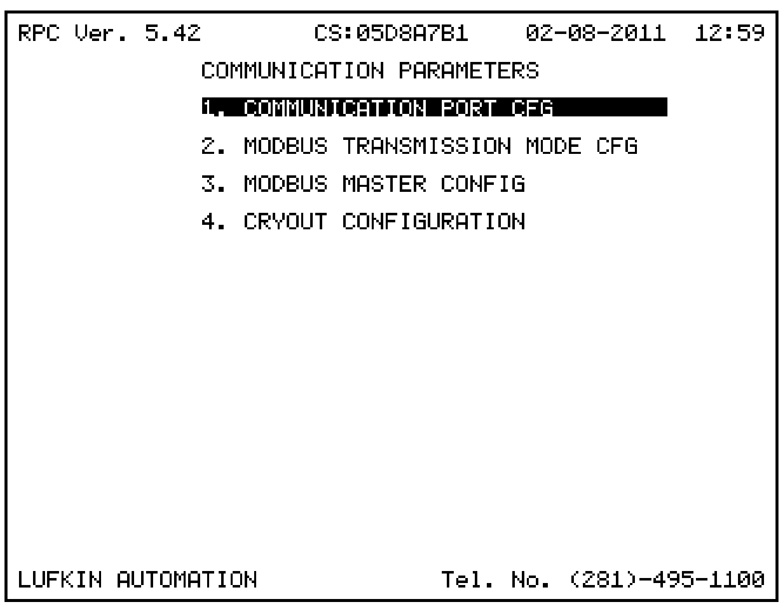


Figure 9-5. Communication Parameters Menu Screen

9.5.1 Configuring Communication Parameters

MENU
2/5/2/1

The communication parameters that you usually need to configure are:

- RTU address
- Data transmission rate
- Keying properties
- Handshake protocol

These parameters are programmed using a Communication Administration screen similar to Figure 9-6. To display this screen, select **1. COMMUNICATION PORT CFG** from the Communication Parameters Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  13:00
             COMMUNICATION ADMINISTRATION
                  RTU Address:    0001

         Radio Port Baud Rate:     9600
          Delay before Key Up:   00075  ms
                  Key Up Time:   00300  ms
                Key Down Time:   00050  ms
     Enable/Disable Radio CTS:   DISABLE
     Enable/Disable Radio DCD:   DISABLE
       Character Gap Timeout:   003.5  chars 03.65  ms

        Laptop Port Baud Rate:   115200
   En/Disable Laptop RTS/CTS:   ENABLE
       Character Gap Timeout:   003.5  chars 00.30  ms

  Expansion Comm. Mode Option:   RS485
    Expansion Comm. Baud Rate:     9600
                 Key Up Delay:   00075  ms
                  Key Up Time:   00300  ms
                Key Down Time:   00050  ms
       Enable/Disable RTS/CTS:   DISABLE

   Reset Comm Regs to Default:   EXECUTE

[UP/DWN] to navigate           [EDIT] to modify item
LUFKIN AUTOMATION            Tel. No. (281)-495-1100
```

Figure 9-6. Communication Administration Screen

Data Field Descriptions

Information about each data field is provided below.

RTU Address

Specify a unique identifier number for the controller that must be coordinated with the address entry in the host computer SCADA software. The Lufkin Well Manager RPC 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. For more information on the ELAM protocol, contact your Lufkin Automation representative.

Radio Port Baud Rate

The Lufkin Well Manager RPC 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.

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.

Key Up Time

Once the RTS line is raised, the controller will delay this amount of time before actually starting to send data.

Key Down Time

At the end of the message string, the RTS is held high for this amount of time.

Enable/Disable Radio CTS and DCD

The Lufkin Well Manager RPC does not need these “handshake” signals, but if your radio requires that protocol, they can be enabled. Typically, leave this value set to **DISABLE**.

Character Gap Timeout

The Lufkin Well Manager RPC uses RTU Modbus communication protocol. In that protocol, the end of a message is marked by a break or gap in the message string that is greater than 3.5 data characters in length. In some communication networks, repeaters or relay stations may break a message into two or more parts with gaps between the parts. If those gaps are longer than the 3.5-character time, the Lufkin Well Manager RPC will not receive a valid message. These situations can be resolved by programming a longer character gap timeout.

Expansion Comm. Mode Option

The Lufkin Well Manager RPC processor has a second communication port that is presently used for the Modbus master function. The settings available include:

- RS485
- RS232
- FSK Modem
- Ethernet
- None

Expansion Comm Baud Rate

The Lufkin Well Manager RPC supports a range of data transmission rates from 300 to 115,200 baud on the expansion port.

Key Up Time

Once the RTS line is raised from the second communication port, the Lufkin Well Manager RPC will delay this amount of time before actually starting to send data.

Key Down Time

At the end of the message string from the second communication port, the RTS is held high for this amount of time.

Enable RTS/CTS

For the second communication port, the Lufkin Well Manager RPC does not need these “handshake” signals, therefore leave this value set to **DISABLE**.

Reset Comm Regs to Default

Executing this option resets all communication parameters (including the RTU Address) to the factory-default values. This option should only be executed by a trained Lufkin Automation technician.

9.5.2 Configuring Modbus Transmission Mode

MENU 2/5/2/2

You can program the parity and stop bits for the Modbus transmission to ensure that it is compatible with the host SCADA software. All other fields must remain as shown to support the Modbus RTU protocol used by the Lufkin Well Manager RPC. This programming is done through a Modbus Transmission Mode CFG screen similar to Figure 9-7. To display this screen, select **2. MODBUS TRANMISSION MODE CFG** from the Communication Parameters Menu screen.

Note: The same parameters should be applied for the laptop and radio ports, because the laptop port is really the same communications port, but redirected to the front panel with DTR.

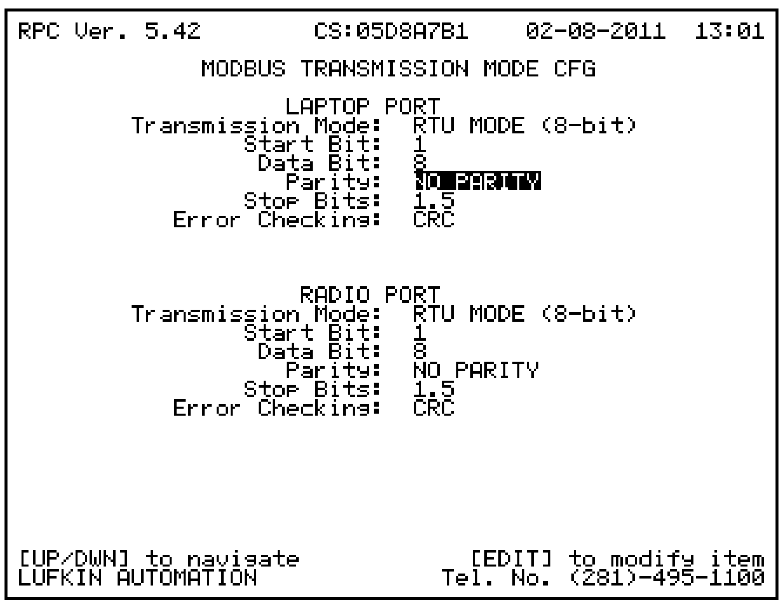


Figure 9-7. Modbus Transmission Mode CFG Screen

Data Field Descriptions

Information about each data field is provided below.

Transmission Mode

Only the Modbus RTU protocol is supported.

Data Bits, Stop Bits, and Parity

These three fields define the data format to be used by the Lufkin Well Manager RPC.

For **Parity**, the choices are **NO PARITY** and **ODD/EVN**. **NO PARITY** should be selected to support the Modbus RTU protocol.

These settings must be the same as the host SACADA software.

Error Checking

Only the CRC (Cyclical Redundancy Check) Modbus protocol is supported.

9.6 Modbus Master and Slave Device Configuration

MENU 2/5/3

A Lufkin Well Manager RPC equipped with an RS-485 communication expansion board (Part No. 520.5012) can use the Modbus Master function and be programmed to poll and collect data from a maximum of 10 slave devices. The Lufkin Well Manager RPC plays the role of master unit and the other devices are configured as slave devices.

Slave Device #1 is automatically configured with all necessary parameters when a Rosemount 3095FB device is selected for one or more of the process variable inputs in the monitored transmitter configuration.

If necessary, you can change the Modbus communication configuration to accommodate these devices. Typically, you will not use this configuration option. If you do need to change the Modbus configuration, contact your Lufkin Automation representative for information about this process.

A maximum of 125 data registers can be read from each configured RTU slave device. The Lufkin Well Manager RPC can automatically poll the slave devices at a programmable interval.

The Lufkin Well Manager RPC can also be configured to write data to the slave devices configured to it. Desired values can be programmed for a maximum of 25 registers in each slave device. The write function requires a manual command to execute.

Modbus/slave device configuration involves the following five processes:

- Assigning a number to a slave device
- Configuring slave device communication parameters
- Configuring a Modbus slave device
- Specifying a polling routine rate
- Configuring a transmission mode for compatibility with host SCADA software

All Modbus and slave device configuration is done with the options available under the Modbus Master Menu screen (Figure 9-8). To display this menu, select **3. MODBUS TRANSMISSION MODE CFG** from the Communication Parameters Menu screen.

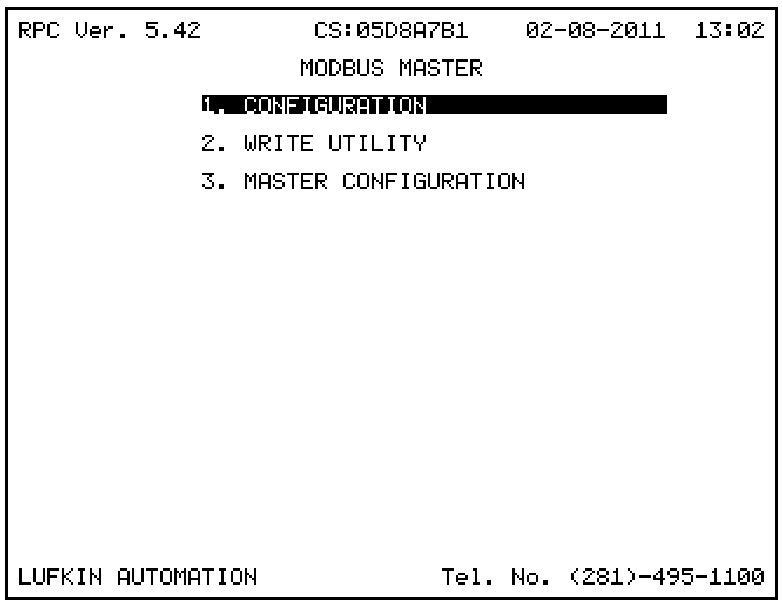


Figure 9-8. Modbus Master Menu Screen

Note: The Lufkin Well Manager RPC must be programmed to recognize an RS-485 communication expansion board before any Modbus master/slave device programming can occur. For information about expansion board configuration, see “Configuring Communication Parameters” on page 9-12.

9.6.1 Configuring Slave Device Parameters

MENU 2/5/3/1

The Lufkin Well Manager RPC can be programmed to poll a maximum of ten slave devices. Each Modbus RTU to be polled by the Lufkin Well Manager RPC must have a slave device number assigned to it, and each device must be programmed separately. This programming is done using the Modbus Master Config selection screen (Figure 9-9). To display this screen, select **1. CONFIGURATION** from the Modbus Master Menu screen.

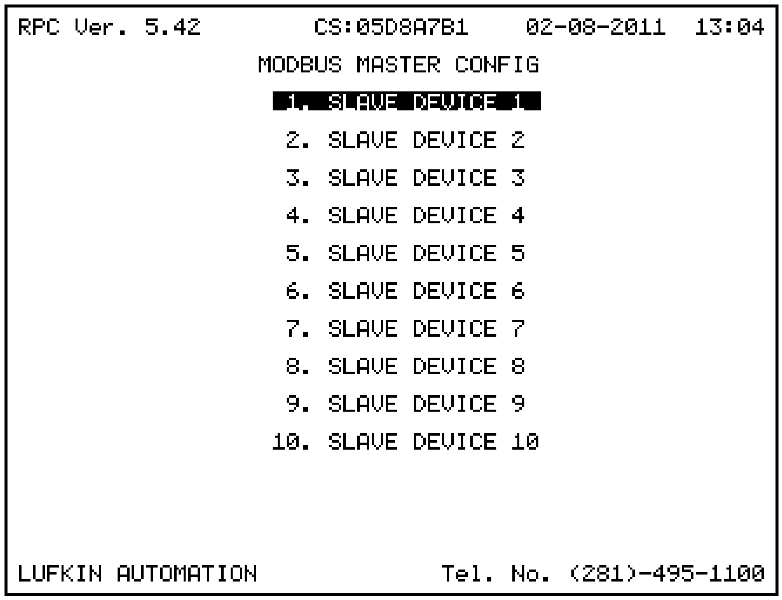


Figure 9-9. Modbus Master Config Screen

After you assign a number to a slave device, you should see a slave device communication configuration screen similar to Figure 9-10 with the slave device number you selected displayed at the top of the screen, such as "Slave Device 1." You need to use these fields to specify the type of slave device used as an RTU and its communication parameters. You can also return to this screen at any time when you need to change parameter values.

Note: Refer to the user manual for the slave device for information about its parameters.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  13:05
                       DEVICE  1

           RTU ADDRESS:         001
           DEVICE TYPE:    MODBUS SLAVE
             BAUD RATE:         9600
             DATA BITS:            8
             STOP BITS:            2
                PARITY:       NO PARITY

   DELAY BEFORE KEY UP:         0000
           KEY UP TIME:         0000
         KEY DOWN TIME:         0000

    # FAILURES ALLOWED:         0005
               TIMEOUT:         0300

                STATUS:      DISABLED

                      [NEXT] - CONFIGURE ADDRESSES
LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 9-10. Slave Device Communication Configuration Screen

Data Field Descriptions

Information about each data field is provided below.

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

Three options are available for specifying a slave device type.

- **MODBUS SLAVE** — Select for any RTU that uses Modbus RTU protocol.

- **SIEMENS LS1000 LEVEL SENSORS** — A special application of the RS-485 master/slave capabilities of the Lufkin Well Manager RPC.

- **Rosemont 3095** — Slave Device #1 is automatically configured with all necessary parameters when a Rosemount 3095FB device is selected for one or more of the process variable inputs in the monitored transmitter configuration. The pre-set parameters include the Rosemount factory default data transfer rate of 9600 baud.

BAUD RATE

Select from a range of options from 300 to 115,200 baud. The value must match the slave device setting.

DATA BITS, STOP BITS, and PARITY

These three fields define the data format to be used by the Lufkin Well Manager RPC. 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 Lufkin Well Manager RPC 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.

 # FAILURES ALLOWED

Specify the number of times that the Lufkin Well Manager RPC will continue to try to poll a slave device once that device is enabled. If the Lufkin Well Manager RPC 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.

TIMEOUT

Specify the time, in milliseconds, that the Lufkin Well Manager RPC waits after sending a poll message to check the reply message buffer.

STATUS

This 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.

Address Association to Registers

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, you 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 20 to a screen. This configuration is performed using a Register Address Configuration screen similar to Figure 9-11. To display this screen, at the Slave Device Communication Configuration screen, press **<NEXT>**.

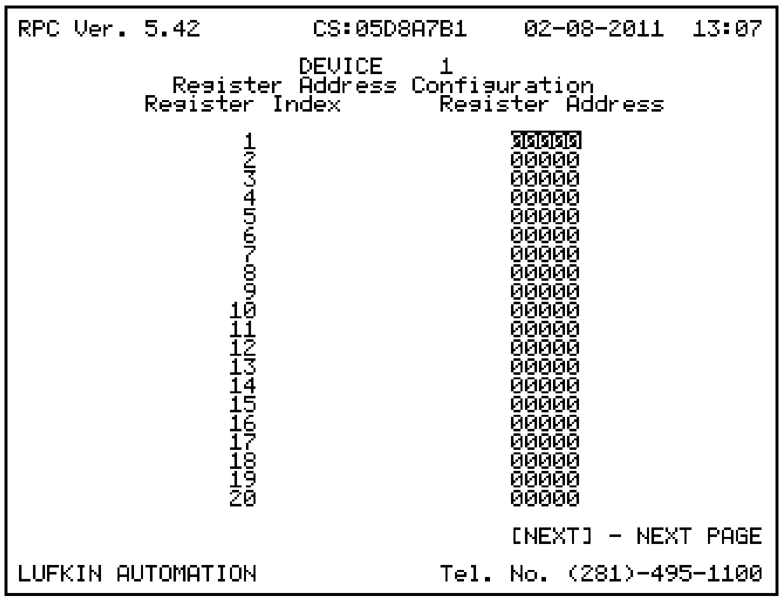


Figure 9-11. Register Address Configuration Screen

The numbers in the **Register Index** column are the numbers assigned in the Lufkin Well Manager RPC buffer of values. The values in the **Register Address** column must be programmed with the register numbers in the slave device that contain the data you want to read. You need to perform this operation separately for each Modbus slave device on the data network.

When you assign 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

Procedure

Follow the steps below to configure slave device parameters.

1. From the **Main Menu** screen, select **2. PROGRAM** to display the Programming Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

---

2. Select **5. RTU LEVEL** and then select **2. COMMUNICATION PARAMETERS** to display the Communication Parameters Menu screen.

3. Select **2. MODBUS TRANSMISSION MODE CFG**, and then select **1. CONFIGURATION** to display the Modbus Master Config screen

   Slave Device 1 highlights.

4. Press <↑> or <↓> to highlight the slave device you want to configure.

5. Do one of the following:

   - ***For all numbers***, press <↑> or <↓> to scroll through the list to highlight the device number you want assigned, and then press **<ENTER>**.

   - ***For numbers 1 through 9***, press the number key representing the slave device number. For 10, press <↓> to highlight it, and then press **<ENTER>**.

Note: Every slave device that is to be polled by the Lufkin Well Manager RPC must have a number assigned to it.

A Slave Device Communication configuration screen similar to Figure 9-10 displays.

6. Press <↑> or <↓> to highlight the data field you want to edit and then do one of the following:

   - ***To enter numerical values***, press **<EDIT>** and then press the number keys. After you press a key, the next digit to the right highlights. You can press <←> to return to a digit to the left to change it. After all numerical values are correct, press **<ENTER>**.

   - ***To select field options***, press **<EDIT>**, press <↑> or <↓> to scroll through available options. Press **<ENTER>** when the desired option is displayed.

   The next field highlights.

Note: If the slave device is to be offline for service, select **DISABLED** in the **Status** field to disable it. This action prevents nuisance communication failure alarms from displaying.

---

7. When all parameters are specified correctly, press **<NEXT>**. The screen that appears next is determined by the type of slave device specified in the **Device Type** field.

8. Make sure all fields in the Slave Device Communication configuration screen (Figure 9-10) have the correct data entered in them, and then press **<NEXT>** to display the Register Address Configuration programming screen (Figure 9-11).

9. Press <↑> or <↓> to highlight the **Register Address** field you want to configure, and then press **<EDIT>**.

10. Press the number keys to enter the value you want, and then press **<ENTER>**.

11. Repeat steps 8 and 9 for each field on the screen you want to configure.

12. To configure the next group of 20 register numbers, press **<NEXT>** to display the next screen, and then repeat steps 9 through 11.

13. When all register numbers are configured, do one of the following:

- To return to the Modbus Master Config Menu screen (Figure 9-10), continue pressing **<EXIT>.**
- To return to the Main Menu screen, press **<MENU>**.

The slave device parameters are saved.

9.6.2 Writing Register Values to Registers and the Slave Device

MENU 2/5/3/2

The Modbus Master 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, you need to specify the Modbus slave device that is to receive these values and then write them to it. The Modbus Master Write Utility screen (Figure 9-12) is used to write and send to the slave device. To display this screen, select **2. WRITE UTILITY** from the Modbus Master menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  13:10
            Modbus Master Write Utility
 Register Index   Register Address   Register Value

        1              00000              00000
        2              00000              00000
        3              00000              00000
        4              00000              00000
        5              00000              00000
        6              00000              00000
        7              00000              00000
        8              00000              00000
        9              00000              00000
       10              00000              00000
       11              00000              00000
       12              00000              00000
       13              00000              00000
       14              00000              00000
       15              00000              00000
       16              00000              00000
       17              00000              00000
       18              00000              00000
       19              00000              00000
       20              00000              00000

                               [NEXT] - NEXT PAGE
LUFKIN AUTOMATION           Tel. No. (281)-495-1100
```

Figure 9-12. First Modbus Master Write Utility Screen

The Lufkin Well Manager RPC writes to one register at a time, so the Modbus guidelines regarding function codes and contiguous registers do not affect a write operation.

The remaining five register values appear on a second screen similar to Figure 9-13. This screen is also where you find the option to write the values to the Modbus slave device.

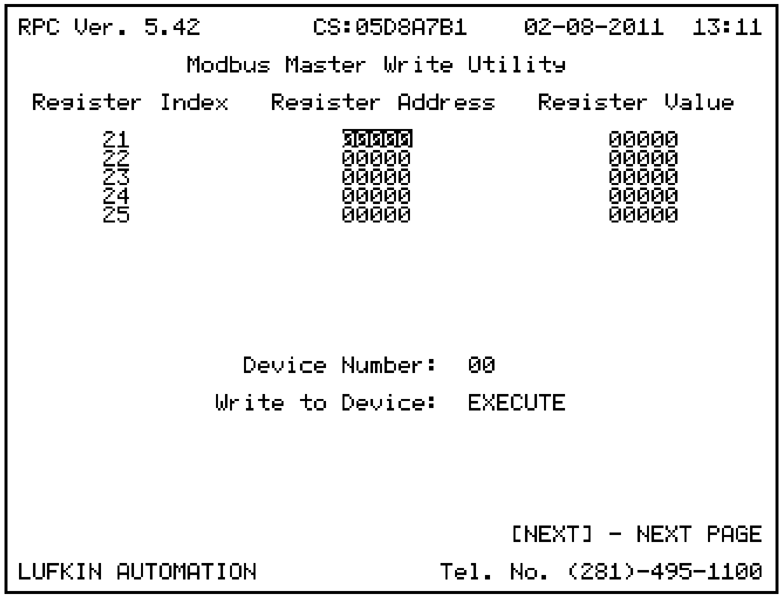


Figure 9-13. Second Modbus Master Write Utility Programming Screen with Write Option

Procedure

Follow the steps below to write register values to register addresses and the slave device.

1. From the **Main Menu** screen, select **2. PROGRAM** to display the Programming Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

2. Select **5. RTU LEVEL** and then select **2. COMMUNICATION PARAMETERS** to display the Modbus Master Menu screen.

3. Select **2. COMMUNICATION PARAMETERS** and then select **2. WRITE UTILITY** to display the Modbus Master Write Utility screen.

   The **Register Address** field for **Register Index 1** highlights.

4. Press <↑> or <↓> to highlight the **Register Address** field you want to configure, and then press **<EDIT>**.

5. Press the number keys to enter the value you want, and then press **<ENTER>**.

6. Press <→> to highlight the corresponding **Register Value** field, and then press **<EDIT>**.

7. Press the number keys to enter the value you want, and then press **<ENTER>**.

8. Press <←> and then press <↑> or <↓> to highlight the next **Register Address** field you want to configure.

9. Repeat steps 5 through 9 for each **Register Address/Register Value** pair you want to configure.

10. After you configure the first 20 pairs on this screen, press **<NEXT>** to configure the remaining five pairs. Repeat steps 5 through 9 for them also.

11. When finished configuring the pairs, press <↓> to highlight the **Device Number** field.

12. Press <**EDIT**>, press the number keys to enter the device number of the Modbus slave device to which you want to write the register values, and then press **<ENTER>**.

13. Press <↓> to highlight the **Write to Device** field, and then press **<ENTER>**.

    The Lufkin Well Manager RPC writes the register values to the specified register addresses in the slave device.

14. Do one of the following:

    - To return the Modbus Master Menu screen, press **<EXIT>**.
    - To return to the Main Menu screen, press **<MENU>**.

The register values written to the register addresses and the slave device are saved.

9.6.3 Specifying a Polling Routine Rate

MENU 2/5/3/3

The Modbus Master function uses a polling routine to retrieve data from all enabled slave devices in the data network. You can specify the poll rate (or interval) for the routine.

The polling routine occurs after the Lufkin Well Manager RPC sends a polling message to a slave device. After the timeout interval elapses, the reply buffer is checked. If the reply is valid, the register index is updated with the new value. If the reply is invalid or no reply occurs, the consecutive communication failure counter is incremented. The next polling message is transmitted without further delay. After all programmed poll messages are completed, the Lufkin Well Manager RPC remains idle for the remainder of the poll rate time.

Here is an example for a wellsite that has two slave devices connected to the Lufkin Well Manager RPC. Each device requires five data transmissions to read all of the desired data, and each data reading takes 500 milliseconds. The timeout is set for 600 milliseconds to give some leeway for the data response. The total poll time for both devices will be 5 × 600 = 3,000 milliseconds per device times two devices, which equals 6,000 milliseconds, or 6 seconds. The quickest possible poll rate would therefore be 6 seconds.

Poll rate times around 60 seconds are recommended. Data from a slave device would be no more than 1 or 2 minutes old when read from the SCADA software, which should be adequate time for this type of historical supervisory data. The Modbus Master function is not designed for an online realtime control function application.

The Master Communications Setup screen (Figure 9-14) is used to specify the poll routine rate. To display this screen, select **3. MASTER CONFIGURATION** from the Modbus Master Menu screen.

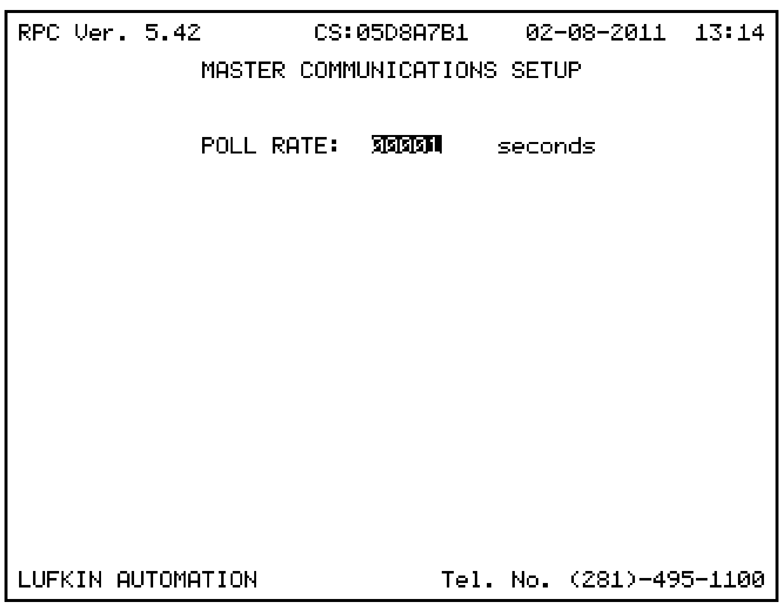


Figure 9-14. Master Communication Setup Screen

Procedure

Follow the steps below to configure the poll routine rate.

1. From the **Main Menu** screen, select **2. PROGRAM** to display the Programming Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

2. Select **5. RTU LEVEL** and then select **2. COMMUNICATION PARAMETERS** to display the Communication Parameters Menu screen.

3. Select **3. MASTER CONFIGURATION**.

   The Master Communication Setup screen appears with the **POLL RATE** field highlighted.

4. Press **<EDIT>** and then use the number keys to specify the desired poll rate, in seconds.

5. When the rate is correct, press **<ENTER>** to complete the programming.

6. Do one of the following:

   - To return to the Modbus Master Menu screen, press **<EXIT>**.
   - To return to the Main Menu screen, press **<MENU>**.

The polling routine rate value is saved.

9.7 Cryout Configuration

MENU 2/5/4

In most SCADA systems, polling activity is controlled by the host computer software. That means that all information from a wellsite controller must be requested by the host SCADA software. One downside of this method is a critical alarm condition for a well that produces a lot of oil might go unnoticed for a period of time. To prevent this situation, the Lufkin Well Manager RPC includes a Cry Out feature you can configure to have the Lufkin Well Manager RPC alert the host computer SCADA software that a critical alarm condition exists. The host software should then promptly download that alarm and associated data from the Lufkin Well Manager RPC. Several alarm conditions can be configured.

Note: In order for this feature to work, the host SCADA software must support the cry out function. The SCADA system must be programmed to “listen” between “normal” scheduled pollings for cry outs from the Lufkin Well Manager RPC at the wellsite.

All cry out parameter configuration and the ability to enable/disable cry out operations are done using the options available under the Cryout Configuration Menu screen (Figure 9-15). To display this menu, select **4. CRYOUT CONFIGURATION** from the Communication Parameters Menu screen.

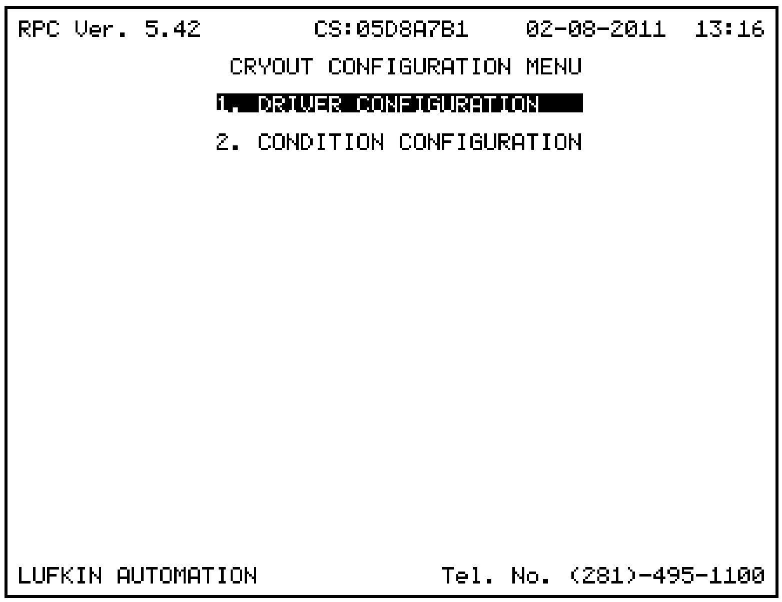


Figure 9-15. Cryout Configuration Menu Screen

9.7.1 Configuring the Cry Out Driver

The Cry Out function must be configured for how many times to repeat the cry out on each attempt if no acknowledgement is received from the host SCADA software. The Lufkin Well Manager RPC must also know how long to “sleep” between cry out attempts. You must also turn on (enable) the Cry Out function. These parameters are configured using the Cryout Driver Configuration screen (Figure 9-16). To displays this screen, select **1. DRIVER CONFIGURATION** from the Cryout Configuration Menu screen.

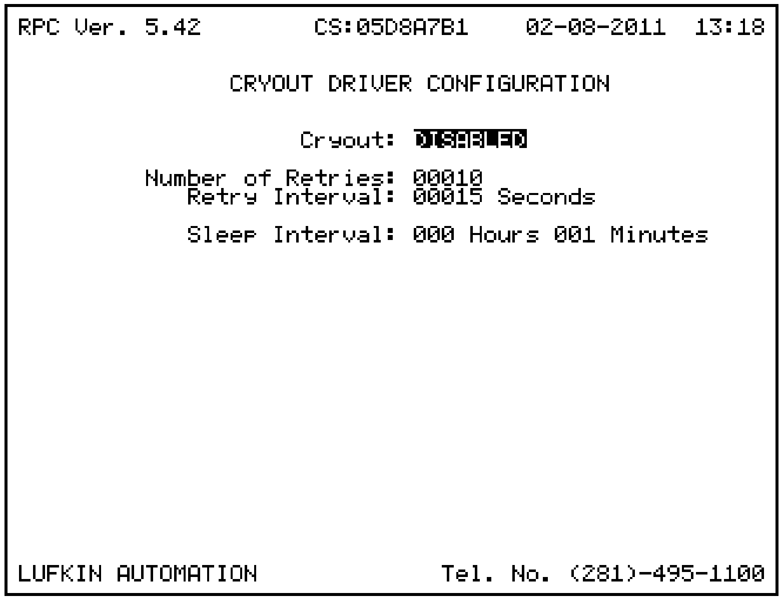


Figure 9-16. Cryout Driver Configuration Screen

Data Field Descriptions

Information about each data field is provided below.

Cryout

Specify whether you want the cry out function to take affect.

- ***To disable it***, select **DISABLE**. Disabled is the default state.
- ***To enable it***, select **ENABLE**.

Number of Retries

Specify the number of times that the Lufkin Well Manager RPC should repeat the cry out for a given attempt. If the Lufkin Well Manager RPC does not receive a response from the host SCADA software, the cry out message is sent again.

Retry Interval

Specify the time that the Lufkin Well Manager RPC should wait for a response from the host SCADA software before sending a retry.

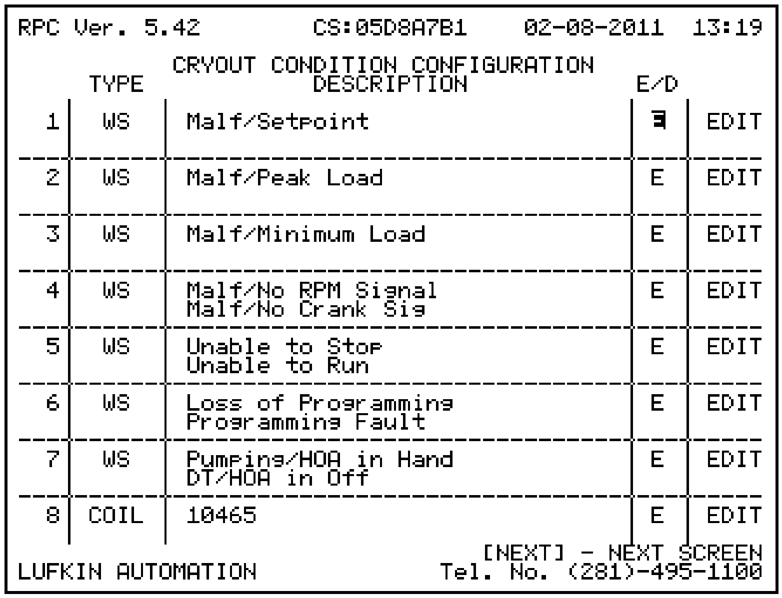
Sleep Interval

Specify the length of time that the Lufkin Well Manager RPC should "sleep" between cry out attempts. If the sleep interval elapses and the cry out condition still exists, the Lufkin Well Manager RPC will repeat a cry out attempt for the programmed number of retries.

9.7.2 Configuring Cry Out Conditions

MENU 2/5/4/2

The alarm conditions that will initiate a cry out sequence must be configured. A combination of well states and alarm registers/coils can be configured as cry out conditions. A maximum of sixteen cry out conditions can be configured. Each condition can be enabled or disabled separately. All cry out conditions are configured using a Cryout Condition Configuration screen similar to Figure 9-17. To display this screen, select **2. CONDITION CONFIGURATION** from the Cryout Configuration Menu screen.


RPC Ver. 5.42 CS:05D8A7B1 02-08-2011 13:19

CRYOUT CONDITION CONFIGURATION

	TYPE	DESCRIPTION	E/D	
1	WS	Malf/Setpoint	E	EDIT
2	WS	Malf/Peak Load	E	EDIT
3	WS	Malf/Minimum Load	E	EDIT
4	WS	Malf/No RPM Signal Malf/No Crank Sig	E	EDIT
5	WS	Unable to Stop Unable to Run	E	EDIT
6	WS	Loss of Programming Programming Fault	E	EDIT
7	WS	Pumping/HOA in Hand DT/HOA in Off	E	EDIT
8	COIL	10465	E	EDIT

[NEXT] - NEXT SCREEN

LUFKIN AUTOMATION Tel. No. (281)-495-1100

Figure 9-17. Cryout Condition Configuration Description Screen

Data Column Descriptions

Information about each data column is provided below.

Type

States the type of condition that triggers the cry out feature. Two types are supported.

- WS (well state)
- COIL

Description

States the well state name or the register number of the coil that controls the cry out feature.

E/D

States whether the cry out condition is enabled (E) or disabled (D).

EDIT

Places the cry out configuration row into Edit mode. **TYPE**, **DESCRIPTION**, and **E/D** are read-only fields. They can be configured when you select the **EDIT** field.

Procedure

Follow the steps below to configure cry out functions.

1. From the **Main Menu** screen, select **2. PROGRAM** to display the Programming Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

2. Select **5. RTU LEVEL** and then select **2. COMMUNICATION PARAMETERS** to display the Communication Parameters Menu screen.

3. Select **4. CRYOUT CONFIGURATION** and then select **2. CONDITION CONFIGURATION** to display the Cryout Configuration Description screen.

4. Use the arrow keys to highlight the **EDIT** field for the row you want to configure and then press **<ENTER>**.

   A Cryout Condition Configuration screen appears. The exact screen displayed depends on the current condition type specified in the **CONDITION TYPE** field.

   - If the current condition is WS (well state), a configuration screen similar to Figure 9-18 displays.

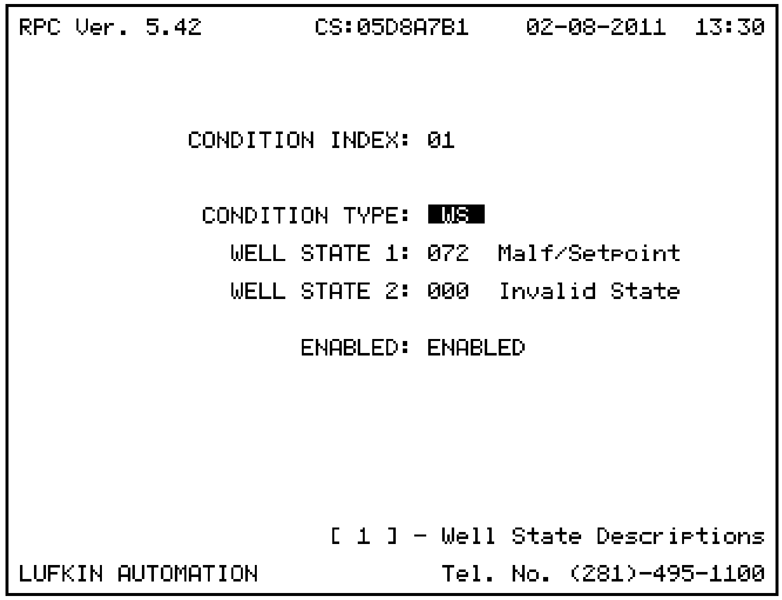


Figure 9-18. Cryout Condition Configuration Screen for Well State

- If the current condition type is coil, a configuration screen similar to Figure 9-19 displays.

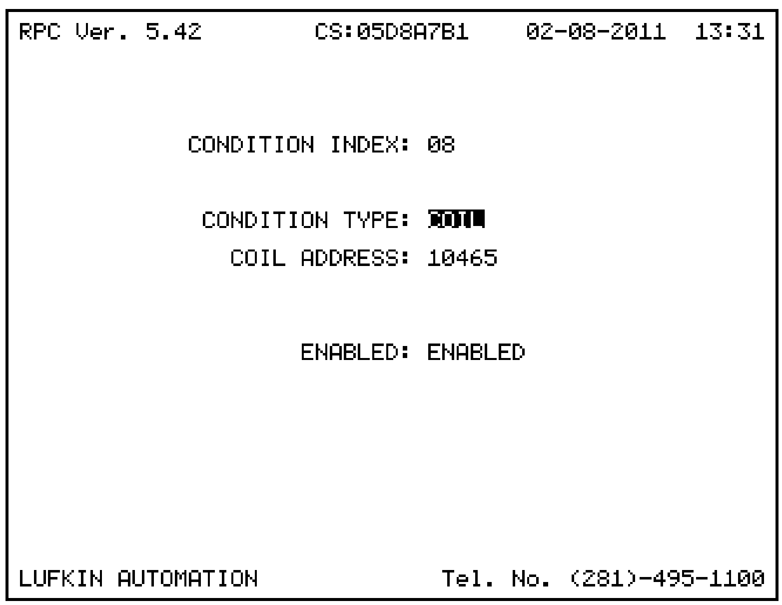


Figure 9-19. Cryout Condition Configuration Screen for Coil

5. If you want to change the condition type to the other type, press <↑> or <↓> to highlight the **CONDITION TYPE** field, press **<EDIT>**, press <↑> or <↓> to select the other type, and then press **<ENTER>**.

6. Make any necessary configuration changes to the condition type you selected.

- ***If you selected WS***, highlight **WELL STATE 1**, or **WELL STATE 2** field, press **<EDIT>**, enter the code number for the well state you want to initiate the cry out, and then press **<ENTER>**. You can press **<1>** to display a list of the well state names along with their numbers. Repeat the process for the other **WELL STATE** field, if necessary.

Note: You can configure both **WELL STATE** fields, but only one is required.

- ***If you selected COIL***, highlight the **COIL** field, press **<EDIT>**, enter the coil address, and then press **<ENTER>**. All coil addresses in the 1xxxx portion of the memory map are supported. If you need a copy of the Lufkin Well Manager register map, contact your Lufkin Automation representative.

7. If you need to change the enabled/disable state of the cry out function for the condition type, press <↑> or <↓> to highlight the **ENABLED** field, press **<EDIT>**, press <↑> or <↓> to select the other type, and then press **<ENTER>**.

8. Press **<EXIT>** to save the configuration and return to the Cryout Condition Configuration Description screen (Figure 9-17).

9. If you want to configure another cry out condition, repeat steps 4 through 8.

10. When you are finished configuring cry out conditions, do one of the following:

    - To return to the Cryout Condition Menu screen, press **<EXIT>**.

    - To return to the Main Menu screen, press **<MENU>**.

The cry out configurations are saved to the Lufkin Well Manager RPC.

9.8 Changing Passwords

MENU 2/5/3

The Lufkin Well Manager RPC has available two levels of password protection (User and Supervisory) for programming parameters. By default, both passwords levels are disabled so that you can commission the controller with a minimum of difficulty.

Passwords are assigned and enabled/disabled with a Password Administration screen similar to Figure 9-20. To display this screen, select **3. PASSWORD ADMINISTRATION** from the RTU Level Menu screen.

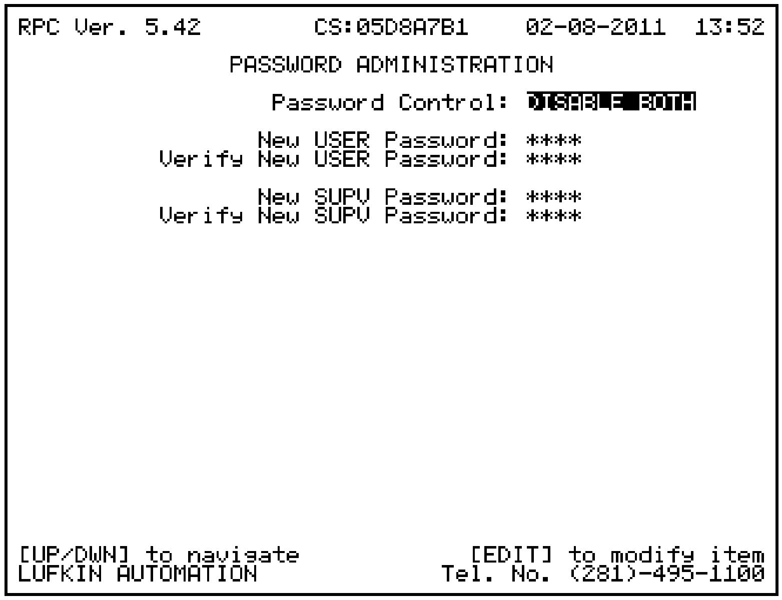


Figure 9-20. Password Administration Screen

Data Field Descriptions

Information about each data field is provided below.

Password Control — The following options are available:

- **DISABLE BOTH** — Disables the password protection feature for users and supervisors (SUPV).
- **ENABLE BOTH** — Enables the password protection feature for users and supervisors.
- **USER Password Only**
- **SUPV Password Only**

When password protection is enabled, you can change either password.

User Password

Specify a password that can be used for all PCP Configuration and Lufkin PCP Configuration operations, except operations available under the RTU Level Menu screen.

SUPV Password

Specify a password that can be used for all PCP Configuration and Lufkin PCP Configuration operations, including operations available under the RTU Level Menu screen.

The factory default is set for no password, so full access to all programming menus is available on new units until passwords are assigned.

Procedure

Follow the steps below to change a password.

1. From the **Main Menu** screen, select **2. PROGRAM** to display the Programming Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

---

2. Select **5. RTU LEVEL**, and then select **3. PASSWORD ADMINISTRATION**.

   The Password Administration screen appears with the **Password Control** field highlighted.

3. If one of the **ENABLED** options is not displayed, press **<EDIT>**, press **<↓>** to select the desired option, and then press **<ENTER>**.

4. Change the password you want changed (USER or SUPV) by doing the following:

   a. Press **<↓>** to highlight the **New Password** field, press **<EDIT>**, use the number keys to enter a four-digit number, and then press **<ENTER>**.

   b. Press **<↓>** to highlight the **Verify New Password** field, press **<EDIT>**, use the number keys to enter the same four-digit number, and then press **<ENTER>**.

5. Repeat step 4 if you need to change another password.

6. When finished, do one of the following:

   - To return to the RTU LEVEL Menu screen, press **<EXIT>**.
   - To return to the Main Menu screen, press **<MENU>**.

The passwords are changed.

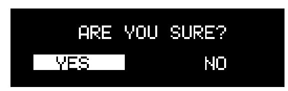
9.9 Resetting Parameters to Factory-Default Values

MENU 2/5/4

This feature returns many parameters to a factory-default value. Normally, parameters will not need to be reset.

Make sure that you really need to use this feature. After you execute this operation, the user-defined parameters cannot be easily restored. Each parameter must be re-programmed one field at a time for your particular well application.

When this option is selected, a message appears with the **YES** option highlighted.



- ***To restore the factory-default settings***, keep **YES** highlighted, and then press **<ENTER>** to complete the reset process.
- ***To cancel the reset operation and keep the current settings***, press **<←>** or **<→>** to highlight **NO**, and then press **<ENTER>** to abort the reset procedure.

WARNING: If you wait a few seconds without taking any action, the message disappears and the highlighted choice goes into effect.

9.10 Diagnostics

MENU 2/5/5

This feature contains diagnostic tools for troubleshooting RPC control system installations. Its features are discussed in section 17, “System Diagnostics Tools.”

9.11 Load and Position Input Configuration

MENU 2/5/6

This feature lists the technical specifications for the selected load and position input devices, and it also displays the current value for each input. Figure 9-21 is an example.

```
RPC Ver. 5.42         CS:05D8A7B1    02-08-2011  13:54
            LOAD AND POSITION INPUT CFG

                      LOAD TRANSDUCER
Current Load          0 lbs -832.70  uV   -3215 Counts
Counts/lbs      00.000    Raw Load Span   0000 Counts

        Load Transducer Type:   Beam Transducer
 Input Swing @ 5V Excitation:   *****  (mV X 1000)
                  Max Weight:   ***** lbs
                Gain Setting:   64
            Bipolar/Unipolar:   BIPOLAR
            Zero Load Offset:   0000   Raw
       Start Load Threshold:    00100  Raw
        Stop Load Threshold:    00300  Raw
      Load Failure Threshold:   00100  Raw
Re-calibrate Load Transducer:   Execute
     Re-configure to Default:   Execute

                    POSITION TRANSDUCER
Current Posn        655 in  0660.09   ms    00090  RPM

         Position Input Type:   RPM / CRANK-BEAM

    Auto Ambient Noise Check:   Execute Ld  00000 Raw

[ENTER] to execute               [UP/DWN] to navigate
                                [EDIT] to modify item
```

Figure 9-21. Load and Position Input Cfg Screen

One instance when this screen is useful is when a “non-standard” load cell is in use. The **Ambient Noise** and **Threshold** fields allow you to fine tune the Lufkin Well Manager RPC load signal testing algorithm.

Only qualified Lufkin Automation service technicians should edit data on this screen. For that reason, no data field descriptions are provided.

9.12 Motor Power Configuration

MENU 2/5/7

The Motor Power control method and the torque calculation features of the Lufkin Well Manager RPC are based on a “normalized” speed/torque curve. Entries on the Motor Power Configuration screen (Figure 9-22) scale that curve for a particular motor.

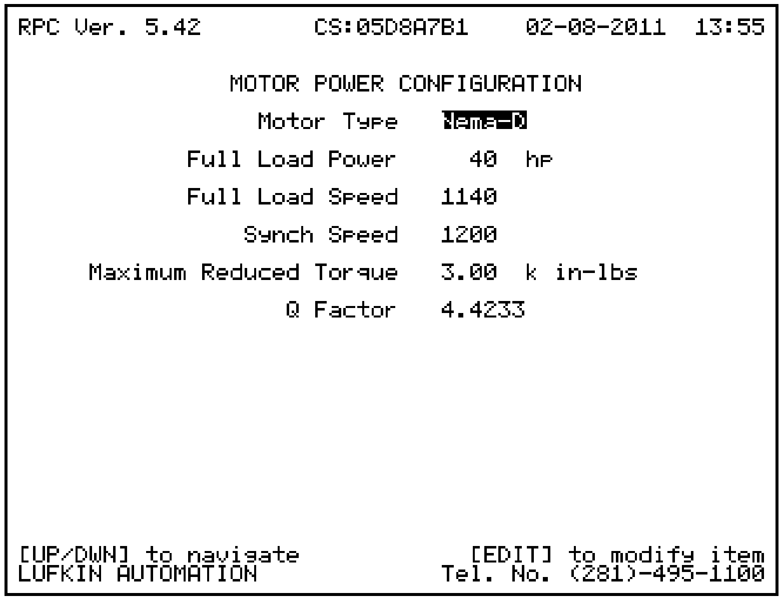


Figure 9-22. Motor Power Configuration Screen

Only qualified Lufkin Automation service technicians should edit data on this screen. For that reason, no data field descriptions are provided.

9.13 Additional Configuration (Default Screen)

MENU 2/5/8

You can specify the screen that automatically displays when no keypad activity occurs for eight minutes. This screen is the screen you will normally see when you arrive at the wellsite.

The RPC Status screen is normally used, and it is the default screen set at the factory. At any time, you can change the default screen to any of the other following screens:

- Main Menu screen
- RT Combo Card screen (realtime surface and downhole dynagraph)
- AGA measurement

You specify the default screen with the Additional Configuration screen (Figure 9-23). To display this screen, select **5. ADDITIONAL CONFIGURATION** from the RTU Level Menu screen.

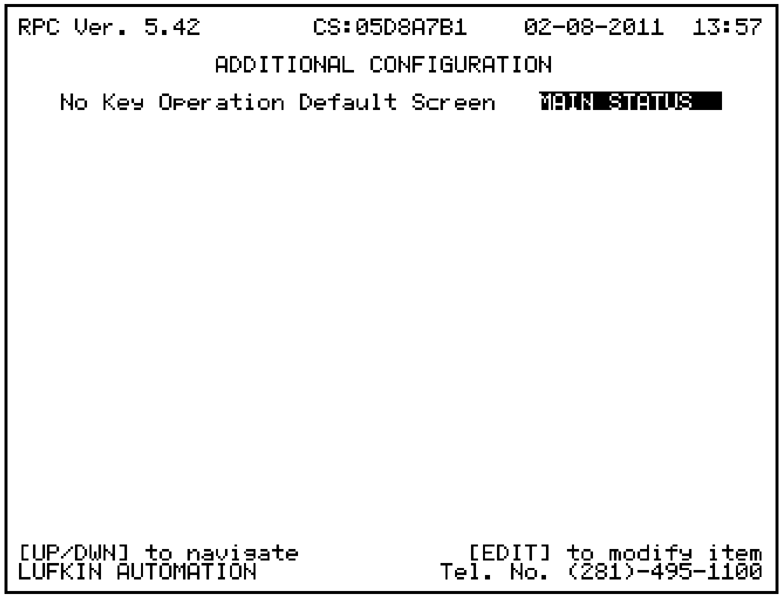


Figure 9-23. Additional Configuration Screen used to Specify the Default Screen

After you make your selection and exit this screen, the Lufkin Well Manager RPC will display your selection as the default screen from now on.

9.14 Engineering Units Configuration

MENU
2/5/9

When the Lufkin Well Manager RPC is first commissioned, all operational parameters in the status screens display their values in engineering units specified at the factory. You can individually change the engineering units for many operational parameters using the Display Unit Configuration screens (Figure 9-24 is an example of the first screen). For example, you can display length in meters instead of feet and volume in cubic meters instead of barrels. To display these screens, select **9. DISPLAY UNIT CONFIGURATION** from the RTU Level Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  13:58
             DISPLAY UNIT CONFIGURATION 1/3

  Atmospheric Pressure            PSIA
  Bubble Point Pressure           psia
  Buoyant Force                   lbs
  Casing Head Pressure            psig
  Counter Balance                 k in-lbs
  Energy                          mmbtu
  Formation Depth                 ft
  Formation Volume Fctr           rb/stb
  Reserved
  Leakage                         b/d
  Lin Pmp Dist Bwt Sprkt          ft
  Lin Pmp Sprkt Radius            ft
  Load                            lbs
  Modulus                         MMPSI
  Oil Density                     Degree API
  Oil Shrinkage Factor            rb/stb
  Position                        in
  Power                           hp
  Pump Depth                      ft
  Pump Diameter                   in

  Reset All to Default Units      EXECUTE

[UP/DWN] to navigate                 [EDIT] to modify item
LUFKIN AUTOMATION                 Tel. No. (281)-495-1100
```

Figure 9-24. Display Unit Configuration Screen

The table below lists the operational parameters that you can change and the engineering units available.

Operational Parameter	Engineering Units Available
AGA Base Pressure	psia, MPa, bar, kg/cm^2, ATM, kPa
AGA Control Override Threshold	mcf/d, m^3/d
AGA Differential Pressure	in H2O@60F, Pa, millibar, kg/cm^2, ATM, mmH2O
AGA Flow Rate	mcf/d, m^3/d
AGA Flowing Pressure	psia, MPa, bar, kg/cm^2, ATM, kPa
AGA Measured Gas Volume	mcf, m^3
AGA Orifice Diameter	in, cm, mm
AGA Pipe Diameter	in, cm, mm
AGA Temperature	degrees F, degrees C
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

Operational Parameter	Engineering Units Available
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
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
Valve Check Calculated Leakage	B/d, m3/d
Valve Check CBE	lbs, kg
Valve Check Load Readings	lbs, kg
Viscosity	cP, Pa-s

Setting Engineering Units

At any time you can change engineering units for any of the listed operational parameters. Each parameter’s unit setting is changed individually. The changes take effect immediately after you change the setting.

Follow the steps below to change engineering units.

1. Do one of the following to select the operational parameter you want to change.

   - ***If you see the operational parameter on the current screen***, press <↑> or <↓> to highlight it.

   - ***If you do not see the operational parameter you want***, press **<NEXT>** to move between the three screens until you find the parameter, and then press <↑> or <↓> to highlight it. Pressing **<NEXT>** on the third screen returns you to the first screen.

2. Press **<EDIT>**, press <↑> or <↓> to scroll through the available units until you find the one you want, and then press **<ENTER>**.

   Your selected operational parameter is now in effect.

3. Repeat steps 1 and 2 for each operational parameter you want to change.

Resetting Units to Default Values

At any time you can return all engineering units to factory-default values. However, make certain that you want to use this feature. After you execute it, any values you want to change must be changed manually one at a time.

Follow the steps below to return the engineering units to factory-default units.

1. At the bottom of the first Display Unit Configuration screen, press <↑> or <↓> to highlight the **Reset All Default Units** field, and then press **<ENTER>**.

   A message appears that asks you to confirm that you want to save your changes. Notice that **OK** is highlighted.

2. Do one of the following:

   - ***To reset the display unit settings to the factory-default values***, keep **OK** highlighted, and then press **<ENTER>**.

   - ***To cancel your changes and keep existing engineering unit settings***, press **<←>** or **<→>** to highlight **CANCEL**, and then press **<ENTER>**.

WARNING: If you wait a few seconds without taking any action, the existing engineering unit settings remain in effect.

9.15 Auxiliary I/O Configuration

MENU 2/6/1

The Lufkin Well Manager RPC firmware design supports analog inputs and outputs, digital inputs and outputs, and accumulators. Up to 32 auxiliary analog inputs and eight analog outputs can be configured. Sixty-four discrete points can also be configured for virtual digital inputs, digital outputs, and accumulators. All 64 can be configured for digital inputs and outputs, and ten can be configured for accumulators. Optional expansion board hardware is required to implement these auxiliary inputs and outputs.

The hardware design of the Lufkin Well Manager RPC is modular in concept to allow auxiliary I/O circuit boards to be developed as customer applications arise. An auxiliary expansion board (Part No. 520.5057) can be added to the Lufkin Well Manager RPC to provide eight discrete points that can be configured as input or output, eight analog inputs, and two analog outputs. Other expansion board options are available. Contact your Lufkin Automation representative about your specific I/O requirements.

Four points available on the standard motherboard can be configured as digital input/output points or for accumulators. If the Hall-Effect option is used for position input, the analog position input on the motherboard is available as an auxiliary input.

The Lufkin Well Manager RPC uses a “virtual I/O” concept that allows you to program any hardware point as any logical input/output point. During the initializing process, the Lufkin Well Manager RPC firmware reads the expansion port to identify which expansion boards are installed. Expansion board address numbers, and in many cases the available range of inputs/outputs, are hardware-configured by jumpers on the expansion board.

All inputs and outputs are configured through the options available on the AUX I/O Configuration Menu screen (Figure 9-25). To display this menu, select **6. AUXILIARY FUNCTIONS** from the Programming Menu screen to display the Auxiliary Functions Configuration Menu screen, and then select **1.AUX I/O**.

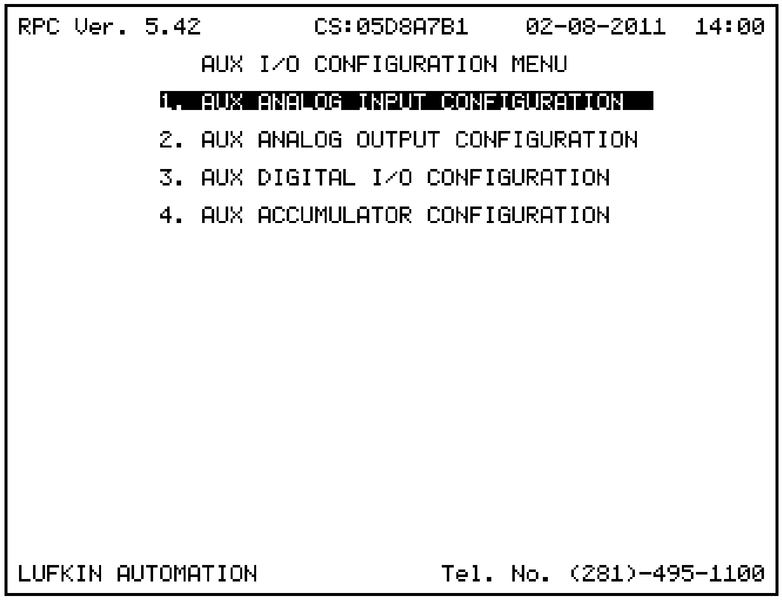


Figure 9-25. AUX I/O Configuration Menu Screen

9.15.1 Configuring Auxiliary Analog Inputs

MENU
2/6/1/1

Analog inputs are configured through the AUX Analog Input Configuration screen (Figure 9-26). To display this screen, select **1. AUX ANALOG INPUT CONFIGURATION** from the AUX I/O Configuration Menu screen.

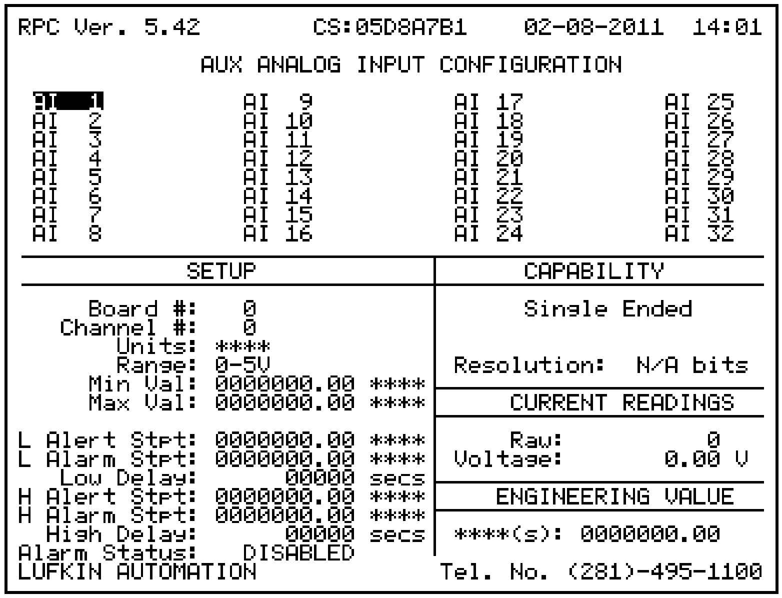


Figure 9-26. AUX Analog Input Configuration Screen

The top portion of this screen lists all 32 of the potentially available "logical" analog input points. The Lufkin Well Manager RPC must be told which physical input is associated with that "logical" or virtual input point. After the input is selected, the **Setup** portion of the screen can be used to define the logical points.

Note: The current operating status of analog inputs is available on the AUX Analog Input Status screen (**MENU: 7/1/1/1**). For information about this screen, see "AUX Analog Input Status" in section 10, "Status Screens."

Data Field Descriptions

Information about each data field is provided below.

Board

Enter the physical board number as set by the jumpers on the board. The motherboard is always designated as Board #0.

Channel

Enter the physical terminal designation on the expansion board to which the transmitter is connected.

Units

Specify the engineering units for device being measured.

Range

Specify one of the following input ranges that the Lufkin Well Manager RPC is to expect from the process transducer:

- 1 — 5V
- 0 — 5V
- 4 — 20ma
- 0 — 20ma

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 Lufkin Well Manager RPC 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.

Logging

This is not a selectable item.

Alarms and Alerts

The Lufkin Well Manager RPC can set flags for the following analog input conditions if limit setpoints are programmed and the alarm status is enabled:

- Low (Alert)
- Low (Alarm)
- High (Alert)
- High (Alarm)

Low and high alert and alarm setpoints should be entered in Engineering units.

Analog input alarms can be used as logic expression inputs to control wellsite functions.

Low and **High Delay**

Specify the delay time before the alarm is declared.

Alarm Status

Be sure to enable alarm status if this feature is to be used.

Capability and Current Readings

The **Capability** and **Current Readings** portions of the programming screen are read only.

- **Capability** is a report about what the Lufkin Well Manager RPC reads during the initialization process regarding the hardware capabilities of the expansion board.
- **Current Readings** indicates the present value of that input.

Engineering Value

Indicates the present value of that input expressed in engineering units.

9.15.2 Configuring Auxiliary Analog Outputs

MENU 2/6/1/2

Analog outputs are configured through the AUX Analog Output Configuration screen (Figure 9-27). To display this screen, select **2. AUX ANALOG OUTPUT CONFIGURATION** from the AUX I/O Configuration Menu screen.

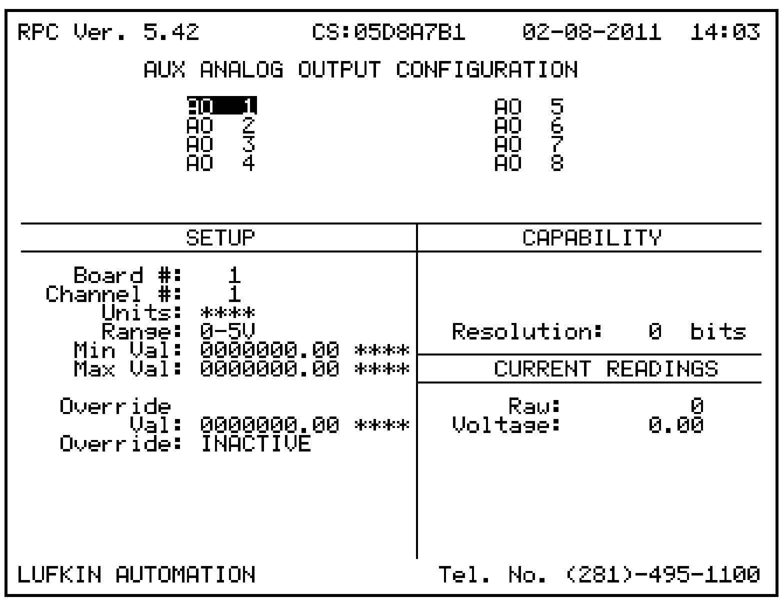


Figure 9-27. AUX Analog Output Configuration Screen

The Lufkin Well Manager RPC application firmware supports only analog output number 1 (AO 1). The following programming information is provided for informational purposes only. Default settings for analog outputs should only be changed by a qualified Lufkin Automation technician.

The top portion of this screen lists all eight of the potentially available “logical” analog output points. The Lufkin Well Manager RPC must be told which physical output is associated with that “logical” or virtual output point. After the output is selected, the **Setup** portion of the screen can be used to define the logical points.

Note: The current operating status of analog inputs is available on the AUX Analog Output Status screen (**MENU: 7/1/1/2**). For information about this screen, see “AUX Analog Output Status” in section 10, “Status Screens.”

Data Field Descriptions

Information about each data field is provided below.

Board

Enter the physical board number as set by the jumpers on the board. The motherboard is always designated as Board #0.

Channel

Enter the physical terminal designation on the expansion board to which the transmitter is connected.

Units

Specify the engineering units for the device being controlled.

Range

Specify one of the following output ranges that the Lufkin Well Manager RPC is to use:

- 0 — 5V
- 0 — 10V
- 4 — 20ma DC

Min. Value

Enter the engineering units that you desire to display on the Aux I/O Status screen when the analog output is set for zero.

Max. Value

Enter the full-scale engineering value to be displayed on the Aux I/O Status screen for the maximum analog output.

Note: Min and Max scaling values are used for the status display only.

Override Val

Specify the value to output through the analog output if the override feature is enabled. When override is enabled, the application has no control over the analog output.

Override

Enable or disable the override feature.

Volt Range (Capability)

Describes the minimum and maximum (range) of the voltage signal that can be output from the channel for the analog output selected.

Resolution

Indicates the number of bits (resolution) that make up a full scale signal for the analog output selected.

Raw (Current Readings)

Describes the current reading in an unscaled format. This ranges from zero to 2^3 bits of resolution.

Voltage (Current Readings)

Displays the current voltage being output from the channel.

9.15.3 Configuring Auxiliary Digital Inputs and Outputs

MENU
2/6/1/3

Digital inputs and outputs are configured through a Digital Configuration screen similar to Figure 7-22. To display this screen, select **3. AUX DIGITAL I/O CONFIGURATION** from the AUX I/O Configuration Menu screen.

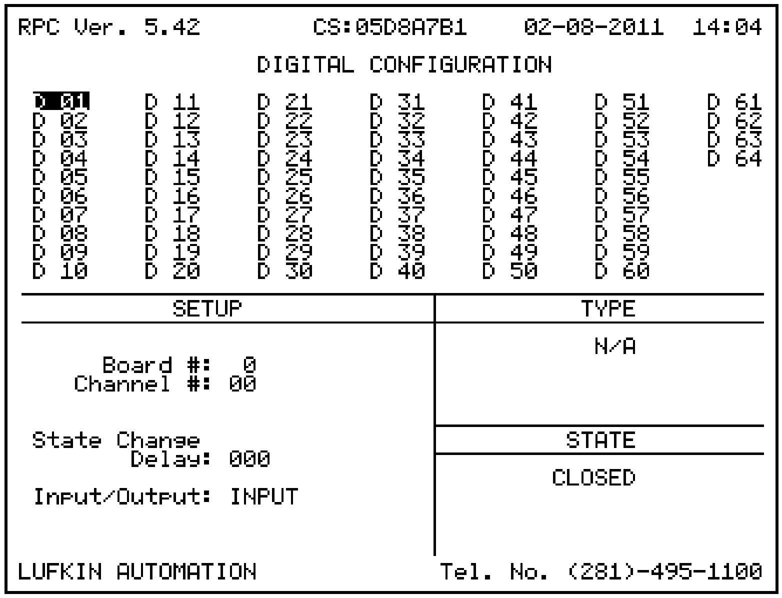


Figure 7-22. Digital Configuration Screen

The top portion of this screen lists all potentially available “logical” digital input/output points. The Lufkin Well Manager RPC must be told which physical input/output is associated with that “logical” or virtual input/output point. After the input/output is selected, the **Setup** portion of the screen can be used to define the logical points.

Note: The current operating status of analog inputs is available on the Digital Status screen (**MENU: 7/1/1/3**). For information about this screen, see “Digital Input/Output Status” in section 10, “Status Screens.”

Field Descriptions

Information about each data field is described below.

Board

Enter the physical board number as set by the jumpers on the board. The motherboard is always designated as Board #0.

Channel

Enter the physical terminal designation on the expansion board to which the transmitter is connected.

State Change Delay

Specify the number of seconds that a digital state change must be observed before Lufkin Well Manager RPC acknowledges the change.

Input/Output

Specify whether the digital point is for Input or Output.

Alarm State

If the alarm is enabled, the alarm state is the digital state which triggers an alarm.

Alarms Enabled

Tells if the alarming functionality for the digital inputs is enabled.

9.15.4 Configuring Auxiliary Accumulators

MENU
2/6/1/4

Digital inputs can be configured as accumulators. The discrete input points on the Lufkin Well Manager RPC are pulled up internally and must be switched down to DC common by a dry contact closure to "accumulate." The Lufkin Well Manager RPC will reliably count contact closures up to a maximum frequency of about 500 Hz. The motherboard inputs are not designed to work with inputs direct from a turbine meter pickup.

One advantage of having accumulator input capability included in the Lufkin Well Manager RPC is the ability to monitor the operation of facilities adjacent to a pumped well without having the additional cost of installing a remote terminal unit (RTU) and data telemetry equipment for that facility. For example, produced volume for a well with an ESP can be monitored by the Lufkin Well Manager RPC on an adjacent pumped well, and the data collected can be read for both wells with a single telemetry network.

Note: The current operating status of analog inputs is available on the AUX Accumulator Status screen (**MENU: 7/1/1/4**). For information about this screen, see "AUX Accumulator Status" in section 10, "Status Screens."

Accumulator Programming

The Lufkin Well Manager RPC firmware design supports a maximum of 10 accumulator inputs. The motherboard has four auxiliary digital points that can be configured as accumulators. Optional expansion board hardware is required to take advantage of the additional accumulators that the firmware can support. For more information about the expansion board, contact you Lufkin representative.

The Lufkin Well Manager RPC uses a "virtual I/O" concept that allows an operator to program any hardware point as any logical input/output point. The virtual I/O for the Lufkin Well Manager RPC must be defined using an AUX Accumulator Configuration screen similar to Figure 9-28**.** To display this screen, select **4. AUX ACCUMULATOR CONFIGURATION** from the AUX I/O Configuration Menu screen.

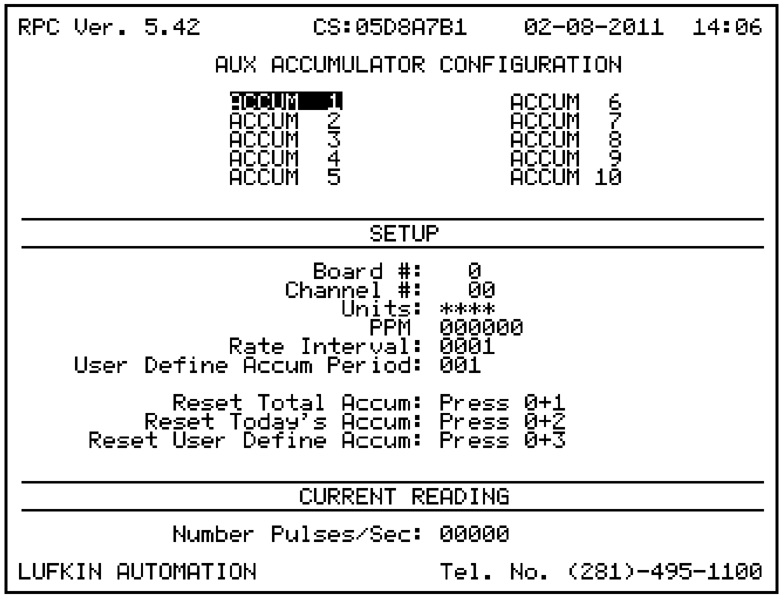


Figure 9-28. AUX Accumulator Configuration Screen

This screen is divided into three portions. The top portion lists all potentially available "virtual" or logical accumulators supported by the firmware. The Lufkin Well Manager RPC must be told the physical input point that is to be associated with any given logical/virtual accumulator. After you select an accumulator, the fields in the **Setup** portion become active for you to define. The **Current Reading** portion displays the number of pulses counted in the last second. This field only provides information and cannot be edited.

Data Field Descriptions

Information about each data field is provided below.

Board

The motherboard is always Board #0. Board numbers are assigned to expansion boards by setting dip switches on those boards.

Channel

The table below provides the channel number designations for digital points on the motherboard.

Channel #	Physical Marking
1	DIO5 (TB5-9)
2	DIO6 (TB5-11)
3	DIO7 (TB5-13)
4	DIO8 (TB5-15)

A DC common terminal is provided next to each digital input terminal so you can conveniently terminate the second lead from the dry contact input.

Units

The Lufkin Well Manager RPC offers approximately 29 options for the unit of measurement to be associated with each auxiliary input. The units selected only displays on the status screen of the Lufkin Well Manager RPC local LED display. 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 Lufkin Well Manager RPC 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

User-defined sampling period, 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:

$$Rate = \frac{\#\ of\ pulses\ for\ last\ 8\ minutes}{PPM} \times \frac{1440\ minutes}{8\ minutes}$$

User Defined Accumulator Period

The Lufkin Well Manager RPC 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 Accumulator Period, the Lufkin Well Manager RPC 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.

Reset Total Accu

Press **<0>** and **<1>** to reset the total accumulated value since the last reset of this value.

A message displays to inform you that the value was cleared.

Reset Today's Accum

Press **<0>** and **<2>** to reset the total accumulated value since Gauge Off Time.

A message displays to inform you that the value was cleared.

Reset User Define Accum

Press **<0>** and **<3>** to reset the user-defined accumulated value, which normally is reset at the rate interval.

A message displays to inform you that the value was cleared.

Number of Pulses/Sec

Displays the actual number of pulses read for the second that just expired.

Procedure for Resetting Accumulator Totals

Accumulator totals for the selected accumulator can be reset (cleared) using the AUX Accumulator Configuration screen by pressing the key combinations indicated at the bottom of the Setup portion of the programming screen.

9.16 Logic Expressions

MENU 2/6/2

Logic expressions can be written and used to perform actions when a specific well condition occurs at the wellsite.

The Lufkin Well Manager RPC can monitor well conditions from analog and/digital input signals from a variety of sensors or transmitters used to monitor conditions. Logic expressions can be programmed in the Lufkin Well Manager RPC using these sensor inputs to make decisions, such as

- Starting or stopping the pump
- Turning on one of the extra digital outputs to start a pump

- Closing a valve
- Sounding an alarm

The Lufkin Well Manager RPC logic expression feature uses the three fundamental Boolean logic operators AND, OR, and NOT. A maximum of eight logical statements can be programmed to act on a selected digital output when a prescribed combination of input conditions occurs.

Multiple logic expressions can be chained so that the result of one logic expression of higher priority can be used as an input in another logic expression of lower priority. Logic expression priority is based on the line/row number. That is, logic expression 1 has a higher priority than logic expression 2.

In order to use the logic expression function, it is necessary to

1. Configure the auxiliary analog inputs and/or digital inputs/outputs ahead of time so that they can be included in the logic expression (see “Configuring Auxiliary Analog Inputs”on page 9-45 and “Configuring Auxiliary Digital Inputs and Outputs” on page 9-50)
2. Enable the logic expression function
3. Program each logic expression needed
4. Program the type of action desired if the condition specified by the logic expression occurs (proves true)

After a logic expression (complete with the desired action) is programmed and enabled, its function can be disabled when necessary for operational reasons.

Note: A Clear Logic Expression State option is included so that a latched output can be cleared or reset. See page 9-68 for more information.

All logic expression enabling, programming, clearing, and enabling/disabling features are performed using the options available on the Logic Expression Configuration Menu screen (Figure 9-29). To display this menu, select **2. LOGIC EXPRESSION** from the Auxiliary Function Configuration Menu screen.

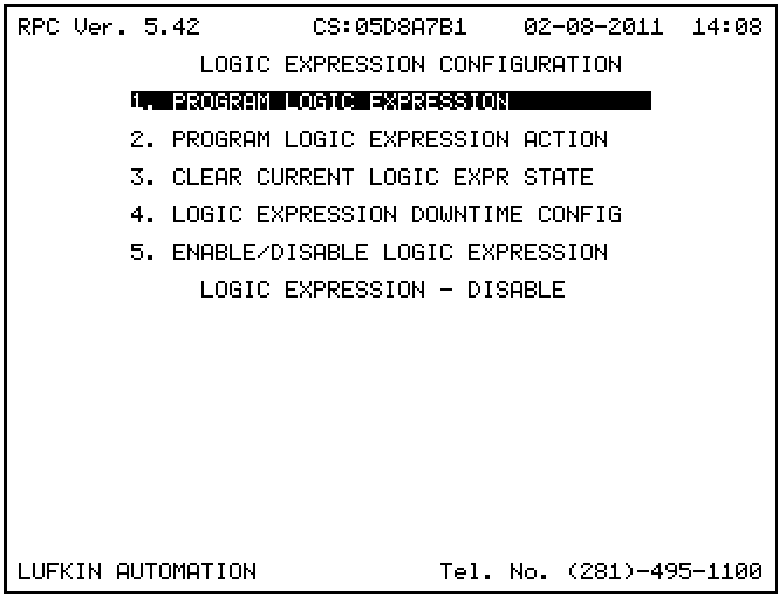


Figure 9-29. Logic Expression Configuration Menu Screen

Note: Options 1 through 4 are not accessible when the Logic Expression feature is "disabled." For information about enabling logic expressions, see "Enabling and Disabling Logic Expressions" on page 9-70.

9.16.1 Programming a Logic Expression

MENU 2/6/2/1

A logic expression must be written (programmed) to define the condition that triggers an action when the expression is proven true. An expression is proven true when the condition defined by the expression occurs.

Note: The logic expression feature must be enabled before a logic expression can be programmed. When it is disabled, the message **NOT REQUIRED** displays. For information about enabling logic expressions, see "Enabling and Disabling Logic Expressions" on page 9-70.

You can write eight logic expressions to define eight unique conditions. The Program Logic Expression screen (similar to Figure 9-30) has a row for each logic expressions that can be programmed. To display this screen, select **1. PROGRAM LOGIC EXPRESSION** from the Logic Expression Configuration Menu screen.

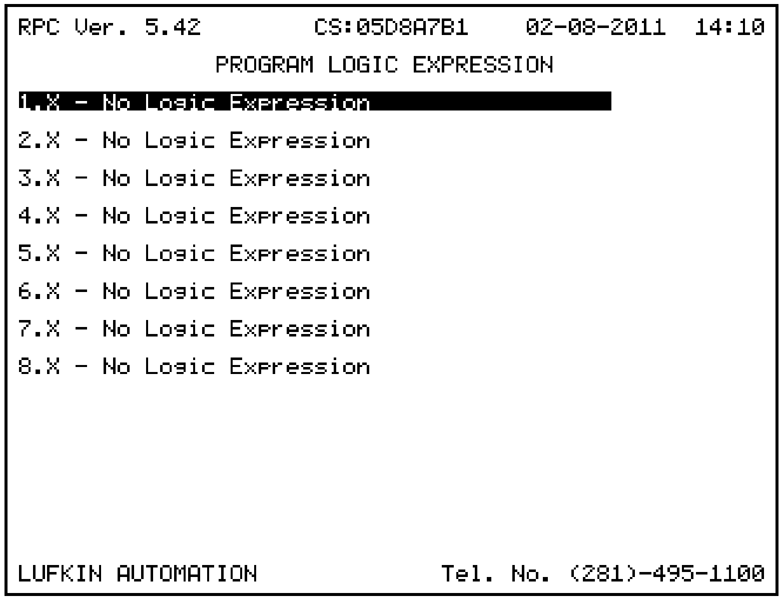


Figure 9-30. Program Logic Expression Screen

All logic expressions already programmed are displayed (row 1 is an example). Any row not having a logic expression programmed displays the message **No Logic Expression**.

Note: Auxiliary analog inputs and digital inputs/outputs must be configured before they can be included in a logic expression. For help programming auxiliary inputs and outputs, see “Auxiliary I/O Configuration” on page 9-44.

Entry code options display at the bottom of the screen when you press **<EDIT>** to program the logic expression. These entry code options define the number keys you press for selecting various inputs and outputs, logical operators, and alarms. The three entry code groups are described in the subsection below. You can scroll through the entry code groups by pressing **<NEXT**>. As you write an expression, the Lufkin Well Manager RPC automatically presents the most likely entry code group for the next character entry.

After you complete an expression and press **<ENTER>**, the Lufkin Well Manager RPC automatically checks the expression to verify that the expression is valid. **VALID** displays to the right of the expression row if it is valid. If the expression is invalid, a syntax error message displays prompting you to correct the invalid parameter. For a list of the error messages possible and their definitions, see “Syntax Error Messages” on page 9-61.

Entry Code Groups

Three entry code groups are available:

- Channel selection
- I/O and Logic Selection
- Alarm and Special Selection

Channel Selection

Channel selection entry codes correspond one-to-one to the actual numbers for the desired channel. Channel number selection must always be two digits (01, 09, 23, etc.). Channel numbers are the virtual, or logical, input/output point numbers configured as described in "Configuring Auxiliary Analog Inputs" on page 9-45 and "Configuring Auxiliary Analog Outputs" on page 9-48.

I/O and Logic Selection

The table below describes the codes that can be used for input/output (I/O) and logic selection.

Key No.	Selection Made Using this Key
1	"M" output point = one of the four dedicated discrete points on TB5 on the motherboard, and are labeled: • M01 = DIO1 (TB5-1) Error Lamp • M02 = DIO2 (TB5-3) Motor Control • M03 = DIO3 (TB5-5) Start Alert • M04 = DIO4 (TB5-7) Fault Output
2	"D" discrete point = virtual digital input or output
3	"A" analog input
4	"C" accumulator input
5	" [" = Opening bracket for nesting logical operations
6	"] " = Closing bracket for nesting logical operations
7	" * " = Logical AND operator
8	" + " = Logical OR operator
9	" ' " = Logical NOT operator
0	" X " =End of logical expression

Alarm and Special Section

The table below describes the codes that can be used for alarm and special selection.

Key No.	Selection Made Using this Key
1	H = Analog input in High Alarm state. Analog input alert states cannot be used as logic expression inputs.
2	L = Analog input in Low Alarm state. Analog input alert states cannot be used as logic expression inputs.
3	Erase Logic Expression. This selection erases the logic expression highlighted by the cursor.
4	Erase All Logic Expression. This selection erases all programmed logic expressions.
5	Character definition. This selection presents a screen that defines characters used in writing logic expressions.

Syntax and Programming Rules

A list of the syntax and programming rules that must be followed are provided below.

- Maximum number of characters per expression is 40.
- Each expression must contain the X character to signify the end of the expression.
- Spaces between characters before X character are not allowed.
- No adjacent operators are allowed except + or *.
- No adjacent parenthesis of different types; that is, ") (".
- Dxx or Mxx (with xx representing the channel number) are the only parameters/characters allowed on the left side of the "=" character.
- AI, DI, and DO that have been configured as auxiliary inputs/outputs can be assigned.
- Logical "NOT" must always be at the end of the IO block. For example, **A01L′** is valid and **′A01L** is invalid.
- Low and High flags can only be assigned to analog inputs with High/Low flag enabled.
- Always write expressions in consecutive number to avoid priority conflict. Do not skip a line.
- Any character after X is invalid.

Syntax Error Messages

The table below defines the logic expressions error messages that may appear when an invalid logic expression is written.

Error Code No.	Error Code Definition
00	None
01	End of expression not defined
02	Multiple terminating characters
03	First character not an output
04	Wrong equal sign location
05	Wrong motherboard digital channel
06	Wrong digital channel
07	Wrong analog channel
08	Wrong accumulator channel
09	Wrong analog alarm
10	Wrong accumulator alarm
11	Mismatching parenthesis
12	Start with OR
13	Start with AND
14	Start with NOT
15	Start with close parenthesis
16	End with OR
17	End with And
18	End with open parenthesis
19	Illegal space
20	Or out of order
21	And out of order
22	Open parenthesis out of order
23	Close parenthesis out of order
24	Not out of order
25	Input out of order
26	Analog not configured
27	Analog alarms not enabled
28	Digital not configured as output
29	Invalid main board number
30	Accumulator not configured
31	Digital not configured

Logic Expression Example

An operator wants to monitor flow line pressure and be able to shut down the pumping unit if the pressure falls too low or rises too high. A leak detector is also connected to shut down the pumping unit in the event of a stuffing box leak.

A pressure transmitter is installed on the flow line and connected to the Lufkin Well Manager RPC as auxiliary analog input A01. High and low alarm levels are configured and enabled.

A float switch type of stuffing box leak detector is connected to the Lufkin Well Manager RPC and configured as auxiliary digital input D01. The switch contacts are normally closed and open when fluid accumulates from a leak.

The logic expression required is **M02=A01H+A01L+D01X.**

The keystrokes sequence used to program this expression is provided below.

1. **<EDIT>**
2. <**1**> (display M)
3. <**0**>
4. <**2**>
5. <**3**> (display A)
6. <**0**>
7. <**1**>
8. <**1**> (display H for high)
9. <**8**> (display + for logical OR)
10. <**3**> (display A)
11. <**0**>
12. <**1**>
13. <**2**> (display L for low)
14. <**8**> (display + for logical OR)

15. <**2**> (display D)

16. <**0**>

17. <**1**>

18. <**0**> (display X for end of expression)

19. <**ENTER**>

20. Press <**EXIT**> to program the desired action.

Procedure

Follow the steps below to write a logic expression. This procedure can also be used to modify an existing expression.

1. From the **Main Menu** screen, select **2. PROGRAM**, and then select **6. AUXILIARY FINCTIONS** to display the Auxiliary Functions Configuration Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

---

2. Select **2. LOGIC EXPRESSION** and then select **1. PROGRAM LOGIC EXPRESSION** to display the Program Logic Expression screen (Figure 9-30).

Note: If the logic expression feature is not enabled, enable it now.

---

3. Highlight the row you want used for the logic expression and press **<EDIT>**. The first character at the left hand end of the row highlights.

4. Use the keypad to enter the characters needed by referring to the entry code group at the bottom of the screen.

   The first three characters of the expression must define the digital output on which you want to act.

   a. The first character must therefore be “M” (motherboard output point) or “D” (virtual discrete point).

   b. The next two characters are the channel number. Channel numbers must be two digits. For example, virtual channel 1 is entered as 01.

After the digital output to use is defined, the Lufkin Well Manager RPC automatically adds the “=” sign.

5. Enter the characters to write the desired logic expression, keeping in mind the syntax and programming rules discussed on page 9-60.

6. Enter “X” as the final character on the line to signify the end of the expression.

7. After the logic expression row reads as desired, press **<ENTER>**.

   The Lufkin Well Manager RPC automatically checks the logic expression to verify that it is valid.

   - If the expression is valid, **VALID** displays to the right of the row.

   - If the expression is invalid, an error message displays to prompt the necessary action that must be taken to make it valid. A list of possible syntax error messages is defined in the table in “Syntax Error Messages” beginning on page 9-61.

8. Press <**EXIT**>.

You can now use the Program Logic Expression Action option to program the desired action for the logic expression.

9.16.2 Programming a Logic Expression Action

MENU 2/6/2/2

After you write a logic expression, you must program an action for the expression. A Program Logic Expression Action screen similar to Figure 9-31 is used to write actions. To display this screen, select **2. PROGRAM LOGIC EXPRESSION ACTION** from the Logic Expression Configuration Menu screen.

Note: The logic expression feature must be enabled before a logic expression action can be programmed.
When it is disabled, the message **NOT REQUIRED** displays. For information about enabling logic expressions, see “Enabling and Disabling Logic Expressions” on page 9-70.

```
RPC Ver. 5.42       CS:05D8A7B1    02-08-2011  14:12
            PROGRAM LOGIC EXPRESSION ACTION
                     Consec Malf Allowed   Logic Time
LOGIC EXP   Action   or Timer Period(min)  Delay (sec)
     1       *****          *****             *****
     2       *****          *****             *****
     3       *****          *****             *****
     4       *****          *****             *****
     5       *****          *****             *****
     6       *****          *****             *****
     7       *****          *****             *****
     8       *****          *****             *****



LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 9-31. Program Logic Expression Action Screen

Column Descriptions

Information about each column is provided below.

Action

An action must be programmed for each logic expression. The available options for a program action are linked to the type of digital output to be acted upon.

A logic expression written to act on the motor control output M02 has the following action options available:

- **START** — When the logic expression proves true, start the pumping unit. Pump until pump off is detected, or one of the other control limits is violated, such as peak torque allowed.
- **MALF** — When the logic expression proves true, stop the pumping unit. Restart it after the programmed down time for the number of successive retries. If the consecutive Malf. Allowed count limit is reached, shut down the unit in a Malfunction Logic state. Operator intervention is required to clear and restart the unit.
- **STOP** — When the logic expression proves true, stop the unit in normal downtime. The unit automatically starts after the programmed downtime expires.

A logic expression written to act on a general-purpose digital output has the following action options available:

- **FLAG** — When the logic expression proves true, set a flag to alert the operator. No control action is taken.

- **TEMP** — When the logic expression proves true, close the programmed digital output. Continue to evaluate the logic expression and hold output on/closed as long as the logic expression proves true. When the logic expression proves false, open the output.

- **LATCH** — When the logic expression proves true, close the programmed digital output and hold it closed until an operator clears the latch.

  To clear a latched output, go to the **Logic Expression Configuration** menu (Figure 9-29) and select **3. CLEAR CURRENT LOGIC EXPR STATE**.

- **TIMER** — When the logic expression proves true, close the programmed digital output and hold it closed for the programmed Timer Period. When the timer period times out, open the digital output and re-evaluate the logic expression.

Consec. Malf Allowed or Timer Period

Accessibility to this column depends on the action programmed for the logic expression.

- ***If the programmed action is*** **MALF**, edit this column to program the desired number of consecutive malfunctions allowed, which is the number of retries allowed before the pumping unit is shut down in a Malfunction well state. Operator intervention is required to reset the unit.

- ***If the programmed action is*** **TIMER**, edit this column to program the desired time in minutes to hold closed the designated digital output.

Logic Time Delay

This is a delay before executing the programmed action when a logic expression proves true. This time delay is in addition to any programmed time delays for the analog alarms and/or digital inputs that are included in a logic expression. Time delays are programmed from the auxiliary input configuration screens discussed in "Configuring Auxiliary Analog Inputs" on page 9-45 and "Configuring Auxiliary Analog Outputs" on page 9-48.

Procedure

Follow the steps below to program a logic expression action.

1. From the **Main Menu** screen, select **2. PROGRAM**, and then select **6. AUXILIARY FINCTIONS** to display the Auxiliary Functions Configuration Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

---

2. Select **2. LOGIC EXPRESSION** and then select **2. PROGRAM LOGIC EXPRESSION ACTION** to display the Program Logic Expression Action screen.

3. Highlight the **Action** column field in the row for the logic expression to be programmed and press <**EDIT**> to enter the edit mode.

4. Press <↑> and <↓> to view the options available.

5. Press <**ENTER**> when the desired option displays.

6. Use arrow keys to move cursor to the next field to be programmed (for example, Logic Time Delay), and then press <**EDIT**> to enter the edit mode.

7. Use the number keys to enter the desired value and then press <**ENTER**> to select the entered value and end the edit mode for that field.

8. Repeat steps 6 and 7 until all fields are programmed as desired.

9. After all the fields on this screen are programmed as desired, do either of the following:

    - To return to the Logic Expression Configuration Menu screen, press <**EXIT**>.

    - To return to the Main Menu screen, press <**MENU**>.

The logic expression program is saved.

9.16.3 Clearing the Logic Expression State

MENU 2/6/2/3

If a logic expression is programmed with a latch action, you can reset the logic expression and clear the latched output by using the Clear Current Logic Expr State screen (similar to Figure 9-32). To display this screen, select **3. CLEAR CURRENT LOGIC EXPR STATE** from the Logic Expression Configuration Menu screen.

Note: The logic expression feature must be enabled before a logic expression action can be cleared. When it is disabled, the message **NOT REQUIRED** displays. For information about enabling logic expressions, see “Enabling and Disabling Logic Expressions” on page 9-70.

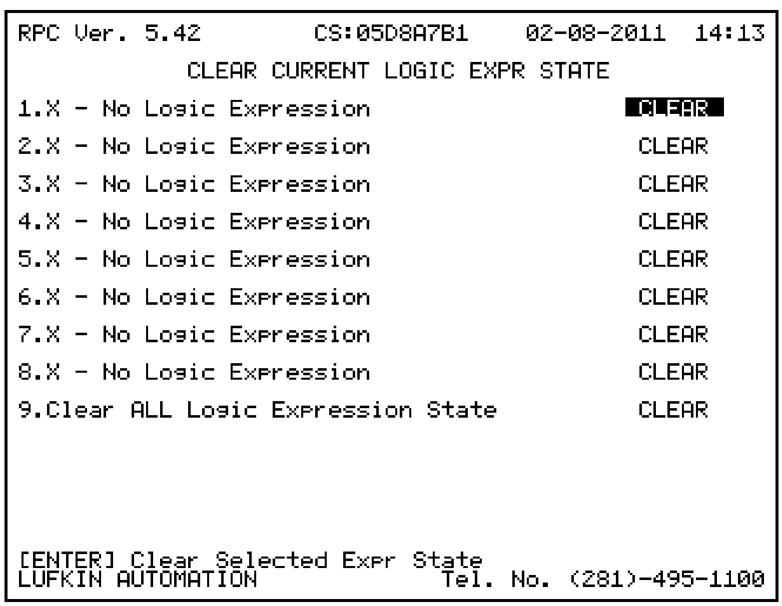


Figure 9-32. Clear Current Logic Expr State Screen

9.16.4 Configuring Logic Expression Downtime

MENU
2/6/2/4

The Lufkin Well Manager RPC can be configured to have a different downtime/idle time for a logic expression shutdown than for normal pumped off shutdown. The downtime used is specified with the Logic Expression Downtime Configuration screen. To display this screen, select **4. LOGIC EXPRESSION DOWNTIME CONFIG** from the Logic Expression Configuration Menu screen.

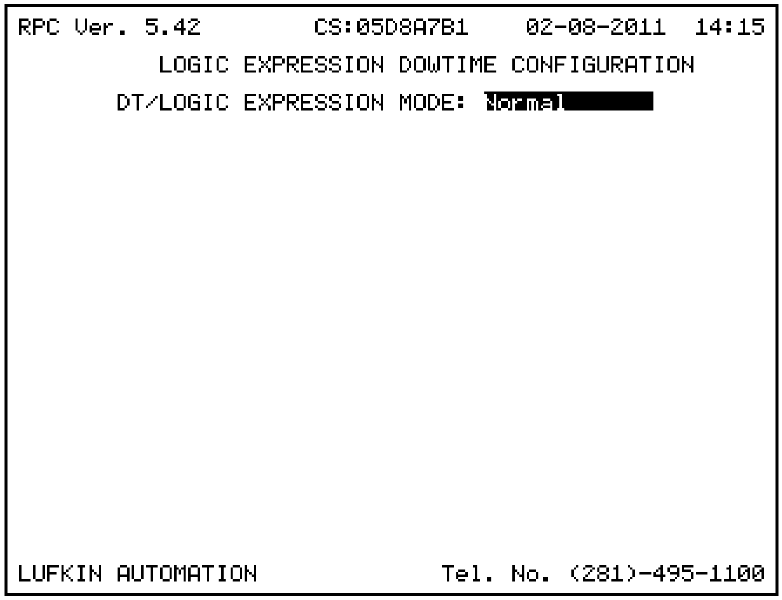


Figure 9-33. Logic Expression Downtime Configuration Screen

Data Field Descriptions

Information about each data field is provided below.

DT/LOGIC EXPRESSION MODE

Specify whether the logic expression has its own downtime.

- **User Defined** allows downtime to be a different duration for the logic expression.
- **Normal** uses the programmed downtime duration used for pump off.

DT/LOGIC EXPRESSION LENGTH

Specify the downtime duration for a logic expression shutdown. This field only appears when **User Defined** is select for the **DT/LOGIC EXPRESSION MODE** field.

9.16.5 Enabling and Disabling Logic Expressions

MENU 2/6/2/5

The logic expression feature must be enabled before a logic expression can be programmed. If the logic expression feature is not enabled, a “Not Required” message displays when you try to program an expression.

This toggle feature allows you to enable and disable these expressions. After a logic expression and action are programmed, you can temporarily disable the logic expression (complete with the desired action), if necessary, for operational reasons. The programmed expression and action are retained in memory so it is not necessary to re-program the expression when you are ready to again enable the logic expression.

The present enable/disable status can be easily determined by looking on the Logic Expression Configuration Menu screen below option 5. It reads either **LOGIC EXPRESSION – ENABLE** if logic expressions are presently disabled or **LOGIC EXPRESSION – DISABLE** if they are enabled.

Procedure

Follow the steps below to enable or disable the logic expression feature.

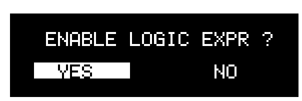
1. From the **Main Menu** screen, select **2. PROGRAM**, and then select **6. AUXILIARY FINCTIONS** to display the Auxiliary Functions Configuration Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

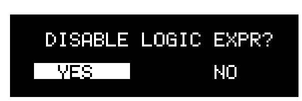
2. Select **2. LOGIC EXPRESSION** and then select **5. ENABLE/DISABLE LOGIC EXPRESSION**.

   A message appears asking you to confirm that you want to enable or disable the log expression.

   - If the logic expression feature is already disabled, **ENABLE LOGIC EXPR?** displays.



   - If the logic expression feature is already enabled, **DISABLE LOGIC EXPR?** displays.



3. Press <**←**> and <**→**> to highlight the **YES** response and then press <**ENTER**>.

Below option 5, you are informed whether the Logic Expression feature is enabled or disabled.

After the Logic Expression feature is enabled, the other logic expression features can be used.

9.17 AGA-3 and NX-19 Parameter Configuration

MENU 2/6/3

The Lufkin Well Manager RPC can perform AGA-3 gas flow rate calculations and accumulate gas production volume data. AGA-3 is calculated once a second, and NX-19 supercompressibility is calculated once a minute and every time setup parameters are modified.

For flange tap measurement, the Lufkin Well Manager RPC implements the AGA-3 1992 Factors method of gas flow calculation. The AGA-2 1985 Pipe Flow Calculation method is used for pipe tap measurement and NX-19 calculation methods are used for the supercompressibility factor. For more detailed explanations about the parameters available for AGA-3 configuration, see appendix D, “AGA-3 and NX-19 Definitions.”

In order to perform these operations, process transmitters must be installed and connected to available analog inputs on the Lufkin Well Manager RPC expansion board to monitor line pressure and pressure drop (DeltaP) across an orifice plate. The DeltaP input is required. Line pressure is optional.

You must configure the analog channels that will be used by the AGA algorithm to calculate gas flow. The Lufkin Well Manager RPC can use analog channel inputs for the following three gas meter run parameters.

- Differential pressure
- Static (gauge) pressure
- Flowing temperature

The Lufkin Well Manager RPC requires that the differential pressure measurement be provided using an analog input channel. Static pressure and flowing temperatures can either be entered as constant values by the user or supplied through analog input channels. For details about how to configure analog channels, see “Configuring Auxiliary Analog Inputs” on page 9-45.

The best method for you to use to configure all necessary parameters for AGA calculations is to perform all operations in the following order:

1. Configure analog input channels (page 9-45)
2. Configure AGA-3 parameters (9-73)
3. Configure NX-19 parameters (9-75)
4. Configure temperature and pressure (9-77)

The first three options available under the AGA Configuration Menu screen (Figure 9-34) are used to configure AGA-3, NX-19, and temperature and pressure. To display this menu, select **3. AGA** from the Auxiliary Functions Configuration Menu screen.

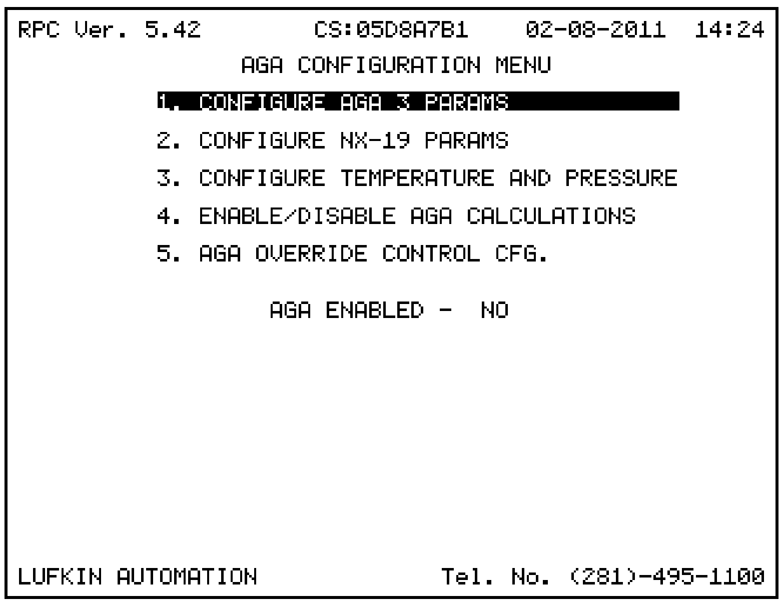


Figure 9-34. AGA Configuration Menu Screen

Before you configure parameters, you must use the fourth option to enable the AGA calculation operations. If they are not enabled and you try to select any of the first three options, the message “NOT REQUIRED” displays and you remain at the AGA Configuration Menu screen. To enable the operations, select **4. ENABLE/DISABLE AGA CALCULATIONS**. For more information about this operation, see “Enabling and Disabling AGA-3 Calculations” on page 9-78.

9.17.1 Configuring AGA-3 Parameters

MENU
2/6/3/1

Use the AGA 3 Design Parameters screen (Figure 9-35) to configure AGA parameters. To display this screen, select **1. AGA 3 PARAMETERS** from the AGA Configuration Menu screen.

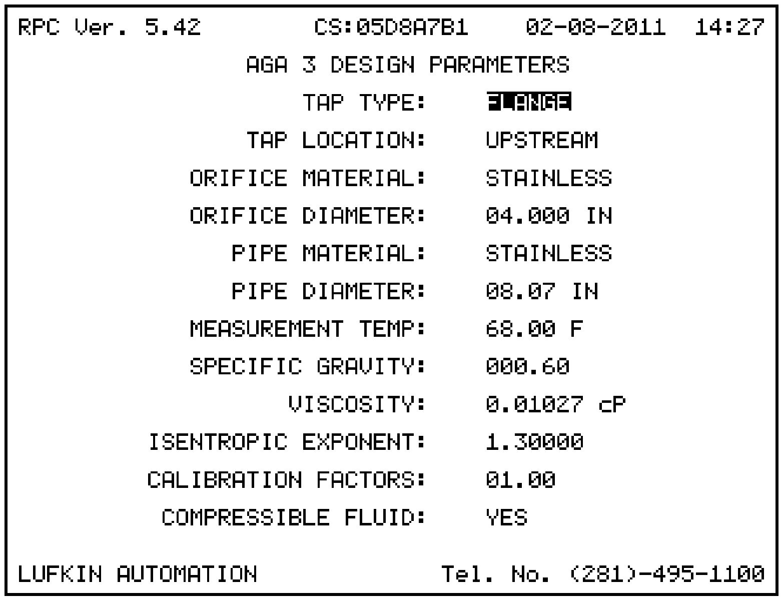


Figure 9-35. AGA 3 Design Parameters Screen

Note: Before you can configure parameters, you must enable the AGA-3 calculation operations. To enable them, select **4. ENABLE/DISABLE AGA CALCULATIONS**. For more information about this operation, see “Enabling and Disabling AGA-3 Calculations” on page 9-78.

Data Field Descriptions

Information about each data field is provided below.

TAP TYPE

Specify the type of pressure tap. The choices available are:

- FLANGE
- PIPE

FLANGE is the default value.

TAP LOCATION

Specify the location of pressure tap. The choices available are:

- UPSTREAM
- DOWNSTREAM

UPSTREAM is the default value.

ORIFICE MATERIAL

Specify the material used to construct the orifice. The choices available are:

- STAINLESS
- MONEL
- CARBON

STAINLESS is the default value.

ORIFICE DIAMETER

Specify the measured diameter of the orifice in inches. The default value is 4.000 in.

PIPE MATERIAL

Specify the material used to construct the pipe. The choices available are:

- STAINLESS
- MONEL
- CARBON

STAINLESS is the default value.

PIPE DIAMETER

Specify the measured diameter of the pipe in inches. The default value is 8.07 in.

MEASUREMENT TEMP

Specify the temperature at which the orifice diameter was measured. The default value is 68° F.

SPECIFIC GRAVITY

Specify the gravity of the gas. The default value is 0.60.

VISCOSITY

Specify the viscosity of the gas. The default value is 0.01027 cP.

ISENTROPIC EXPONENT

Specify the ratio of specific heat at constant pressure to specific heat at constant volume (cp/cv) for the given gas composition. The default value is 1.30000.

CALIBRATION FACTORS

Specify a value to calibrate the meter. Associated factors are Fam, Fwt, Fpwl, Fhgm, and Fhgt. The default value is 1.00.

COMPRESSIBLE FLUID

Specify whether the fluid is compressible. This answer determines if the expansion factor Y is calculated. **NO** is the default value.

9.17.2 Configuring NX-19 Design Parameters

MENU 2/6/3/2

Use the NX-19 Design Parameters screen (Figure 9-36) to configure NX-19 parameters. Make the appropriate selections and enter the correct data in each field. Default values are provided for all data fields, but for best results, thought needs to be given to the data in each and every field. To display this screen, select **2. CONFIGURE NX-19 PARAMS** from the AGA Configuration Menu screen.

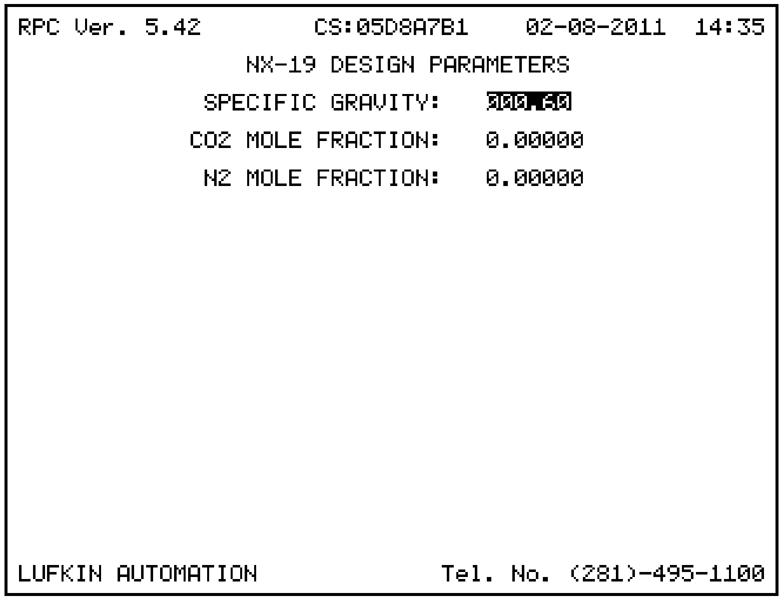


Figure 9-36. Configure NX-19 Parameters Screen

Note: Before you can configure parameters, you must enable the AGA-3 calculation operations. To enable them, select **4. ENABLE/DISABLE AGA CALCULATIONS**. For more information about this operation, see “Enabling and Disabling AGA-3 Calculations” on page 9-78.

Data Field Descriptions

Information about each data field is provided below.

SPECIFIC GRAVITY

Specify the specific gravity of the gas, which is the same value as the specific gravity on the AGA3 Design Parameters screen (Figure 9-35 on page 9-73). The default value is 0.60.

CO2 MOLE FRACTION

Specify the mole fraction of $CO_{2.}$ Note that 5.93% should be entered as 0.05930. The default value is 0.00000.

N2 MOLE FRACTION

Specify the mole fraction of $N_{2.}$ Note that 5.93% should be entered as 0.05930. The default value is 0.00000.

9.17.3 Configuring Temperature and Pressure

MENU
2/6/3/3

Use the Temperature/Pressure Configuration screen (Figure 9-37) to configure temperature and pressure values required for AGA-3 gas calculations. Make the appropriate selections and enter the correct data in each field.

Default values are provided for all data fields, but for best results, thought needs to be given to the data specified in every field. To display this screen, select **3. CONFIGURE TEMPERATURE AND PRESSURE** from the AGA Configuration Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  14:37
         TEMPERATURE/PRESSURE CONFIGURATION
                  BASE CONDITIONS
            BASE PRESSURE:   014.73 PSIA
         BASE TEMPERATURE:   060.00 F
             ADJ PRESSURE:   014.73 PSIA

                 FLOWING CONDITIONS
    DIFFERENTIAL PRESSURE:   AI 01  IN H20@60F
              ZERO CUTOFF:  0001.00 IN H20@60F

          STATIC PRESSURE:   AI 02  PSIG
      FLOWING TEMPERATURE:   CONST 060.00 F



LUFKIN AUTOMATION            Tel. No. (281)-495-1100
```

Figure 9-37. Temperature/Pressure Configuration Screen

Note: Before you can configure parameters, you must enable the AGA-3 calculation operations. To enable them, select **4. ENABLE/DISABLE AGA CALCULATIONS**. For more information about this operation, see “Enabling and Disabling AGA-3 Calculations” on page 9-78.

Data Field Descriptions

Information about each data field is provided below.

BASE PRESSURE

Specify the base pressure for the volume flow rate calculation. The default value is 14.73 PSIA.

BASE TEMPERATURE

Specify the base temperature for volume flow rate calculation. The default value is 60º F.

ADJ PRESSURE

Specify the pressure to add to static “gauge” pressure to get “absolute” static pressure. The default value is 14.73 PSIA.

DIFFERENTIAL PRESSURE

Select from available analog input channels. Analog channels must be setup using the AUX Analog Input Configuration Programming screen (Figure 9-26 on page 9-46). The default channel is AI1.

STATIC PRESSURE

Specify the analog input channel to be assigned for static pressure, or enter a user-defined value. Analog channels must be set up using the AUX Analog Input Configuration Programming screen. The default channel is AI02.

FLOWING TEMPERATURE

Specify the analog input channel to be assigned for flowing pressure, or enter a user-defined value. Analog channels must be set up using the AUX Analog Input Configuration Programming screen. The default value is CONST 060.00 F.

9.17.4 Enabling and Disabling AGA-3 Calculations

MENU
2/6/3/4

The Enable/Disable AGA Calculations option on the AGA Configuration Menu screen (Figure 9-34) is a toggle option for turning on and off the AGA-3 calculation feature. The present on/off state of AGA-3 calculations is displayed below option 4. After the AGA-3 calculations feature is enabled, the other AGA-3 calculation features can be used.

Below option 4, you can see whether the AGA Calculations feature is presently enabled or disabled.

Procedure

Follow the steps below to enable and disable the AGA-3 calculations feature.

1. From the **Main Menu** screen, select **3. CONFIGURATION**, and then select **AUXULIARY FUNCTIONS** to display the Auxiliary Functions Configuration Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

2. Select **4. ENABLE/DISABLE AGA CALCULATIONS**.

   A message appears asking you to confirm that you want to enable or disable the AGA-3 calculations.

   - If the logic expression feature is already disabled, **ENABLE AGA CALCS?** displays.

   - If the logic expression feature is already enabled, **DISABLE AGA CALCS?** displays.

3. Press <←> and <→> to highlight the response you want, and then press <**ENTER**>.

Your selection immediately goes into affect and is displayed below option 4.

9.17.5 Configuration AGA Override Control

MENU 2/6/3/5

The Lufkin Well Manager RPC can be configured to override a downtime pump-off well state and start the pump if the measured gas flow rate falls below a defined override threshold. This control override threshold is the lower limit for the calculated gas flow rate. When the current rate equals to or falls below the specified threshold, and the Lufkin Well Manager RPC is in a Downtime Pump Off well state, the Lufkin Well Manager RPC will start the pumping unit immediately, regardless of the elapsed time specified for downtime.

You can enable/disable override control and specify the control override threshold limit using the AGA Control Override Cfg screen (Figure 9-39). To display this screen, select **5. AGA OVERRRIDE CTRL** from the AGA Configuration Menu screen.

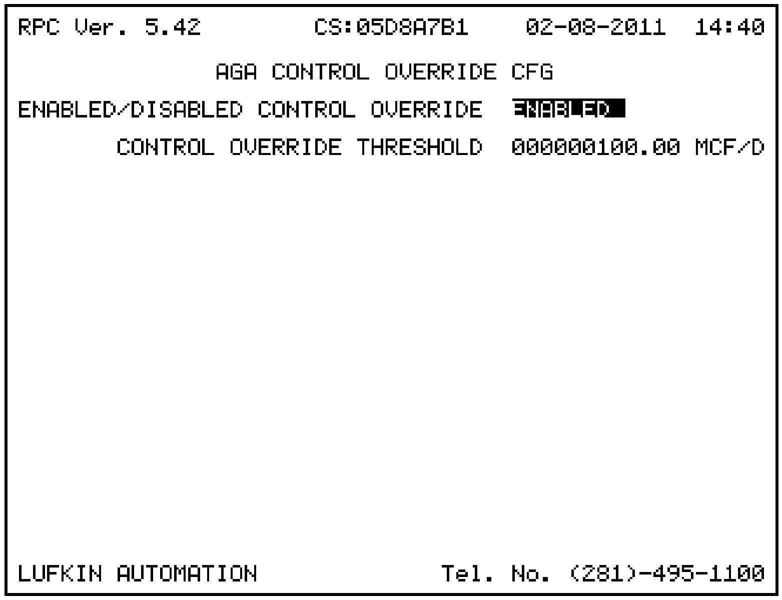


Figure 9-38. AGA Control Override Cfg Screen

Data Field Descriptions

Information about each data field is provided below.

ENABLE/DISABLE CONTROL OVERRRIDE

Specify whether you want to enable or disable the control threshold override feature.

CONTROL OVERRIDE THRESHOLD

Specify the lower limit for the calculated gas flow rate. This field is only available when this feature is enabled.

9.18 Custody Transfer

MENU 2/6/4

If the Lufkin Well Manager RPC is equipped with an optional I/O expansion board programmed for EFM (electronic flow measurement or electronic flow metering) capabilities, you can access the Custody Transfer Main Menu screen (Figure 9-39). Custody transfer operations are where you program configuration parameters for transmitters, gas mixture, well stream variables, low flow cutoff, pipe diameters, and plate sizes. These menu options should be used as an alternative method for configuring EFM parameters.

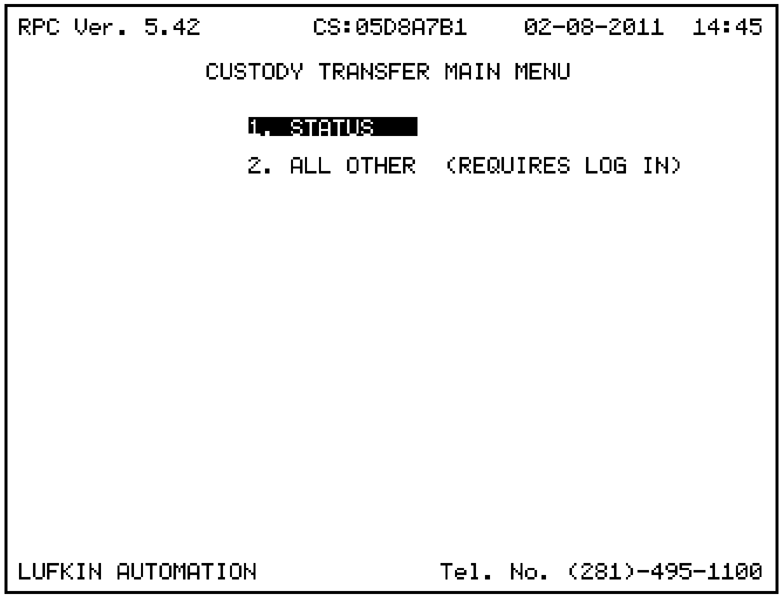


Figure 9-39. Custody Transfer Main Menu Screen

An easier method you can use to perform custody transfer is to use the *Lufkin EFM Utility* software available from Lufkin Automation. This interface can be installed on a laptop computer connected to the communications port on the Lufkin Well Manager RPC. All custody transfer operations can be password-protected so that users can only have access to these operations and no other Lufkin Well Manager RPC programming privileges, if desired. For more information about the *Lufkin EFM Utility* software, refer to the *Lufkin EFM Utility Software User Manual* (Part No. 099.5070) or contact your Lufkin Automation representative.

9.19 Register Functions Configuration

MENU 2/7

The Lufkin Well Manager RPC has three features that you can use to work with registers. They are:

- Configuring eight register alarms based on any of the measured or calculated values in the controller memory files (page 9-82)
- Configuring ten historical plots from any physical input or calculated value in the Lufkin Well Manager RPC (page 9-85)
- Configuring ten register calculations that are a combination of status values from different register logs to obtain new values that can be used for monitoring and creating register alarms (page 9-88)

Each feature is a separate option available under the Register Functions Configuration Menu screen (Figure 9-40). To display this menu, select **7. REGISTER FUNCTIONS** from the Programming Menu screen.

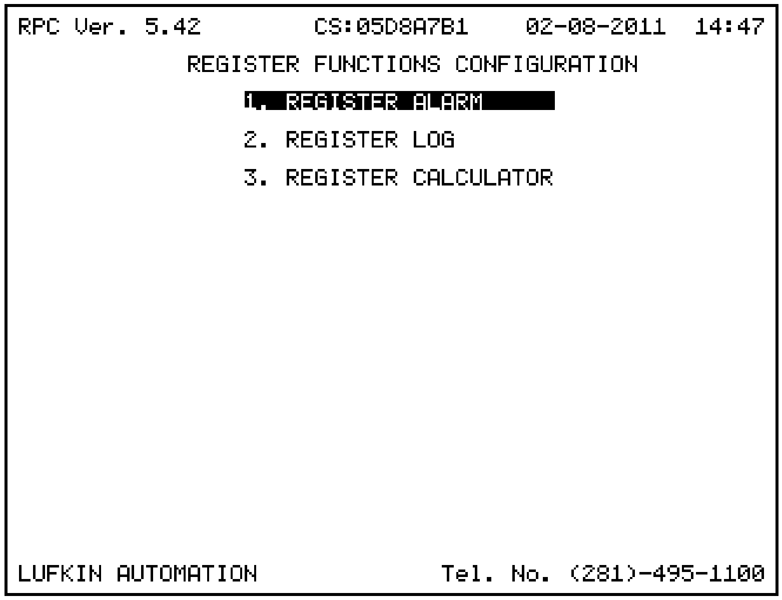


Figure 9-40. Register Functions Configuration Menu Screen

9.19.1 Configuring a Register Alarm

MENU 2/7/1

The Lufkin Well Manager RPC has a register alarm feature that allows you to program for actions based on any of the measured or calculated values in the controller memory files. You can configure a total of eight register alarms. This feature complements the logic expression capabilities to give the Lufkin Well Manager RPC some flexibility to perform functions other than rod pump control. These features might be useful when a wellsite is near a pump station and you want to monitor and control other process variables, such as tank level, tank pressure, by-pass valve activity, etc.

Register alarms are configured using the Register Alarm Config screen similar to Figure 9-41. To display this screen, select **1. REGISTER ALARM CONFIG** from the Register Functions Configuration Menu screen.

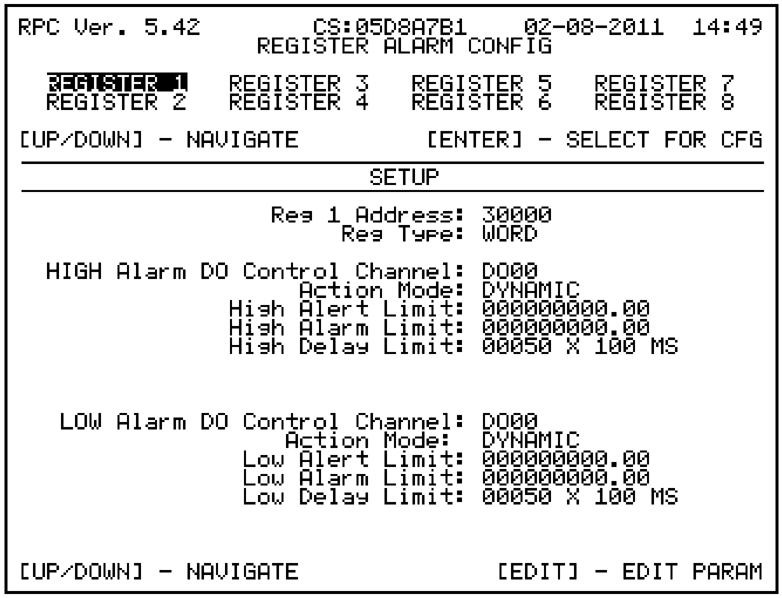


Figure 9-41. Register Alarm Config Screen

Note: You must configure the digital output you want to control before you can configure the register alarm. For information about configuring digital outputs, see “Configuring Auxiliary Digital Inputs and Outputs” on page 9-50.

Data Field Descriptions

Information about each data field is provided below.

Register Number

Select the virtual register number you want to assign to a register alarm.

Reg Address

Specify the actual register address you want to use for the selected virtual alarm register. Addresses are listed in the PCP register map. Contact your Lufkin Automation representative to obtain the latest register map.

Reg Type

Specify the type of register you want to use. Choices are **WORD** (16-bit integer), **FLOAT** (32-bit floating point value), and **LONG** (32-bit integer value).

HIGH Alarm DO Control Channel

Specify the digital output channel that the register alarm is to control when the action is required for the High Alarm Limit violation.

Action Mode

Specify the action the digital output channel is to perform when the action is required for the High Alarm Limit violation. Choices are **DYNAMIC**, **LATCHED**, **TIMER**, and **PULSE**.

High Alert Limit

Specify the alert setpoint value that must be exceeded for the Lufkin Well Manager RPC to consider the monitored value a violation.

High Alarm Limit

Specify the high point you want used as the violation setpoint to trigger the alarm.

High Delay Limit

Specify the amount of time, in milliseconds, that the High Alarm Limit value is to exist (delay) before the value is considered a violation.

LOW Alarm DO Control Channel

Specify the digital output channel that the register alarm is to control when the action is required for the Low Alarm Limit violation.

Action Mode

Specify the action the digital output channel is to perform when the action is required for the Low Alarm Limit violation. Choices are **DYNAMIC**, **LATCHED**, **TIMER**, and **PULSE**.

Low Alert Limit

Specify the alert setpoint value that the present monitored value must fall below for the Lufkin Well Manager RPC to consider the monitored value a violation.

Low Alarm Limit

Specify the low point you want used as the violation setpoint to trigger the alarm.

Low Delay Limit

Specify the amount of time, in milliseconds, that the Low Alarm Limit value is to exist (delay) before the value is considered a violation.

9.19.2 Configuring a Register Log

MENU 2/7/2

You can configure an historical plot for any of the data in the Lufkin Well Manager RPC. Any physical input or calculated value in the Lufkin Well Manager RPC memory can be sampled and stored in a buffer for display. Plot resolution is programmable to capture a value as often as once per minute or only once per day. A total of ten plots can be configured.

Register logs are configured using the Register Logging Config screen similar to Figure 9-42. To display this screen, select **2. REGISTER LOG** from the Register Functions Configuration Menu screen.

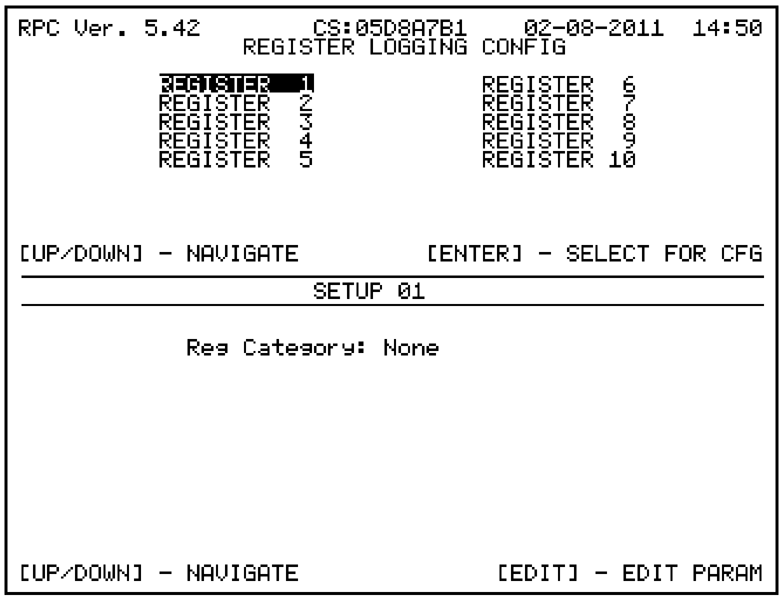


Figure 9-42. Register Logging Config Screen Example

You can display this information as a plot by selecting the Register Log Plots option (**MENU: 3/5**), which is available under the Historical Data Menu screen. For information about this historical plot, see “Register Log” in section 11, “Historical Data.”

Data Field Descriptions

Information about each data field is provided below.

Register Number

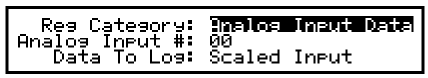
Select the virtual register number you want to assign to a register log.

Reg Category

Specify the category of data to be polled. Several categories are available. The category selected displays its own subset of fields that require you to configure additional parameters.

- **None** — Select this option when you want to cancel a register log already configured. No additional fields display.

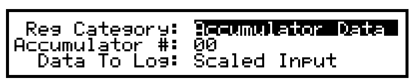
- **Analog Input Data** — Select this option when you want to configure a register log for data acquired from an analog input channel. The following additional fields display:



– **Analog Input #** — Specify the analog input channel used for the data you want to log.

– **Data to Log** — Specify whether the analog data is scaled or raw.

- **Accumulator Data** — Select this option when you want to configure a register log for data acquired from an accumulator input channel. The following additional fields display:



– **Accumulator #** — Specify the accumulator channel used for the data you want to log.

– **Data to Log** — Specify whether the analog data is scaled or raw.

- **Register Data** — Select this option when you want to configure a register log for data acquired from a memory register. The following additional fields display:

– **Register #** — Specify the actual register address used for the data you want to log. Addresses are listed in the RPC register map. Contact your Lufkin Automation representative to obtain the latest register map.

– **Register Type** — Specify the type of register used for the register address. Choices are **WORD** (16-bit integer), **FLOAT** (32-bit floating point value), **LONG** (32-bit integer value), and **COIL**.

- **Slave Data** — Select this option when you want to configure a register log for data acquired from a slave device. For information about slave devices, see “Modbus Master and Slave Device Configuration” on page 9-16.

  The following additional fields display:

```
  Reg Category: Slave Data
      Device #: 00
 Register Type: WORD
Register Index: 000
```

– **Device #** — Specify the slave device whose data you want to log.

– **Register Type** — Specify the type of register used for the register address. Choices are **WORD** (16-bit integer), **FLOAT** (32-bit floating point value), **LONG** (32-bit integer value), and **COIL**.

– **Register Index** — Specify the index of the data point being read from the slave device. This index can be found in the Modbus Master configuration for that particular device. For more information, see “Configuring Slave Device Parameters” on page 9-18.

- **AGA Data** — Select this option when you want to configure a register log for calculated AGA-3 data. For more information about AGA-3, see “AGA-3 and NX-19 Parameter Configuration” on page 9-71.

  One additional field displays.

```
Reg Category: AGA Data
AGA Log Data: Flow Rate
```

– **AGA Log Data** — Specify the type of AGA-3 data being measured. Choices are **Flow Rate**, **Diff. Pressure**, **Static Pressure**, **Flowing Temperature**, and **Supercompressibility**.

Sample Mode

Specify whether you want the data logged as an average value during the sample period or you want a value logged once during each sample period. The duration of a sample period is specified with the **Sample Rate** field.

Sample Rate

Specify how often, in seconds, you want the data sampled.

Logging Enabled

Specify whether you want to start logging the data specified for the register.

- ***To start the logging process***, select **YES**.
- ***To prevent the logging process from occurring***, select **NO**. This option is useful when you want to configure the parameters now and then start logging data at a later date, or to turn off the logging process if you need to service the end device configured for the register log.

9.19.3 Configuring Register Calculations

MENU 2/7/3

You can combine values from different memory registers to obtain new values that can be used for monitoring and creating register alarms. You can configure up to ten register calculations.

You can display the calculated results in the Programmable Calculations Status screen (**MENU: 7/4/2**). For information about the features this screen has, see "Register Calculations Status" in section 9, "Status Screens."

Three screens are used to configure register calculations. The first screen is the Programmable Calculations Setup screen (Figure 9-43), which you use to select a programmable calculation register that is to contain the register calculation. To display this screen, select **3. REGISTER CALCULATIOR** from the Register Functions Configuration Menu screen.

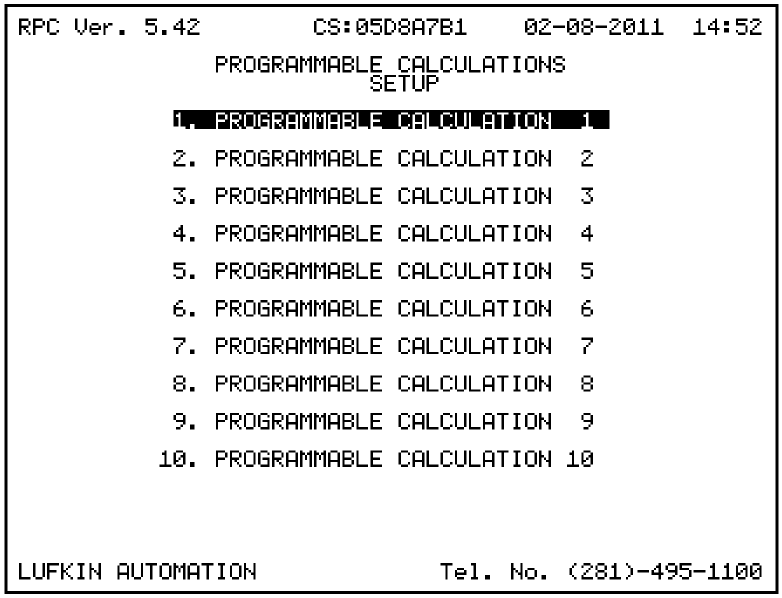


Figure 9-43. Programmable Calculations Setup Screen

After you select a programmable calculation register in the Programmable Calculations Setup screen, the Programmable Calculation screen displays (Figure 9-44), which is where you combine the status values (referred to as inputs) for your calculation. The configuration process involves specifying an input value, choosing an operation (+, –, ×, ÷), and then selecting a second input value. You can only define two input values and one operation for each calculation register.

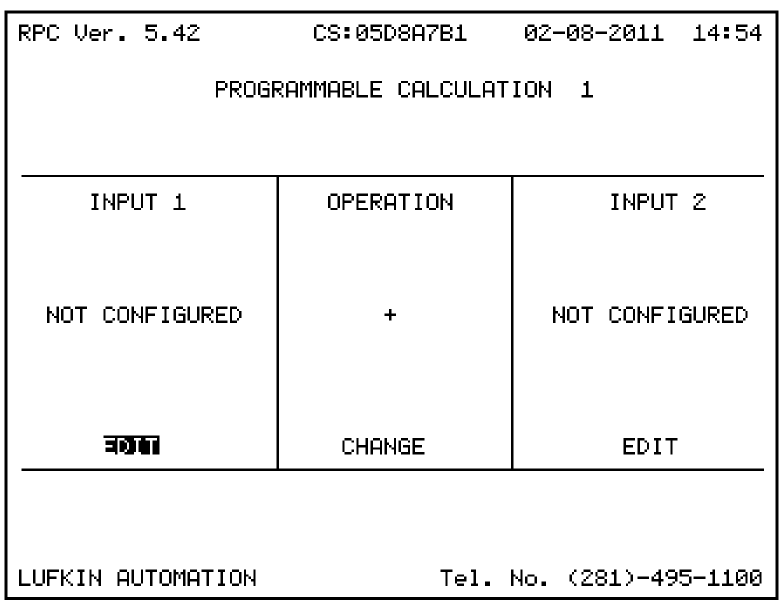


Figure 9-44. Programmable Calculation Screen

After you press **<ENTER>** on the highlighted **EDIT** field or an input, the Programmable Calculation Input Setup screen (Figure 9-45) displays for you to define the input type you want used in the calculation.

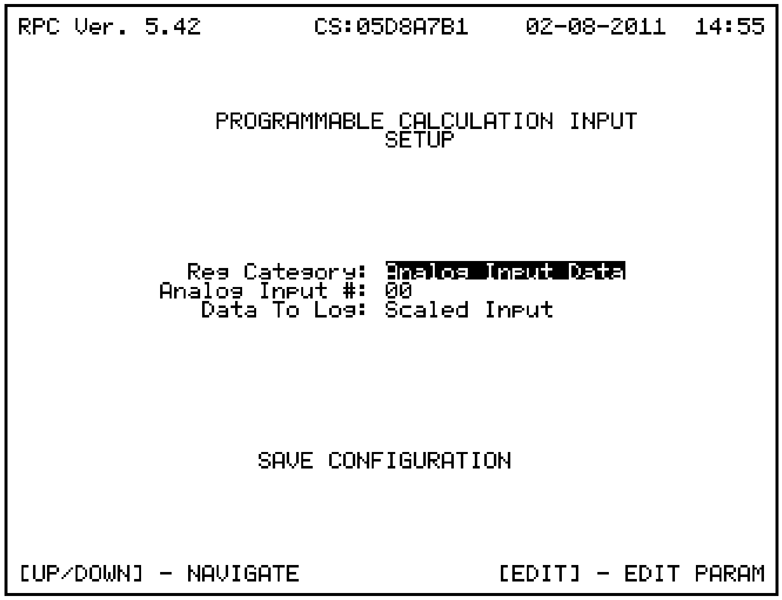


Figure 9-45. Programmable Calculation Input Setup Screen Example

After you define the input and save its configuration, you are returned to the Programmable Calculation screen where you can define the operation you want performed on the inputs. After it is defined, you can define the second input for the calculation using the same methods as you did for the first input. When the calculation is correctly configured, you can return to the Programmable Calculation Setup screen to configure another register calculation.

WARNING: You must save the configuration before you exit this screen. Highlight the **SAVE CONFIGURATION** field, and then press **<ENTER>**.

Data Field Descriptions

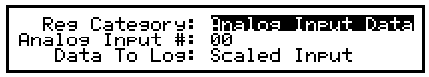
Information about each data field is provided below.

Reg Category

Specify the category of data to be polled. Several categories are available. The category selected displays its own subset of fields that require you to configure additional parameters.

- **None** — This option indicates that no data is to be used in the calculation. This option is illogical and would therefore never be selected.

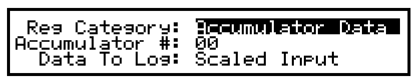
- **Analog Input Data** — Select this option when you want to use data acquired from an analog input channel as an input to a calculation. The following additional fields display:



– **Analog Input #** — Specify the analog input channel used for the data you want to use.

– **Data to Log** — Specify whether the analog data is scaled or raw.

- **Accumulator Data** — Select this option when you want to use data acquired from an accumulator input channel as an input to a calculation. The following additional fields display:



– **Accumulator #** — Specify the accumulator channel used for the data you want to use.

– **Data to Log** — Specify whether the analog data is scaled or raw.

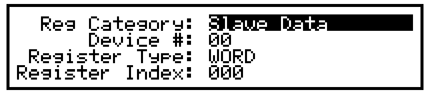
- **Register Data** — Select this option when you want to use data acquired from a memory register as an input to a calculation. The following additional fields display:

– **Register #** — Specify the register address used for the data you want to use in the calculation. Addresses are listed in the PCP register map. Contact your Lufkin Automation representative to obtain the latest register map.

– **Register Type** — Specify the type of register used for the register address. Choices are **WORD** (16-bit integer), **FLOAT** (32-bit floating point value), **LONG** (32-bit integer value), and **COIL**.

- **Slave Data** — Select this option when you want to use data acquired from a slave device as an input to a calculation. For information about slave devices, see “Modbus Master and Slave Device Configuration” on page 9-16.

The following additional fields display:



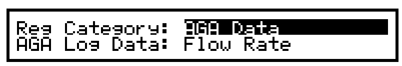
– **Device #** — Specify the slave device whose data you want to log.

– **Register Type** — Specify the type of register used for the register address. Choices are **WORD** (16-bit integer), **FLOAT** (32-bit floating point value), **LONG** (32-bit integer value), and **COIL**.

– **Register Index** — Specify the index of the data point being read from the slave device. This index can be found in the Modbus master configuration for that particular device. For more information, see “Configuring Slave Device Parameters” on page 9-18.

- **AGA Data** — Select this option when you want to use calculated AGA-3 data as an input to a Register Calculation. For more information about AGA-3, see “AGA-3 and NX-19 Parameter Configuration” on page 9-71.

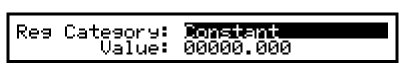
  One additional field displays.



– **AGA Log Data** — Specify the type of AGA-3 data being measured. Choices are **Flow Rate**, **Diff. Pressure**, **Static Pressure**, **Flowing Temperature**, and **Supercompressibility**.

- **Constant** — A data type of constant is selected to use a constant number as an input to a calculation.

  One additional field displays.



– **Value** — Specify the constant value to be used as an input to the register calculation.

- **Calculator Result** — This data type allows the use of the result of another register calculation in the current calculation. This result provides the ability to create longer calculations with a series of single calculations.

  One additional field displays.

– **Equation Num** — Specify the number of the register calculations from which the result is to be pulled.

Procedure

Follow the steps below to configure a register calculation.

1. From the **Main Menu** screen, select **2. PROGRAM**, and then select **7. REGISTER FUNCTIONS** to display the Register Functions Configuration Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

---

2. Select **3. REGISTER CALCULATIOR** to display the Programmable Calculations Setup screen.

   The **PROGRAMMABLE CALCULATION 1** field highlights.

3. Press <↑> or <↓> to select the field you want used to configure the calculation data, and then press **<ENTER>**.

   The Programmable Calculation screen displays with the **EDIT** field highlighted for **Input 1**.

4. Press **<ENTER>**.

   The Programmable Calculation Input Setup screen displays with the **Reg Category** field highlighted.

5. Press **<EDIT>**, press <↑> or <↓> to select the register category type you want, and then press **<ENTER>**.

   For all register category options except **None**, additional fields display that are specific to your category choice.

6. Do one of the following to specify values for each remaining field:

   - ***To enter numerical values***, press **<EDIT>** and then press the number keys. After you press a key, the next digit to the right highlights. You can press <←> to return to a digit to the left to change it. After all numerical values are correct, press **<ENTER>**.

   - ***To select field options***, press **<EDIT>**, press <↑> or <↓>**,** and then press **<ENTER>**.

   The next field highlights.

7. After you finish specifying values for all fields, save the configuration. Highlight the **SAVE CONFIGURATION** field, and then press **<ENTER>**.

   A Save Configuration message displays for a few seconds to inform you that your data is saved for the register log.

8. Press <**EXIT**> to return to the Programmable Calculation screen.

Note: If you exit the Programmable Calculation Input Setup screen without saving the configuration, all parameters values are not saved for the input.

---

9. Press **<→>** to highlight the **CHANGE** field for **Operation**.

10. Press **<ENTER>** to scroll through the four possible operations (+, −, ×, ÷) you can perform.

    When the correct operation is selected, press <→> to highlight the **EDIT** field for **Input 2**.

11. To configure the register category type for **Input 2**, repeat steps 4 through 10.

12. When finished, do either of the following:

    - To return to the Programmable Calculations Setup screen to configure another register calculation, press <**EXIT**>.

    - To return to the Main Menu screen, press <**MENU**>.

9.20 Coil Tracking Configuration

MENU 2/8

The amount of time that the Lufkin Well Manager RPC is in a particular alarm condition can be accumulated and tracked. These alarm flags are referred to as “coils.” Alarm tracking allows you to track the amount of time an alarm is active during a 24-hour period. This feature gives you the ability to determine the accumulated downtime caused by a particular alarm. The accumulated time is presented in an hour/minute/second format. Sixteen alarms coils can be tracked.

Alarm tracking is configured with the Coil Tracking Configuration screen (Figure 9-46). To display this screen, select **8. COIL TRACKING** from the Programming Menu screen.

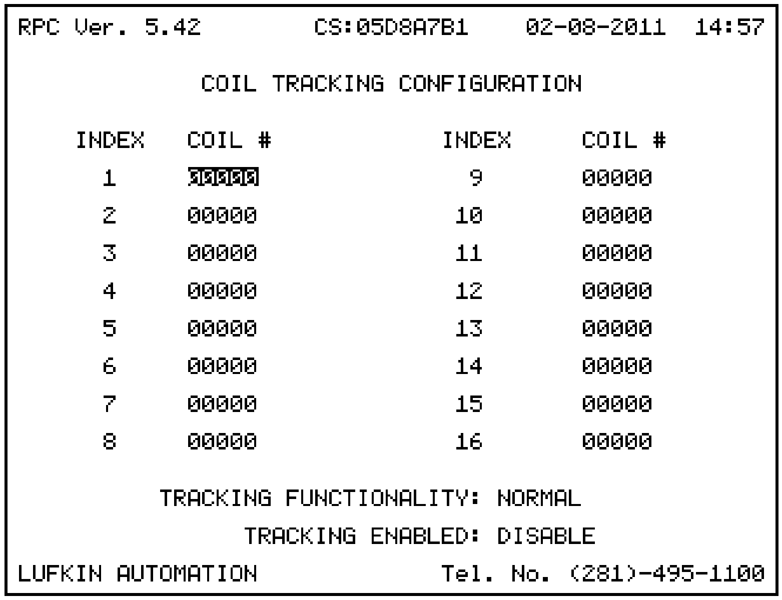


Figure 9-46. Coil Tracking Configuration Screen

Along with a 24-hour value, a 60-day history is also available for each tracked alarm. This alarm information can be a displayed as a plot by using the Coil Tracking option (**MENU: 3/3**), which is available under the Historical Data Menu screen. For more information, see “Coil Tracking” in section 11, “Historical Data.”

Data Field Descriptions

Information about each data field is provided below.

INDEX

This reference field shows which coil is being configured. This field cannot be edited.

COIL

Specify the number in the RPC register map you want to configure to monitor. The alarm range is 10001 to 19999. Contact your Lufkin Automation representative to obtain the latest register map.

TRACKING FUNCTIONALITY

Three tracking modes are available for tracking and accumulating time. The choices are:

- **Normal** — Each configured alarm is tracked and the amount of time it is active is accumulated in a 24-hour period.

- **First Occurrence** — Time is accumulated from the moment the first alarm is active to the moment the last alarm become inactive. In other words, time is tracked from the first alarm occurrence to the point in time when no configured alarms are active. The entire accumulated time is “charged” to the first active alarm.

- **Cascading** — The first alarm to occur is charged with the entire amount of time that it was active. Following the change in state of the first alarm, the highest priority alarm is then charged with the remaining period it is active. This routine will take place as long as any alarm is active.

TRACKING ENABLED

Specify whether you want the coil tracking feature to go into effect.

Section 10

Status Screens

The Lufkin Well Manager RPC has several status screens that display information about current values for measured process variables, alarms and alerts, and reminders for you about how control parameters are configured.

The topics covered in this section include:

10.1 Overview of the Status Screens

Two types of status screens can be displayed.

- RPC Status screens displaying information about the primary RPC control functions. Most of this data is based on parameter values configured through the RPC Parameters Menu screens (see section 8, “RPC Parameter Programming”).

- Several Lufkin Status screens displaying information useful to check and troubleshoot background tasks that the Lufkin Well Manager RPC performs. Most of this data is based on parameter values configured through the Lufkin Configuration Menu screens (see section 9, “Lufkin Parameter Programming”).

Both types of status screen are accessed from the Main Menu screen. Figure 10-1 shows where all status screens are located.

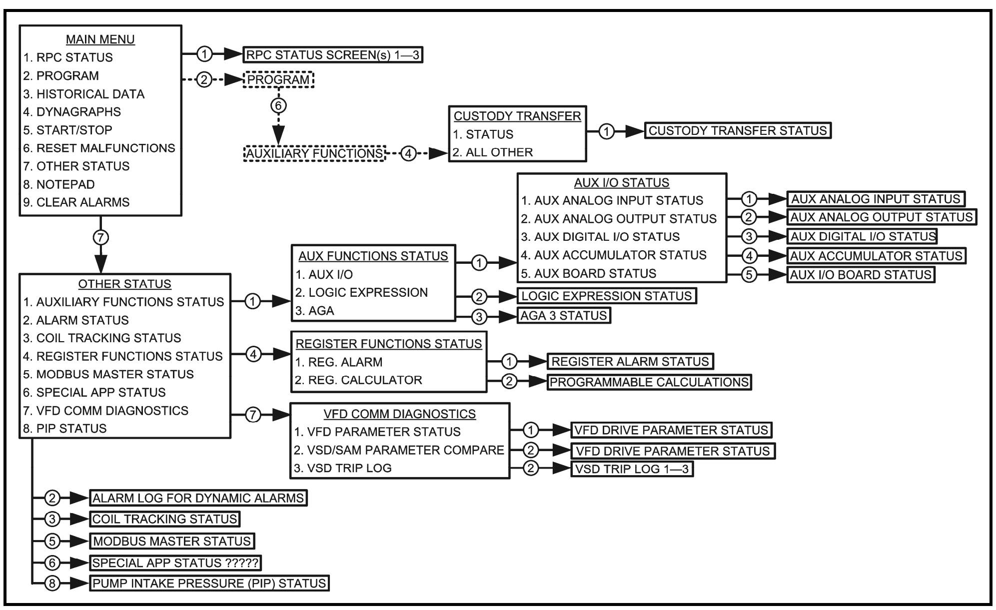


Figure 10-1. Status Screen Options

10.2 RPC Parameters Status Screens

MENU 1

The Lufkin Well Manager RPC presents a combination of current operating values and some historical data about the primary rod pump control (RPC) function. This information is displayed on three status screens.

Note: Earlier firmware versions display the status information on two screens instead of three.

The exact information presented on the status screens depends on the load/position end devices used, control mode selected, and control functions enabled. All of the described data fields may not be displayed.

Data field descriptions for RPC Status screen 1 (Figure 10-2) are described on page 10-4, screen 2 (Figure 10-3) on page 10-8, and screen 3 (Figure 10-4) on page 10-10.

To display the RPC Status screens, select **1. RPC STATUS** from the Main Menu screen. Screen contents are described below.

The Lufkin Well Manager RPC normally automatically returns to RPC Status Screen 1 when no keypad activity has occurred for eight minutes. Therefore, most of the time the Lufkin Well Manager RPC displays this screen when you arrive on site.

Note: If a different screen is the default screen, and you want the RPC Status screen used instead, use the Additional Configuration option (**MENU: 2/5/8**) to change it. For more information about this feature, see “Additional Configuration (Default Screen)” in section 9, “Lufkin Parameter Programming.”

Screen Navigation

You cannot edit any data on these screens, but when one the status screens is displaying, you can:

- Press **<NEXT>** to display the other RPC status screens.
- Press <**MENU**> or <**EXIT**> to display the Main Menu screen and then access other screens in Lufkin Well Manager RPC (dynagraphs, historical data, parameter configuration, etc.).

10.2.1 RPC Status Screen 1

Information about each data field in RPC Status Screen 1(Figure 10-2) is provided below.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  12:55
                 RPC Status Screen 1

          RTU Address  0001
    Current Well State  Load Uncalibrated
          Elapsed Time  000:04:19

          Control Mode  SURFACE
        Operation Mode  NORMAL
  Minimum Pump Strokes  003
              Downtime  000:05(hh:mm)

   Gauge Off Time(GOT)  07:00

         Run Yesterday  000 %  00:00 (hh:mm)
         Run Since GOT  000 %  00:00 (hh:mm)

                       Liquid  Oil     Water   TBGas
                       bbls    bbls    bbls    mscf
         LWT Since GOT  0000.0  0000.0  0000.0  *****
         Yesterday LWT  0000.0  0000.0  0000.0  *****
     Inst LWT(per day)  0000.0  0000.0  0000.0  *****
Projected LWT(per day)  0000.0  0000.0  0000.0  *****

        Pumping Speed  00.00 spm

Lufkin Automation                  [NEXT] Next Screen
```

Figure 10-2. RPC Status Screen 1

RTU Address

If the Lufkin Well Manager RPC is part of a SCADA network, it must have a unique address. This address allows the central host computer software to identify and interrogate this specific Lufkin Well Manager RPC. The address is programmed using the Communication Administration programming screen (**MENU: 2/5/2**).

Current Well State

Shows the present operating state of the Lufkin Well Manager RPC. For information about these states, see appendix C, “Well State List.”

Elapsed Time

States how long (HHH:MM:SS format) the Lufkin Well Manager RPC has been in the current well state.

Control Mode

Indicates which control algorithm Lufkin Well Manager RPC is currently using for well control decisions. In some cases, the Lufkin Well Manager RPC automatically changes the control method. You can change this mode using the RPC Control Parameter programming screen (**MENU: 2/1/1/1**).

Operation Mode

The current operation mode that the Lufkin Well Manager RPC is programmed to operate under. Three operation modes are available.

- **Normal** — Controls the pump as a function of the Pumpoff setpoint. The malfunction and load violation setpoints are active.
- **Host** — Sets the well to the "OFF" or "ON" state. The well stays in the selected state until you change it. If ON is selected, the Lufkin Well Manager RPC shuts down the pumping unit only when a peak or minimum load violation occurs. Shutdown lasts for the downtime selected during the Normal mode. If no time was selected for downtime, a default downtime of 5 minutes is used. Both the malfunction and pumpoff control setpoints are ignored.
- **Timed** — Sets the pump to run for a fixed "ON" time and then turns off for a fixed "OFF" time. The Lufkin Well Manager RPC shuts down the pumping unit only when a peak or minimum load violation occurs. Both the malfunction and pumpoff control setpoints are ignored.

For more information about these modes and how to change the current mode, see "Configuring RPC Control Parameters" in section 8, "RPC Parameter Programming" (**MENU: 2/1/1/1**).

Minimum Pump Strokes

The Lufkin Well Manager RPC will pump this number of strokes regardless of dynagraph shape changes. Peak and Min load violation protection is active during Minimum Pump Strokes. You can specify the desired number of strokes using the RPC Control Parameter programming screen (**MENU: 2/1/1/1**).

Down Time

The present downtime mode that was user-programmed as Manual or Automatic. The presently set downtime is indicated on the right edge in HHH:MM format. If in Manual mode, you can program downtime using the RPC Control Parameter programming screen (**MENU: 2/1/1/1**).

Gauge Off Time (GOT)

States the time of day that the Lufkin Well Manager RPC updates all of the historical data buffers.

You can change GOT using the Gauge Off Time/Peak Energy Mgnt programming screen (**MENU: 2/1/7**). For more information about GOT see “Setting Gauge Off Time and Peak Energy Management” in section 9, “Lufkin Parameter Programming.”

Run Yesterday

States the percentage and time that runtime occurred during the 24-hour period from GOT to GOT.

Run Since GOT

States the percentage and time that runtime has occurred today since GOT.

LWT Since GOT

States the volume produced today since GOT.

For more information about the Lufkin Well Test (LWT) feature, see appendix E, “Pump Intake Pressure and Lufkin Well Test.”

Yesterday LWT

States the volume for the previous 24-hour period from GOT to GOT.

Fluid, Oil, Water, and **TBGas** columns

States the total volumes of fluid (oil plus water), oil, water, and tubing gas (TBGas) for the four rows described below.

LWT Since GOT

States the volume produced so far today (i.e. since the most recent GOT).

Yesterday LWT

States the volumes for the previous 24-hour period as defined by GOT.

INST (instantaneous) **LWT (per day)**

States a value that assumes that every pump stroke for the full 24-hour period will be identical to the stroke just completed. Unless the well is pumping 24 hours per day in a very stable condition, these numbers can be misleading.

Projected LWT (per day)

States the average values over several strokes, and should be more accurate than the instantaneous LWT rates. This calculation assumes that well performance will continue for the 24-hour period in the same way that it has since GOT.

Pump Fillage

When operating in Downhole control mode, the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC 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 Lufkin Well Manager RPC stops the pumping unit for the programmed Downtime.

Pumping Speed

States the actual pumping speed in strokes per minute as measured by the Lufkin Well Manager RPC using the position input data. Slight variations may be shown from one stroke to the next.

10.2.2 RPC Status Screen 2

Information about each data field in RPC Status Screen 2 (Figure 10-3) is provided below.

Note: For descriptions about **RTU Address**, **Current Well State**, and **Elapsed Time**, see page 10-4.

Polished Rod HP

The Lufkin Well Manager RPC calculates this polished rod horsepower (PRHP) number from the area inside the surface dynagraph. This value is updated once a stroke, but this parameter is not used for any control functions. This parameter will set an alarm flag if current PRHP exceeds a programmed Peak PRHP Limit.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  12:57
                 RPC Status Screen 2

           RTU Address    0001
     Current Well State   Load Uncalibrated
          Elapsed Time    000:05:40

     Polished Rod Power   000.0  hp
       Today's Peak PRP   000.0  hp

   Motor Rev/Stroke(NREV)   000
 Avg Downstroke Motor Pwr   000.00         (pseudo)


     Todays Average SPM   000.00
   Yesterdays Average SPM 000.00

    Todays Total Strokes  00000
 Yesterdays Total Strokes 00000


    Rodometer/Pumpometer   0000000000/0000000000
    Accumulated Run Time   00541 Minutes

Lufkin Automation              [NEXT] Next Screen
```

Figure 10-3. RPC Status Screen 2

This parameter is defined in the Others programming screen (**MENU: 2/1/8**).

Today's Peak PRHP

States the peak PRHP calculated today since GOT.

Pump HP

The Lufkin Well Manager RPC calculates the pump horsepower number from the area inside the downhole pump card. This value is updated once a stroke, but it is not used for any control functions.

Motor Rev per Stroke (NREV)

The Lufkin Well Manager RPC counts the number of motor revolutions each pump cycle (from crank switch input to next crank switch input) and displays that numbering in this field. A variation of one or two counts from stroke to stroke is fairly typical.

Average Downstroke Motor Power (pseudo)

Displays a relative number that indicates the amount of work being done in the downstroke by the pumping unit. This number is the control parameter for the Motor Power control method.

Todays Average SPM and Yesterdays Average SPM

Displays the average strokes per minute thus far for the current day and the average strokes per minute for the entire previous day as defined by gauge off time (GOT).

Todays and Yesterdays Total Strokes

Displays the accumulated number of pumping strokes thus far for the current day and the accumulated total number of strokes for the previous day as defined by GOT.

Rodometer/Pumpometer

The Lufkin Well Manager RPC counts and accumulates the number of strokes since the last time rod string work and/or pump work was performed. This count gives operators a tool to measure rod and pump life.

The rollover value is 4,294,967,295 cycles. However, you can clear these counters independently using the Others programming screen (**MENU: 2/1/8**). You can also clear them using the Reset to Defaults option (**MENU: 2/5/4**), but be aware that it clears several other counters simultaneously.

Accumulated Run Time

States the number of minutes run time has occurred since rollover or this value was reset. It is not affected by GOT.

10.2.3 RPC Status Screen 3

Information about each data field in RPC Status Screen 3 (Figure 10-4) is provided below.

Note: For descriptions about **RTU Address**, **Current Well State**, and **Elapsed Time**, see page 10-4.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  12:58
                 RPC Status Screen 3

              RTU Address   0001
       Current Well State   Load Uncalibrated
             Elapsed Time   000:06:56

                 Consec Consec Cumltv   Cfg  Present
 Malfunctions E/D Allowd Occurd Occurd  Limit   Value

    Peak Load  E   0005   0000   0000  50000       0
     Min Load  E   0005   0000   0000      0   65535
       No RPM  E   0003   0000   0000  *****   00073
     No Crank  E   0003   0000   0000  *****   *****
Low Motor RPM  E   0003   0000   0000  01050   65535
  Peak Torque  D   0005   0000   0000   9999       0
Malf Setpoint  E   0004   0000   0000  *****   *****

             Other Options   Enabled/Disabled

   Peak Energy Management   DISABLED
          AGA Calculation   DISABLED
         Logic Expression   ENABLED
               HOA Switch   DISABLED
              Prod Cutoff   ENABLED

Lufkin Automation                 [NEXT] Next Screen
```

Figure 10-4. RPC Status Screen 3

Column Descriptions

E/D

- **E** indicates that the function is enabled.
- **D** indicates that the function is disabled.

Each parameter can be enabled or disabled independently using the RPC Control Parameter programming screen (**MENU: 2/1/1/2**). For more information about this screen, see “Configuring RPC Control Parameters” in section 8, “RPC Parameter Programming.”

Consec Allowed

The number of programmed retries (consecutive allowed) for that function. For more information about Consec Allowed, see “Configuring RPC Control Parameters.”

Consecutive Occurd

The Lufkin Well Manager RPC maintains this historical record. Use the Reset Malfunctions option (**MENU: 6**) to clear this count.

Cumultv Occurd

The Lufkin Well Manager RPC maintains this historical record of the total number of times this malfunction has occurred with no consecutive criteria. Use the Reset Malfunctions option (**MENU: 6**) to clear this count.

Cfg Limit

Most of these malfunction controls have a user-defined limit, such as low RPM, high load, or high torque.

To set the malfunction setpoint, use one of the dynagraph displays described in section 12, “Dynagraph Cards.”

Peak Torque Limit is displayed in thousands of inch-pounds.

Present Value

The current value of the variable associated with the malfunction control. Typically, the Lufkin Well Manager RPC updates present values at the bottom of stroke when in a pumping well state.

Peak Torque is presented in thousands of inch-pounds.

Row Descriptions

Bottom Section

Peak Load

States the maximum allowed value for load input.

Minimum Load

States the lowest allowed value for load input.

No RPM

The signal from the RPM Hall-Effect sensor has failed, or the well has been turned off thus overriding the Lufkin Well Manager RPC.

No Crank

The signal from the crank arm sensor has failed, or the drive belts have broken so that the motor is turning but the unit is not pumping.

Low Motor RPM

States the lowest motor RPM at which the Lufkin Well Manager RPC will continue to run the pumping unit.

Peak Torque

The maximum allowed calculated torque value in thousands of inch-pounds

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. To configure the malfunction setpoint location (limit), use one of the dynagraph displays described in section 12, “Dynagraph Cards.”

Low Fluid Load

States the lowest fluid load allowed for load input.

Peak Energy Management

States whether the Peak Energy Management feature is enabled or disabled.

To enable/disable it, use the Gauge Off Time/Peak Energy Mgnt screen (**MENU: 2/1/7**). For information about this feature, see “Setting Gauge Off Time and Peak Energy Management” in section 9, “Lufkin Parameter Programming.”

AGA Calculation

States whether the AGA Calculation feature is enabled or disabled.

To enable/disable it, use the Enable/Disable option in the AGA Configuration Menu screen (**MENU: 2/6/3/4**). For information about AGA Calculations, see appendix D, “AGA Definitions.”

Logic Expression

States whether the logic expression feature is enabled or disabled.

To enable/disable it, use the Enable/Disable option in the Logic Expression Configuration Menu screen (**MENU: 2/6/2/5**). For information screen about logic expressions, see “Logic Expressions” in section 9, “Lufkin Parameter Programming.”

HOA Switch

States whether the H-O-A switch feature is enabled or disabled.

To enable/disable it, use the Others programming screen (**MENU: 2/1/8**).

Prod Cutoff

States 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.

To enable/disable it, go to the **LWT Cutoff Control** field located in the first LWT/PIP Parameters screen (**MENU: 2/1/3**). For more information, see "Configuring LWT/PIP Parameters" in section 8, "RPC Parameter Programming."

10.3 Lufkin Parameter Status Screens

MENU 7

You can display several status screens that contain information useful for checking and troubleshooting background tasks that the Lufkin Well Manager RPC performs. These screens provide the following types of status information:

- Auxiliary functions, including analog I/O, digital I/O, accumulator, logic expressions, and AGA-3 calculations
- Alarms/alerts that are set and alarm tracking
- Coil tracking
- Values for programmed registers and register calculations
- Register addresses and values for Modbus slave devices
- VSD parameters and VFD/Lufkin parameter comparisons
- Pump intake pressure (PIP)

These screens are available through the Other Status Menu screen (Figure 10-5). To display this menu, select **7. OTHER STATUS** from the Main Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:08
                     OTHER STATUS
             1. AUXILIARY FUNCTIONS STATUS
             2. ALARM STATUS
             3. COIL TRACKING STATUS
             4. REGISTER FUNCTIONS STATUS
             5. MODBUS MASTER STATUS
             6. SPECIAL APP STATUS
             7. VFD COMM DIAGNOSTICS
             8. PIP STATUS




LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 10-5. Other Status Menu Screen

10.4 Auxiliary Functions Status Screens

MENU 7/1

Several auxiliary (AUX) status screens are used to view current values for all the process variable transmitters connected to the Lufkin Well Manager RPC. Analog I/O, digital I/O, accumulator values, auxiliary I/O, programmed logic expressions, and AGA-3 status can be displayed.

If the Lufkin Well Manager RPC is equipped with optional I/O expansion boards, current values for each configured auxiliary or expansion I/O points can be seen on these status screens. The Lufkin Well Manager RPC uses a 12-bit A/D converter for auxiliary analog points. Raw numbers will therefore be in the range of zero to 4095.

An Auxiliary Functions Status Menu screen (Figure 10-6) is used as a secondary menu to access the I/O type you want displayed and the status of auxiliary boards. To display this menu, select **1. AUXILIARY FUNCTIONS STATUS** from the Other Status Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:09
             AUXILIARY FUNCTIONS STATUS
                1. AUX I/O
                2. LOGIC EXPRESSION
                3. AGA













LUFKIN AUTOMATION               Tel. No. (281)-495-1100
```

Figure 10-6. Auxiliary Functions Status Menu Screen

10.4.1 Overview of the Auxiliary Input/Output Status Screens

MENU 7/1/1

You can display the status of analog I/O, digital I/O, accumulators, and boards. This information is displayed on separate status screens that are selected from the AUX I/O Status Menu screen (Figure 10-7). To display this menu, select **1. AUX I/O STATUS** from the Auxiliary Functions Status Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:10
                AUX I/O STATUS MENU
             1. AUX ANALOG INPUT STATUS
             2. AUX ANALOG OUTPUT STATUS
             3. AUX DIGITAL I/0 STATUS
             4. AUX ACCUMULATOR STATUS
             5. AUX BOARD STATUS











LUFKIN AUTOMATION               Tel. No. (281)-495-1100
```

Figure 10-7. AUX I/O Status Menu Screen

10.4.2 AUX Analog Input Status

MENU 7/1/1/1

You can use an AUX Analog Input Status screen similar to Figure 10-8 to display status data about the analog inputs. To display this screen, select **1. AUX ANALOG INPUT STATUS** from the AUX I/O Status Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:11
                AUX ANALOG INPUT STATUS
                                                ALARM
 AI#     RAW COUNTS    SCALED VALUE      UNITS    E/D
  1               0           0.000      ****      D
  2               0           0.000      ****      D
  3               0           0.000      ****      D
  4               0           0.000      ****      D
  5               0           0.000      ****      D
  6               0           0.000      ****      D
  7               0           0.000      ****      D
  8               0           0.000      ****      D



[NEXT] - NEXT SET
LUFKIN AUTOMATION                Tel. No. (281)-495-1100
```

Figure 10-8. AUX Analog Input Status Screen

Auxiliary analog inputs are displayed in sets of eight per screen. The present status for auxiliary analog inputs 1 through 8 displays on the first screen (see Figure 10-8). Press **<NEXT>** to display the next set of eight.

Auxiliary analog input channels are configured using the Auxiliary Analog Input Configuration screen. For information about this screen, see "Configuring Auxiliary Analog Inputs" in section 9, "Lufkin Parameter Programming."

Data Field Descriptions

Information about each data field is provided below.

AI#

States the virtual analog input number as programmed in section 8.

Raw Counts

States the numerical representation of the present value of the analog input as a raw BCD number (0 to 4095).

Scaled Value

States the present value of the analog input in engineering units.

Units

States the unit of measurement used.

Alarm E/D

States whether an alarm is enabled (E) or disabled (D) for the channel.

10.4.3 AUX Analog Output Status

MENU 7/1/1/2

You can use an AUX Analog Output Status screen similar to Figure 10-8 to display status data about the analog outputs. To display this screen, select **2. AUX ANALOG OUTPUT STATUS** from the AUX I/O Status Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:13
                AUX ANALOG OUTPUT STATUS

     AO#     RAW COUNTS   SCALED VALUE     UNITS
       1              0          0.000     ****
       2              0          0.000     ****
       3              0          0.000     ****
       4              0          0.000     ****
       5              0          0.000     ****
       6              0          0.000     ****
       7              0          0.000     ****
       8              0          0.000     ****



LUFKIN AUTOMATION                Tel. No. (281)-495-1100
```

Figure 10-9. AUX Analog Output Status Screen

Auxiliary analog output channels are configured using the Auxiliary Analog Input Configuration screen. For information about this screen, see “Configuring Auxiliary Analog Outputs” in section 9, “Lufkin Parameter Programming.”

Data Field Descriptions
Information about each data field is provided below.

AO#

States the virtual analog output number as programmed.

Raw Counts

States the numerical representation of the present value of the analog output as a BCD number (0 to 4095).

Scaled Value

States the present value of the analog output in engineering units.

Units

States the unit of measurement used.

10.4.4 Digital Input/Output Status

MENU 7/1/1/3

You can use a Digital Status screen similar to 10-18 to display status data about the digital inputs. This data is useful for verifying the operation of input switches. To display this screen, select 3**. AUX DIGITAL I/O STATUS** from the AUX I/O Status Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:15
                     DIGITAL STATUS
 DIG#  STATE  DIG#  STATE  DIG#  STATE  DIG#  STATE
  01 -  ****   09 -  ****   17 -  ****   25 -  ****
  02 -  ****   10 -  ****   18 -  ****   26 -  ****
  03 -  ****   11 -  ****   19 -  ****   27 -  ****
  04 -  ****   12 -  ****   20 -  ****   28 -  ****
  05 -  ****   13 -  ****   21 -  ****   29 -  ****
  06 -  ****   14 -  ****   22 -  ****   30 -  ****
  07 -  ****   15 -  ****   23 -  ****   31 -  ****
  08 -  ****   16 -  ****   24 -  ****   32 -  ****



[NEXT] - Next Screen
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 10-10. Digital Status Screen

Auxiliary digital inputs status screens only display the open or closed state for each input that is configured. The present status for auxiliary digital inputs 1 through 32 displays on the first screen (see Figure 10-10). Press **<NEXT>** to display the next set of digital inputs.

Digital channels are configured using the Digital Configuration screen. For information about this screen, see “Configuring Auxiliary Digital Inputs and Outputs” in section 9, “Lufkin Parameter Programming.”

Data Field Descriptions

Information about each data field is provided below.

DIG#

States the digital channel number.

State

States whether the digital channel is open or closed.

10.4.5 AUX Accumulator Status

MENU
7/1/1/4

The Lufkin Well Manager RPC firmware design supports a maximum of ten accumulator inputs. The motherboard has four auxiliary digital points that can be configured as accumulators. Optional expansion board hardware is required to take advantage of the additional six accumulators that the firmware can support.

You can use an Aux Accumulator Status screen similar to Figure 10-11 to display status data about the auxiliary accumulators. To display this screen, select **4. AUX ACCUMULATOR STATUS** from the AUX I/O Status Menu screen.

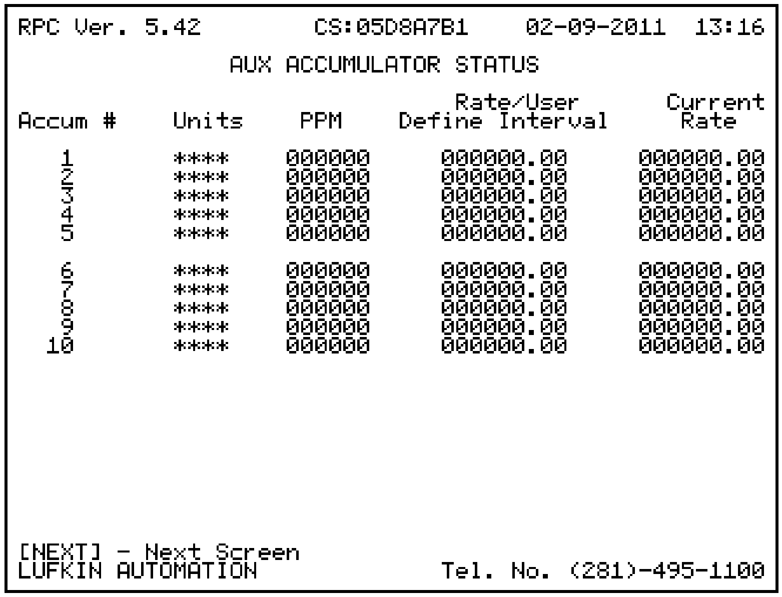


Figure 10-11. AUX Accumulator Status Screen

These inputs provide the ability to monitor the operation of facilities adjacent to a well without having the additional cost of installing a remote terminal unit (RTU) and data telemetry equipment for that facility.

Data Field Descriptions

Information about each data field is provided below.

Accum

States the virtual channel number for the accumulator.

Units

States the unit of measurement to be associated with each auxiliary input.

PPM

States the pulses per unit of measure (PPM). This value is an integer that programs the Lufkin Well Manager RPC 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/User Defined Interval

States the projected units per day rate based on the most recent sampling period count. This projection assumes that the input will continue at the same rate for the full 24-hour period.

Current Rate

States the projected units per day based on the most recent sampling period count. The projection assumes that the input will continue at the same rate for the full 24-hour period.

10.4.6 AUX I/O Board Status

MENU 7/1/1/5

You can use the AUX I/O Boards Status screen (Figure 10-12) as a troubleshooting tool to see if the different auxiliary I/O boards are present and working properly. A total of eight boards can be stacked to the motherboard. For each board, you can see its operating state, model, build, checksum, and the number each has available for I/O configuration. To display this screen, select **5. AUX BOARD STATUS** from the AUX I/O Status Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:18
                         AUX I/O BOARDS STATUS
NUM    STATE  MODEL  VER  BUILD  XSUM  AI  AO  ACC  DIG
 1   POWERON   0003  005   000   6BEB   8   0   8    16
 2    ABSENT   0000  000   000   0000   0   0   0    00
 3    ABSENT   0000  000   000   0000   0   0   0    00
 4    ABSENT   0000  000   000   0000   0   0   0    00
 5    ABSENT   0000  000   000   0000   0   0   0    00
 6    ABSENT   0000  000   000   0000   0   0   0    00
 7    ABSENT   0000  000   000   0000   0   0   0    00
 8    ABSENT   0000  000   000   0000   0   0   0    00



LUFKIN AUTOMATION               Tel. No. (281)-495-1100
```

Figure 10-12. AUX I/O Boards Status Screen

Data Field Descriptions

Information about each data field is provided below.

NUM

States the board number as defined by the board dipswitches.

STATE

Present state of the expansion board.

MODEL

Model number read from the expansion board processor on power up.

VER

States the firmware version of the board.

BUILD

States the secondary version description.

XSUM

Displays the board’s checksum number. This number is used to check the validity of the firmware. It should match the number written on the chip on the board.

AI

States the number of analog inputs available on the board.

AO

States the number of analog outputs available on the board.

ACC

States the number of pulse accumulators available on the board.

DIG

States the number of digital inputs/outputs available on the board.

10.4.7 Logic Expressions Status

MENU 7/1/2

You can display the present status for each logic expression and the action programmed for that expression on a Logic Expression Status screen similar to Figure 10-13. To display this screen, select **2. LOGIC EXPRESSION** from the Auxiliary Functions Status Menu screen.

Note: If the Logic Expression function is disabled, this screen will not show current data. To enable it, use **MENU: 2/6/2/5**. For more information about enabling it, see “Enabling and Disabling Logic Expressions” in section 9, “Lufkin Parameter Programming.”

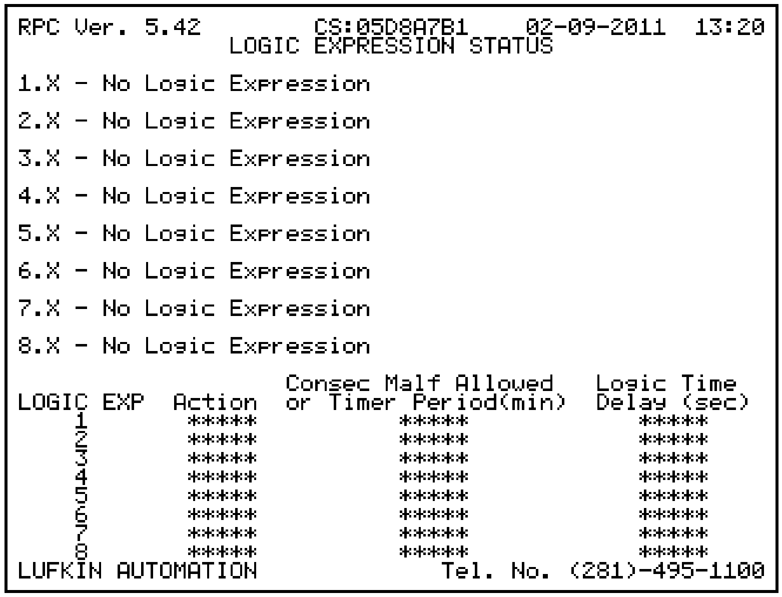


Figure 10-13. Logic Expression Status Screen

Each programmed logic expression is displayed, and the present condition of each programmed logic expression is displayed at the far right edge of the screen as **T** for true or **F** for false.

Data Field Descriptions

Information about each data field is provided below.

LOGIC EXP

States the logic expression number.

Action

States the action parameters programmed for the logic expression. For descriptions about each action available, see “Programming a Logic Expression Action” in section 8, “Lufkin Parameter Programming.”

Consec Malf Allowed or Timer Period(min)

States the action programmed for the logic expression.

- If the programmed action is MALF, it states the number of retries allowed before the pumping unit is shut down in a Malfunction well state.

- If the programmed action is TIMER, it states the desired time in minutes to hold closed the designated digital output.

Logic Time Delay (sec)

States the delay before executing the programmed action when a logic expression proves true. This time delay is in addition to any programmed time delays for the analog alarms and/or digital inputs that are included in a logic expression.

10.4.8 AGA-3 Status

MENU 7/1/3

If the Lufkin Well Manager RPC has proper optional hardware, and it is configured to perform the AGA-3 gas flow rate and volume calculations, you can display the calculation results on a status screen similar to Figure 10-14. To display this screen, select **3. ALARM STATUS** from the Auxiliary Functions Status Menu screen.

Note: If the AGA-3 Calculations feature is disabled, this screen will not show current data. To enable it, use **MENU: 2/6/3/4**. For more about enabling it, see “Enabling and Disabling AGA-3 Calculations” in section 9, “Lufkin Parameter Programming.” If the AGA-3 is disabled and you try to access this screen, you will probably see a message appear for a few seconds that reads **Not Available**.

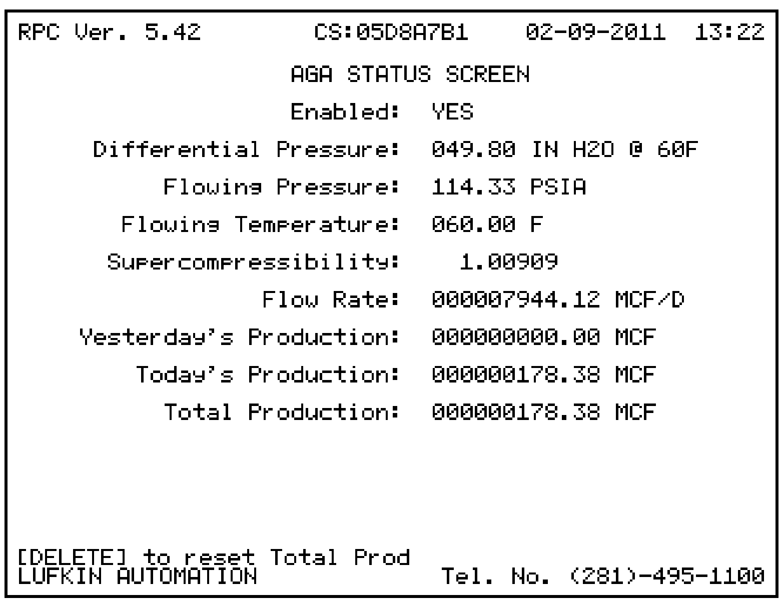


Figure 10-14. AGA Status Screen

Data Field Descriptions

Information about each data field is provided below.

ENABLED

States whether or not the AGA calculations are enabled.

DIFFERENTIAL PRESSURE

States the present measured differential pressure.

FLOWING PRESSURE

States the present measured flowing pressure, or user-specified pressure if not measured.

FLOWING TEMPERATURE

States the present measured flowing temperature, or user-specified temperature if not measured.

SUPERCOMPRESSIBILITY

States the calculated supercompressibility factor.

FLOW RATE

States the present flow rate measured in MCF/DAY.

Yesterdays Production

States the total production volume for the previous day as defined by gauge off time (GOT).

TODAY'S PRODUCTION

States the production since last GOT.

TOTAL PRODUCTION

States the total production accumulated since last reset.

Note: Press <**DELETE**> while viewing the AGA Status screen to reset the total production accumulator.

10.5 Alarm/Alert Status

MENU 7/2

If a dynamic alarm and/or alert condition exists anywhere in the Lufkin Well Manager RPC, an alarm alert box blinks on and off at the top of every screen. Figure 10-15 is an example of a screen displaying an Alarm/Alert notification.

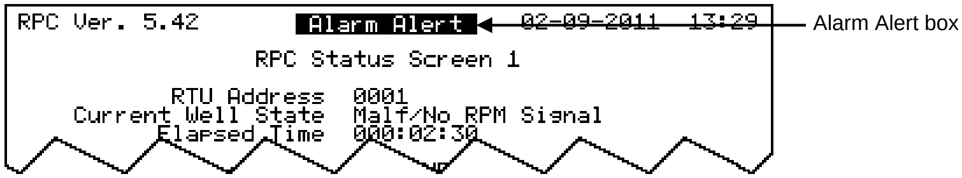


Figure 10-15. Alarm Status (Log) Screen with Alarm Alert Message

Note: This notification box does not display when latched alarms are not cleared.

You can check which dynamic, latched, alarm/alert is set by using the Alarm Status screens. Nine screens are available. Figure 10-15 is an example of the first screen displayed. To display this screen, select **3. ALARM STATUS** from the Other Status Menu screen.

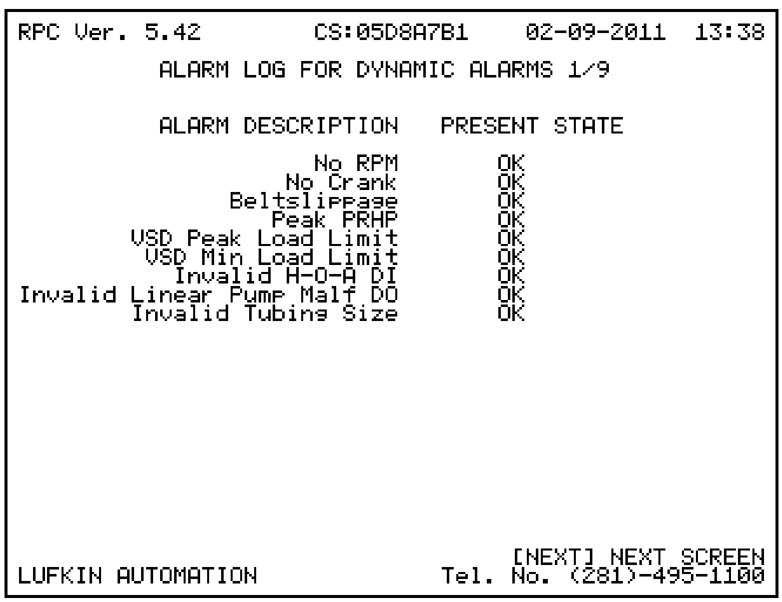


Figure 10-16. First Alarm Status Screen Displayed

Press **<NEXT>** to scroll through the Alarm Status screens.

Note: Dynamic alarm and/or alert conditions can be cleared at any time using the Clear Alarms option (**MENU: 9**). For information about this feature, see section, 16, “Alarm Clearing.”

10.6 Coil Tracking Status

MENU 7/3

You can view the number of times that the Lufkin Well Manager RPC went into a particular alarm condition and the total time that an alarm was active for the day since gauge-off time (GOT). These alarm flags are referred to as “coils.” You can display this information on a Coil Tracking Status screen similar to Figure 10-17. To display this screen, select **4. COIL TRACKING STATUS** from the Other Status Menu screen.

Note: You can view the coil tracking data displayed in a table and plotted for the amount of time each day for the previous 60 days. For information about this historical data, see “60 Day Alarm Tracking” in section 11, “Historical Data.”

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:40

             COIL TRACKING STATUS

    INDEX    COIL #    TIME ACTIVE    # Occurences
      1      00000      000:00:00        00000
      2      00000      000:00:00        00000
      3      00000      000:00:00        00000
      4      00000      000:00:00        00000
      5      00000      000:00:00        00000
      6      00000      000:00:00        00000
      7      00000      000:00:00        00000
      8      00000      000:00:00        00000
      9      00000      000:00:00        00000
     10      00000      000:00:00        00000
     11      00000      000:00:00        00000
     12      00000      000:00:00        00000
     13      00000      000:00:00        00000
     14      00000      000:00:00        00000
     15      00000      000:00:00        00000
     16      00000      000:00:00        00000
          TRACKING FUNCTIONALITY: NORMAL
                TRACKING ENABLED: DISABLE
LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 10-17. Coil Tracking Status Screen

Data Field Descriptions

Information about each data field is provided below.

INDEX

A reference to show which coil is configured.

COIL #

States the number in the RPC register map configured to be monitored. Contact your Lufkin Automation representative to obtain the latest register map.

TIME ACTIVE

Displays the total amount of time the alarm has been active since GOT.

 # Occurrences

States how many times the particular alarm condition has occurred since GOT or the last time it was reset.

TRACKING FUNCTIONALITY

States how multiple coils occurring simultaneously are monitored. Choices are:

- Normal
- First Occurrence
- Cascading

TRACKING ENABLED

States whether the coil tracking function is enabled or disabled. For information about enabling/disabling tracking, see “Configuring Alarm (Coil) Tracking” in section 9, “Lufkin Parameter Programming.”

10.7 Register Functions Status

MENU
7/4

The Lufkin Well Manager RPC has status screens that can display the address and current value for any configured register alarm and the status values obtained from register calculations. Screens for displaying this data are available through the Register Functions Status Menu screen (Figure 10-18). To display this menu, select **4. REGISTER FUNCTIONS STATUS** from the Other Status Menu screen.

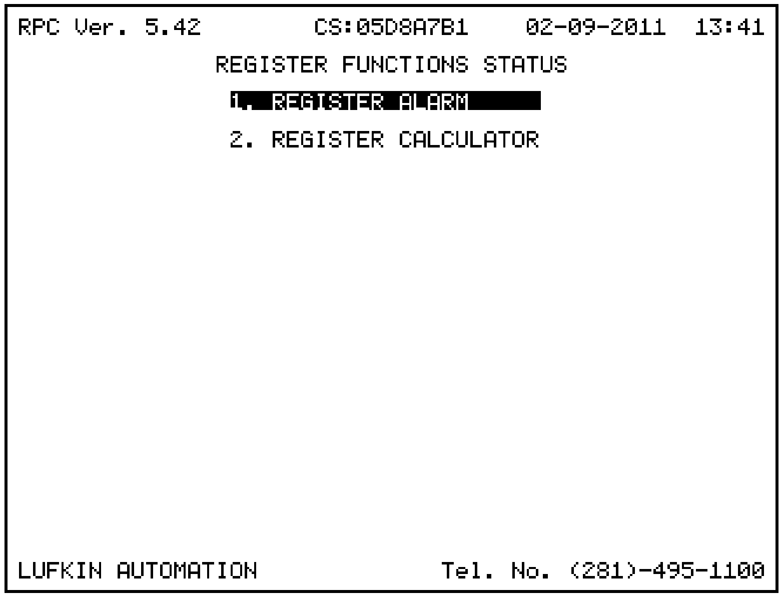


Figure 10-18. Register Functions Status Menu Screen

10.7.1 Register Digital Output Status

MENU 7/4/1

The Lufkin Well Manager RPC has a register alarm feature that can be programmed for actions based on any of the measured or calculated values entered in the controller memory files. You can display a Register Digital Output Status screen similar to Figure 10-19 that shows the address and current value for each register alarm programmed. To display this screen, select **1. REGISTER ALARM** from the Register Functions Status Menu screen.

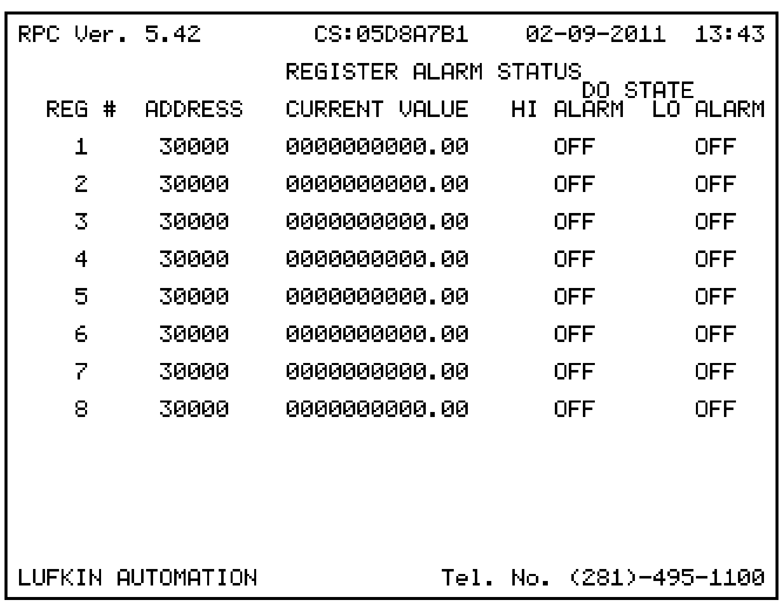


Figure 10-19. Register Digital Output Status Screen

Data Field Descriptions

Information about each data field is provided below.

REG #

States the index of the register alarm described on that line.

ADDRESS

States the Modbus register address being monitored by the register alarm on that line.

CURRENT VALUE

States the value of the Modbus register being monitored by the register alarm on that line.

10.7.2 Register Calculations Status

MENU 7/4/2

You can combine status values from different registers to obtain new values that can be used for monitoring and creating register alarms. You can display the calculated results in a Programmable Calculations Status screen similar to Figure 10-20. To display this screen, select **2. REGISTER CALCULATOR** from the Register Functions Status Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:44
               PROGRAMMABLE CALCULATIONS
 1. NOT CONFIGURED   + NOT CONFIGURED    = 00000.0000
    00000.0000         00000.0000
 2. NOT CONFIGURED   + NOT CONFIGURED    = 00000.0000
    00000.0000         00000.0000
 3. NOT CONFIGURED   + NOT CONFIGURED    = 00000.0000
    00000.0000         00000.0000
 4. NOT CONFIGURED   + NOT CONFIGURED    = 00000.0000
    00000.0000         00000.0000
 5. NOT CONFIGURED   + NOT CONFIGURED    = 00000.0000
    00000.0000         00000.0000
 6. NOT CONFIGURED   + NOT CONFIGURED    = 00000.0000
    00000.0000         00000.0000
 7. NOT CONFIGURED   + NOT CONFIGURED    = 00000.0000
    00000.0000         00000.0000
 8. NOT CONFIGURED   + NOT CONFIGURED    = 00000.0000
    00000.0000         00000.0000
                                    [NEXT]-NEXT PAGE
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 10-20. Programmable Calculations Status Screen

For information about configuring register calculations, see “Configuring Register Calculations” in section 9, “Lufkin Parameter Programming.”

10.8 Modbus Master Slave Device Status

MENU 7/5

At any time you can retrieve and display the register addresses and register values for a Modbus slave device configured to a Modbus master in the data network. This information is displayed in a Modbus Master Status Menu screen (Figure 10-21). To display this screen, select **5. MODBUS MASTER STATUS** from the Other Status Menu screen.

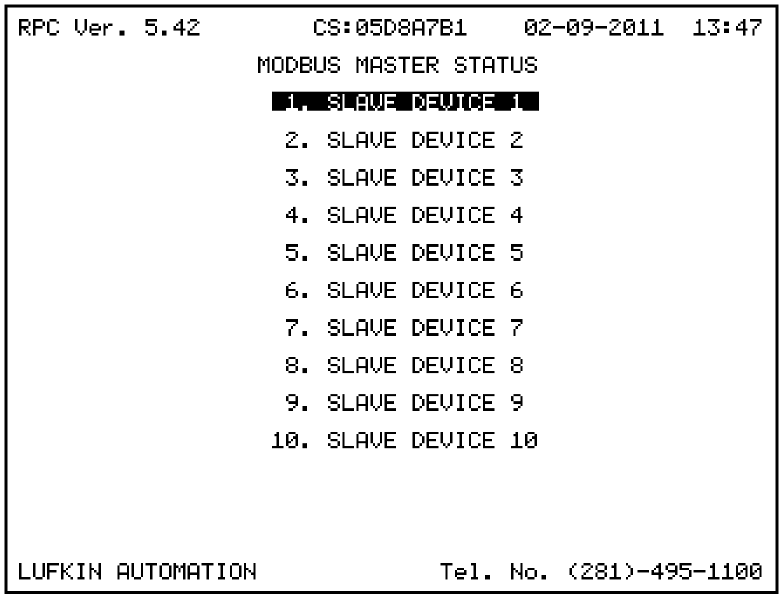


Figure 10-21. Modbus Master Status Menu Screen

Highlight the slave device you want displayed and then press **<ENTER>**. A register address and register value status screen similar to Figure 10-22 appears for a Modbus slave device. You can press **<NEXT>** to view the next status screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:48
                     DEVICE    1
                Master Register Values
 Register Index   Register Address   Register Value

        1              00000              00000
        2              00000              00000
        3              00000              00000
        4              00000              00000
        5              00000              00000
        6              00000              00000
        7              00000              00000
        8              00000              00000
        9              00000              00000
       10              00000              00000
       11              00000              00000
       12              00000              00000
       13              00000              00000
       14              00000              00000
       15              00000              00000
       16              00000              00000
       17              00000              00000
       18              00000              00000
       19              00000              00000
       20              00000              00000

                                    [NEXT] - NEXT PAGE
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 10-22. Typical Status Screen for a Modbus Slave Device Showing Its Register Addresses and Values

10.9 Special App Status

MENU 7/6

The Lufkin Well Manager RPC firmware architecture makes provision to provide special features for some customers and applications. A special firmware version is compiled for these situations. With standard RPC firmware, this status screen is not available.

10.10 VFD Comm Diagnostics

MENU 7/7

The VFD COMM Diagnostics Menu screen offered by option **7. VFD COMM DIAGNOSTICS** on the Other Status Menu screen is for use with the Lufkin integrated VSD system and not supported when the Lufkin Well Manager RPC is used with a generic variable speed drive. For information about the integrated VSD system available from Lufkin Automation, contact your Lufkin Automation representative.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  13:50
                    VFD COMM DIAGNOSTICS
             1. VSD PARAMETER STATUS
             2. VSD/LWM PARAMETER COMPARE
             3. VSD TRIP LOG

LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 10-23. VFD COMM Diagnostics Status Screen

10.11 PIP Status

MENU 7/8

Pump intake pressure (PIP) is the pressure at the pump intake that causes fluid to enter the pump barrel during the upstroke when the standing valve is open. The Lufkin Well Manager RPC calculates PIP each stroke. The formula for PIP in terms of fluid load, area of the pump, and foot of the tubing pressure (or hydrostatic pressure) is:

$$P_i = P_a - \frac{F_o}{A_p}$$

The Pump Intake Pressure (PIP) Status screen (Figure 10-24) displays the current PIP calculations. To display this screen, select **8. PIP STATUS** from the Other Status Menu screen.

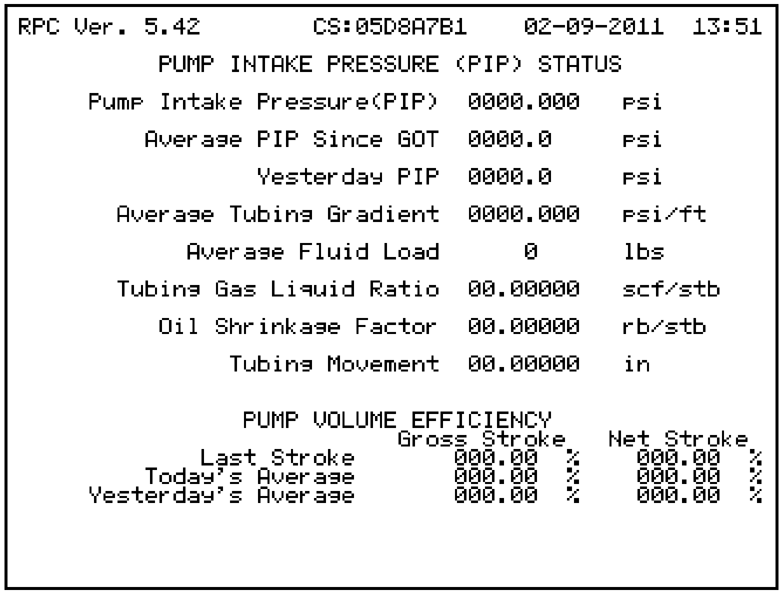


Figure 10-24. Pump Intake Pressure (PIP) Status Screen

For more details about PIP and PIP theory, see “appendix E, “Pump Intake Pressure and Lufkin Well Test Theory.”

Data Field Descriptions

Information about each data field is provided below.

Pump Intake Pressure (PIP)

Displays the PIP value of the latest 100-stroke sampling period.

You can reinitialize PIP at any time to obtain an updated current value using the Reinitialize PIP function available in the second LWT/PIP Parameters screen (**MENU: 2/1/3**). For more information about reinitializing PIP and about configuring PIP parameters, see “Configuring LWT/PIP Parameters” in section 8, “RPC Parameter Programming.”

Average PIP since GOT

The calculated PIP is updated at the end of each 100-stroke sample period. This value is the average of those calculated values since the most recent gauge off time (GOT).

Yesterday PIP

Displays the average of all PIP calculations from the previous 24-hour period before GOT.

Average Tubing Gradient

Displays the average tubing gradient in psi/ft. This value is determined by calculating a gas liquid ratio for the tubing liquid and then using flowing gradient curves to determine the gradient of the fluid in the tubing. This value is updated at the end of each 100-stroke sampling period.

Average Fluid Load

Displays the average of all the fluid loads that were measured from the previous 24-hour period before GOT. The value can be found by resolving the given pump intake pressure equation or by:

Fluid load = Traveling Valve Load – Standing Valve Load – Residual Friction

Tubing Gas Liquid Ratio

Displays a calculated gas/liquid ratio using flowing gradient curves. The formula is:

$$GLR = \frac{SolutionGOR \cdot (STBOPD) + FreeGas}{STBFPD}$$

This value is updated at the end of each 100-stroke sampling period

Oil Shrinkage Factor

Displays the amount the oil will gain in volume from the standard pressure and temperature to given temperature and pressure. This value is updated at the end of each 100-stroke sampling period.

Tubing Movement

Displays the amount that the unanchored portion of the tubing string will stretch given the load that the fluid column exerts. The formula is:

$$Stretch = \frac{Unanchored\ Tubing\ Length \cdot Fluid\ Load}{Young's\ Modulus \cdot Cross\ Sectional\ Area}$$

This number is updated at the bottom of each stroke.

Pump Vol Eff Net Stroke

The volumetric efficiency E_v of the pump is given by the formula:

$$E_v = \frac{STBOPD \cdot ShrinkageFactor + STBWPD}{\left(Adjusted\ Gross\ Stroke - TubingMovement\right) \cdot (.1166 * PumpDiam\hat{}2 * SPM)} \cdot 100\%$$

Pump Vol Eff Gross Stroke

The mechanical efficiency E_m of the pump is given by the formula:

$$E_m = \frac{STBOPD \cdot ShrinkageFactor + STBWPD - Leakage}{NetStroke \cdot (.1166 * PumpDiam^2 * SPM)} \cdot 100\%$$

This number is updated at the bottom of each stroke.

Section 11

Historical Data

The Lufkin Well Manager RPC maintains historical data in various formats to provide useful information about RPC production and performance.

The topics covered in this section include:

11.1 Overview of the Historical Data Features

MENU 3

The Lufkin Well Manager RPC saves in 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.

All historical data is accessed from the Historical Data Menu screen (Figure 11-1). To display this screen, select **3. HISTORICAL DATA** from the Main Menu screen.

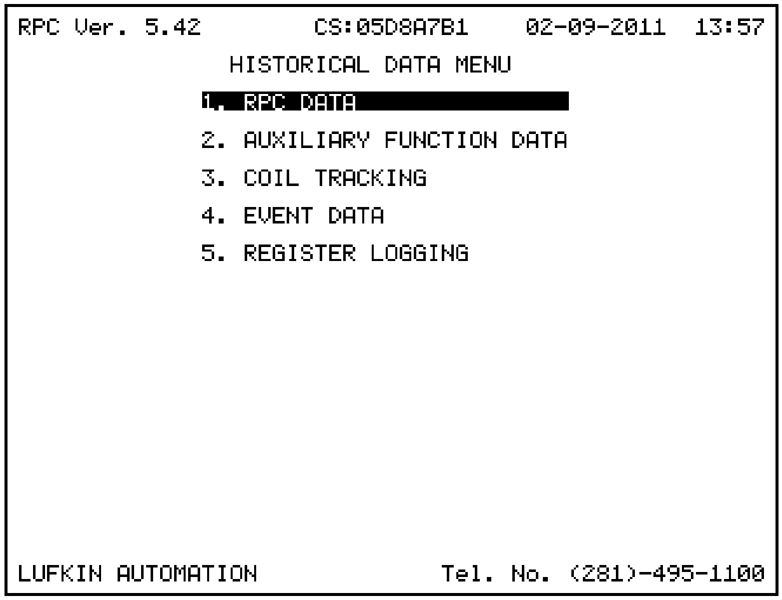
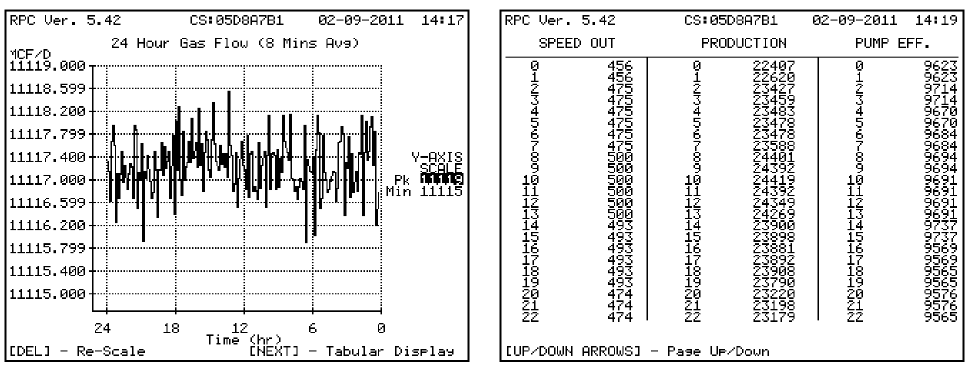


Figure 11-1. Historical Data Menu Screen

Most historical data is displayed as a graphical plot while other data is only displayed in a table. Some data types can be displayed in both formats (see Figure 11-2 for examples). You can press **<NEXT>** to toggle between the formats for any screens that display **NEXT** at the bottom of them.



SPEED OUT		PRODUCTION		PUMP EFF.	
0	456	0	22407	0	9623
1	456	1	22620	1	9623
2	475	2	23427	2	9714
3	475	3	23459	3	9714
4	475	4	23483	4	9670
5	475	5	23478	5	9670
6	475	6	23478	6	9684
7	475	7	23588	7	9684
8	500	8	24401	8	9694
9	500	9	24392	9	9694
10	500	10	24419	10	9691
11	500	11	24392	11	9691
12	500	12	24349	12	9691
13	500	13	24269	13	9691
14	493	14	23900	14	9737
15	493	15	23898	15	9737
16	493	16	23881	16	9569
17	493	17	23892	17	9569
18	493	18	23908	18	9565
19	493	19	23790	19	9565
20	474	20	23220	20	9576
21	474	21	23198	21	9576
22	474	22	23179	22	9565

Figure 11-2. Historical Data Displayed as a Graphical Plot and Table on Separate Screens

11.2 RPC Historical Data

MENU 3/1

The RPC Historical Menu screen (Figure 11-3) has options that display RPC activity, such as runtime, downtime, VFD speed, and valve check analysis data. To display this menu, select **1. RPC DATA** from the Historical Data Menu screen.

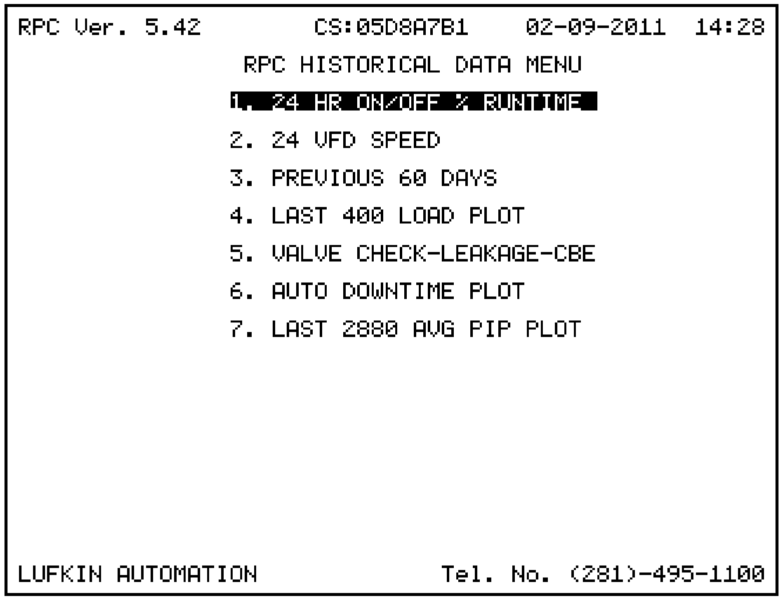


Figure 11-3. RPC Historical Data Menu Screen

11.2.1 24-Hour On/Off Percent Runtime

MENU 3/1/1

This plot displays a record of the runtime activity for the pervious 24 hours. The Lufkin Well Manager RPC 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 right of the plot) is the present time. Time numbers increase as you read to the left 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.

11.2.2 24-Hour VFD Speed

MENU 3/1/2

This plot displays the VFD speed for the previous 24 hours. The Lufkin Well Manager RPC takes one sample point each minute (1440) 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 right of the plot) is the present time. Time numbers increase as you read to the left going back in time.

11.2.3 Previous 60 Days

MENU 3/1/3

This option displays the Previous 60 Day History Menu screen, which has several options available for displaying historical data for the previous 60 days. For information about this menu, see "60-Day Historical Data" on page 11-6.

11.2.4 Last 400 Load Plot

MENU 3/1/4

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 Lufkin Well Manager RPC 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.

11.2.5 Valve Check-CBE-Leakage

MENU 3/1/5

This option displays the RPC Valve Check Menu screen which has options for you to use to record SV, TV, RF, and CBE data and to analyze the recorded results. For information about this menu, see appendix B, "Valve Checks, Counter Balance Effect, and Residual Friction."

11.2.6 Auto Downtime Plot

MENU 3/1/6

This plot displays the downtime-runtime (D/T-R/T) “buildup” curve. For an explanation about the auto downtime feature, see appendix A, “Auto Downtime Feature.”

11.2.7 Last 2880 Average PIP Plot

MENU 3/1/7

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. Press **<NEXT>** to toggle between the two data display formats.

11.3 60-Day Historical Data

MENU 3/1/3

The Previous 60 Day History Menu screen (Figure 11-4) has options to plot historical data for runtime, volume production, peak and minimum load, and PIP for the previous 60 days. The daily values are updated each day at gauge off time (GOT). Day 1 is the most-recent day shown, which is yesterday. After 60 days, data from the oldest day is deleted from memory and replaced with data from the newest day. To display this menu, select **3. PREVIOUS 60 DAYS** the RPC Historical Data Menu screen.

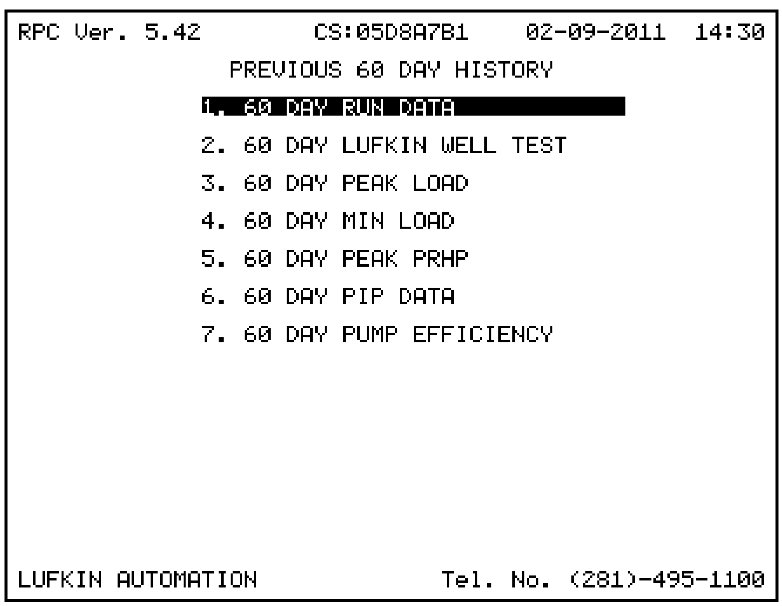


Figure 11-4. Previous 60 Day History Menu Screen

11.3.1 60-Day Run Data

MENU 3/1/3/1

This table shows the run time for each of the previous 60 days in percent. The tabular data is presented in two columns with Day 1, the most recent, being the upper left value, Day 2, the value just to the right of Day 1, Day 3 being the value just below Day 1, etc. Press <**NEXT**> to toggle between the most recent 30 days and the oldest 30 days.

11.3.2 60-Day Lufkin Well Test

MENU 3/1/3/2

This table shows the calculated production volume calculated for the previous 60 days using the Lufkin Well Test (LWT) algorithm. For information about LWT, see appendix E, "Pump Intake Pressure and Lufkin Well Test Theory."

11.3.3 60-Day Peak Load

MENU 3/1/3/3

The highest value for the peak load recorded for each of the previous 60 days.

11.3.4 60-Day Min Load

MENU 3/1/3/4

The lowest value for minimum load recorded for each of the previous 60 days.

11.3.5 60-Day Peak PRHP

MENU 3/1/3/5

The highest value for the polished rod horse power (PRHP) recorded for each of the previous 60 days.

11.3.6 60-Day PIP Data

MENU 3/1/3/6

The Previous 60 Day PIP History Menu screen (Figure 11-5) has options that display the peak and minimum values for pump intake pressure (PIP) and the daily average PIP for each of the previous 60 days. To display this menu, select **6. 60 DAY PIP DATA** from the Previous 60 Day History Menu screen.

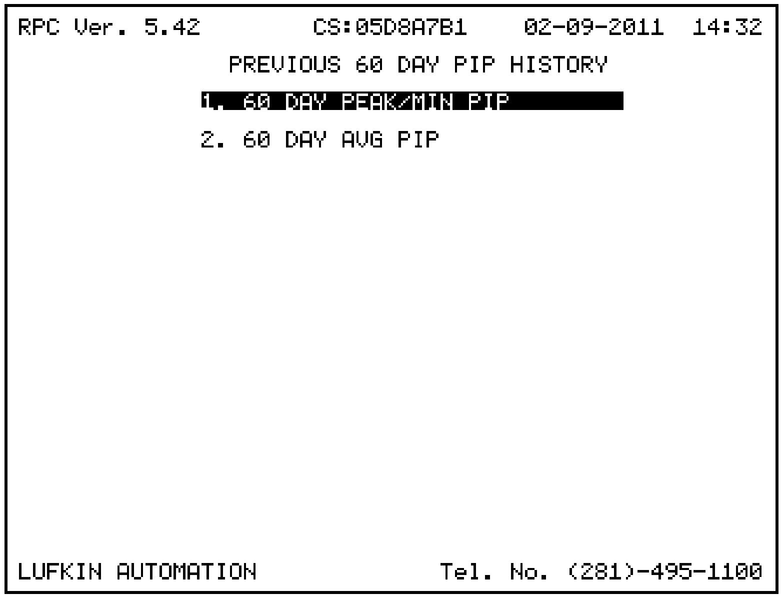


Figure 11-5. Previous 60 Day PIP History Menu Screen

11.3.7 60 Day Peak and Minimum PIP

MENU 3/1/3/6/1

This data represents the peak and minimum values for PIP for each of the previous 60 days. It can be displayed as a plot or table. Press **<NEXT>** to toggle between both data display formats. For information about PIP, see appendix E, “Pump Intake Pressure and Lufkin Well Test Theory.”

11.3.8 60 Day Average PIP

MENU 3/1/3/6/2

This table shows the average PIP value for each of the previous 60 days.

You can press **<DELETE>** to rescale the axis so that you can view small variances easily by editing the **Y-AXIS SCALE** field.

11.3.9 60-Day Pump Efficiency

MENU 3/1/3/7

The Lufkin Well Manager RPC calculates a gross pump efficiency and a net pump efficiency for each day of operation. The Previous 60 Day Pump Efficiency History Menu screen (Figure 11-6) has options to display their calculated results. To display this menu, select **7. 60 DAY PUMP EFFICIENCY** from the Previous 60 Day History Menu screen.

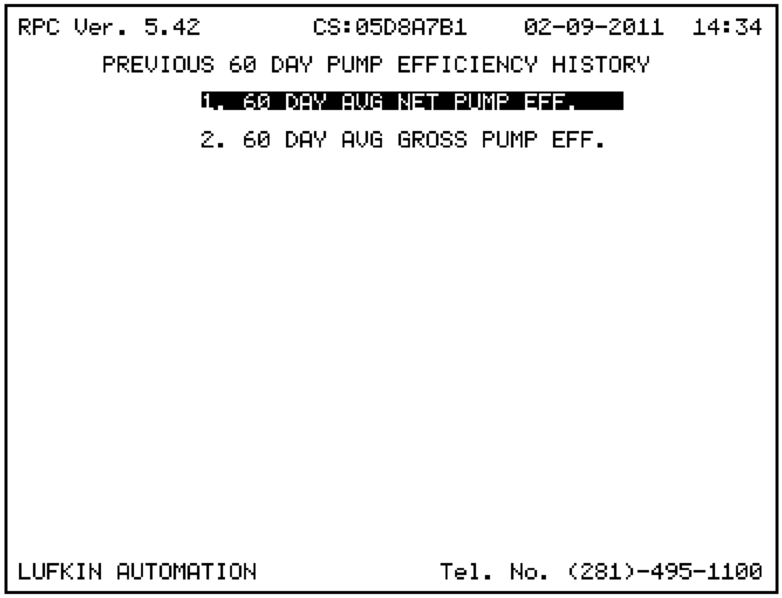


Figure 11-6. Previous 60 Day Pump Efficiency History Menu

11.3.10 60 Day Average Net Pump Efficiency

MENU 3/1/3/7/1

This data represents the average pumping efficiency of the pumping unit for each of the previous 60 days. The net efficiency number is LWT results as a percentage of LWT results plus pump leakage. A low net efficiency number indicates significant pump leakage. For information about the Lufkin Well Test (LWT) algorithm, see appendix E, “Pump Intake Pressure and Lufkin Well Test Theory.”

This data can be displayed as a plot or table. Press **<NEXT>** to toggle between the two data display formats.

11.3.11 60 Day Average Gross Pump Efficiency

MENU 3/1/3/7/2

The gross efficiency number is the Lufkin Well Test results as a percent of theoretical volume from gross downhole pump stroke. This number will reflect when the pump is not operating with complete pump fillage.

This data can be displayed as a plot or table. Press **<NEXT>** to toggle between the two data display formats.

11.4 Last 400 Loads

MENU 3/1/4

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 Lufkin Well Manager RPC shutdown decision due to a peak or minimum load violation. The dynagraph card record might not capture those types of events 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.

11.5 RPC Valve Checks

MENU 3/1/5

The Lufkin Well Manager RPC can store up to 1,200 load and position samples versus time. These samples are stored as records that you can analyze to measure traveling valve (TV) and standing valve (SV) loads, residual friction (RF), and counterbalance effect (CBE). At any time you can gather and replace the sampled data with a new sample.

The options for recording and analyzing this data are available under the RPC Valve Check Menu screen (Figure 11-7). To display this menu, select **5. VALVE CHECK** from the RPC Historical Menu screen.

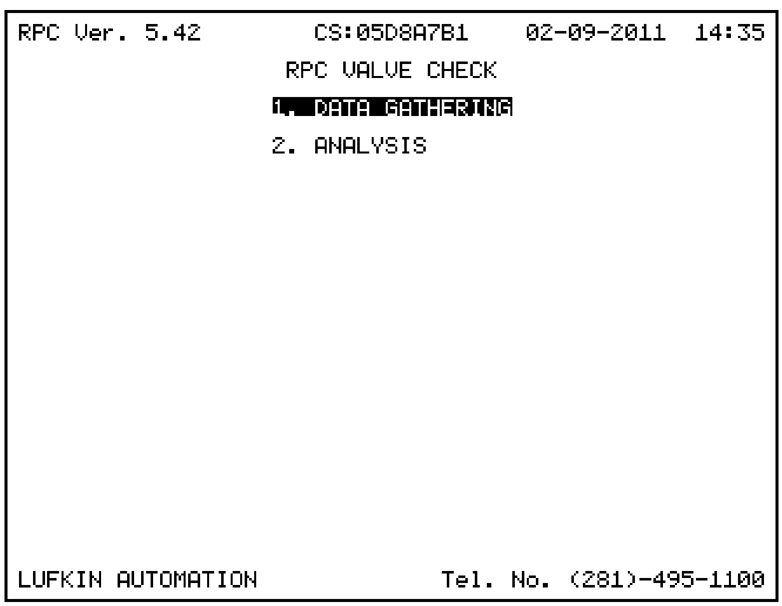


Figure 11-7. RPC Valve Check Menu Screen

Note: The procedures for recording and analyzing these values are lengthy and therefore not described here. Instead, only brief descriptions about each option are provided below. For information about valve checks and how to record and store them, see appendix B, "Valve Checks, Counter Balance Effect, and Residual Friction."

11.5.1 Valve Check Data Gathering

MENU 3/1/5/1

Use this option to start the valve check recording process. For instructions about using this feature, see appendix B, "Valve Checks, Counter Balance Effect, and Residual Friction."

11.5.2 Valve Check Analysis

MENU 3/1/5/2

Use this option to analyze the standing valve, traveling valve, counterbalance effect, and residual friction data previously gathered. Preparing the data for analysis involves the following steps:

1. Marking standing valve, traveling valve, residual friction, and counter balance effect load
2. Calculating traveling valve leakage
3. Saving the analysis as reference data
4. Returning to normal operation

For instructions about preparing the data for analysis, see appendix B, "Valve Checks, Counter Balance Effect, and Residual Friction."

11.6 Auxiliary Functions Data

MENU 3/2

The Lufkin Well Manager RPC maintains records for configured auxiliary inputs and for the results of configured AGA calculations. Data is available for the current 24-hour period and for the past 60 days. This data is accessible through options available under Auxiliary Functions History Menu screen (Figure 11-8). To display this menu, select **2. AUXILIARY FUNCTION DATA** from the Historical Data Menu screen.

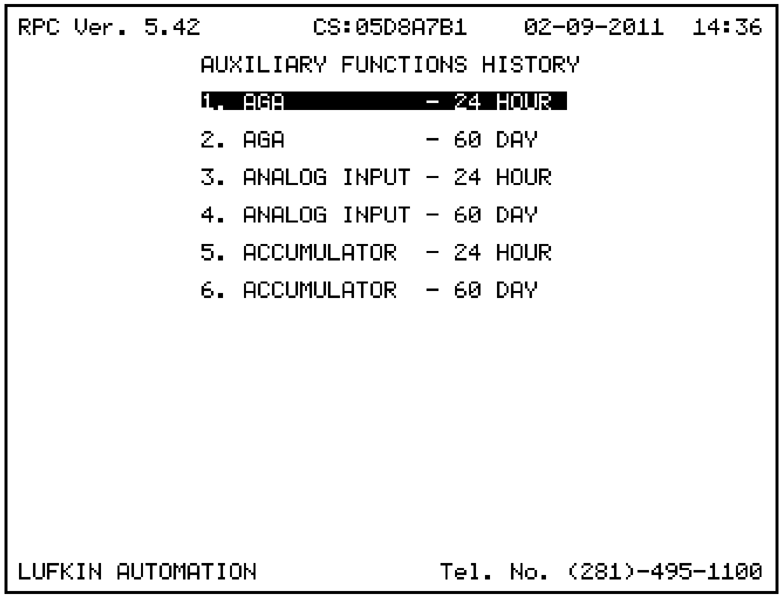


Figure 11-8. Auxiliary Functions History Menu Screen

Note: A day in the Lufkin Well Manager RPC is defined by the programmed gauge off time (GOT — **MENU: 3/2/6**).

11.6.1 24-Hour AGA-3 Gas Flow

MENU 3/2/1

Data for AGA-3 gas flow rate in MCF/Day is collected over the previous 24-hour period and can be displayed as a graphical plot and in a table. This data consists of 180 values that are an average value for an eight-minute interval. Figure 11-9 is an example. To display this screen, select **1. AGA — 24 HOUR** from the Auxiliary Functions History Menu screen.

Note: This plot will not display when the AGA-3 calculation function is disabled. For information about enabling it, see “Enabling and Disabling AGA-3 Calculations” in section 9, “Lufkin Parameter Programming.”

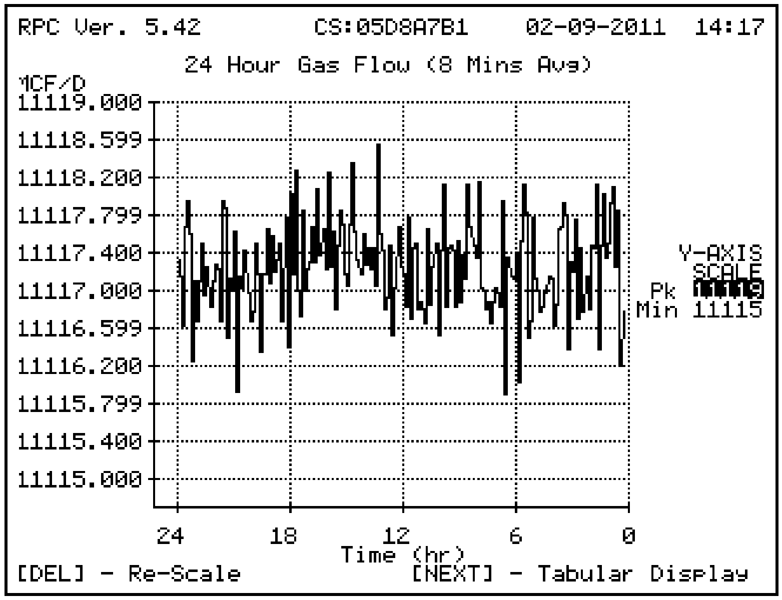


Figure 11-9. 24 Hour AGA-3 Gas Flow Plot

Plot Rescaling

The Y-axis is automatically scaled to fit in the minimum and maximum values for the 24-hour period. This axis can be rescaled so that you can view small variances easily by editing the **Y-AXIS SCALE** field. This field is located along the right edge of the display screen. To change the rescaling, highlight the **Pk** or **Min** field, press **<EDIT>**, use the number keys to enter a new value, and then press **<ENTER>**. To return to the original scaling, press **<DEL>**.

11.6.2 60-Day AGA-3 Gas Flow

MENU 3/2/2

The last 60-day totals for the calculated gas flow volume in MCF/Day can be displayed as a graphical plot and displayed as a table. To display this screen, select **2. AGA — 60 DAY** from the Auxiliary Functions History Menu screen.

Note: This plot will not display when the AGA-3 calculation function is disabled. For information about enabling it, see “Enabling and Disabling AGA-3 Calculations” in section 9, “Lufkin Parameter Programming.”

Plot Rescaling

The Y-axis is automatically scaled to fit in the minimum and maximum values for the previous 60 days. This axis can be rescaled so that you can view small variances easily by editing the **Y-AXIS SCALE** field. This field is located along the right edge of the display screen.

To change the rescaling, highlight the **Pk** or **Min** field, press **<EDIT>**, use the number keys to enter a new value, and then press **<ENTER>**. To return to the original scaling, press **<DEL>**.

11.6.3 24-Hour Analog Input

MENU 3/2/3

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. Figure 11-9 is an example. To display this screen, select **3. ANALOG INPUT — 24 HOUR** from the Auxiliary Functions History Menu screen.

11.6.4 60-Day Analog Input

MENU 3/2/4

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. To display this screen, select **4. ANALOG INPUT — 60 DAY** from the Auxiliary Functions History Menu screen.

11.6.5 24-Hour Accumulator

MENU 3/2/5

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 as either a graphical plot or as a table. To display this screen, select **5. ACCUMULATOR — 24 HOUR** from the Auxiliary Functions History Menu screen.

11.6.6 60-Day Accumulator

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 as either a graphical plot or as a table. To display this screen, select **6. ACCUMULATOR — 60 DAY** from the Auxiliary Functions History Menu screen.

11.7 Coil Tracking

MENU 3/3

This 60-day historical data is the amount of time each day that the Lufkin Well Manager RPC was in a particular alarm condition. This data can be displayed as a plot or table.

Alarm flags are referred to as "coils." Alarm coils are configured using the Coil Tracking option. For information about this option, see "Configuring Alarm (Coil) Tracking" in section 9, "Lufkin Parameter Programming."

Selecting a Specific Alarm Coil for Display

You can select for display any one of a possible sixteen different alarm coils. Use the procedure described below to display a specific alarm coil.

1. Press **<EDIT>**. The **Coil Track #** field at the top of the plot displays the current coil track number.
2. Press <↑> or <↓> to scroll through coil track numbers.
3. When the coil number displays, press **<ENTER>**.

11.8 Event Data

MENU 3/4

The Event Data Menu screen (Figure 11-10) displays the recorded date and time that significant events relating directly to the RPC control processes occurred, including startups/shutdowns and alarms. To display this menu screen, select **4. EVENT DATA** from the Historical Data Menu screen.

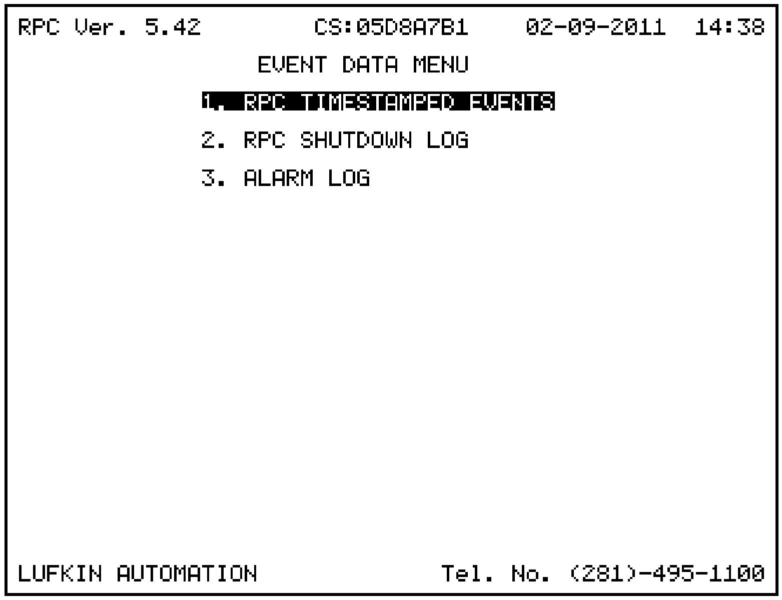


Figure 11-10. Event Data Menu Screen

11.8.1 RPC Timestamped Events

MENU 3/4/1

This log screen displays a list of 22 significant RPC events and a date/time stamp for the last time each event occurred. Figure 11-11 is an example. To display this screen, select **1. RPC TIMESTAMP EVENTS** from the Event Data Menu screen.

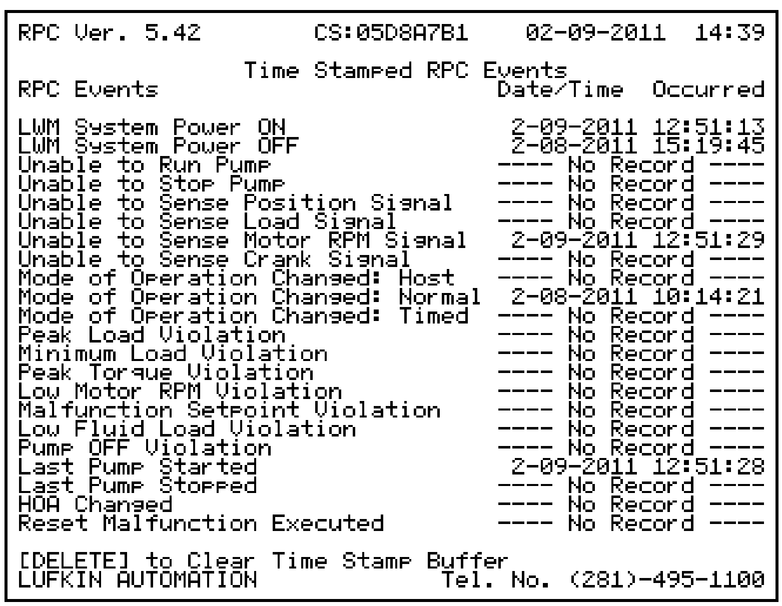


Figure 11-11. RPC Time Stamped RPC Events Log Screen

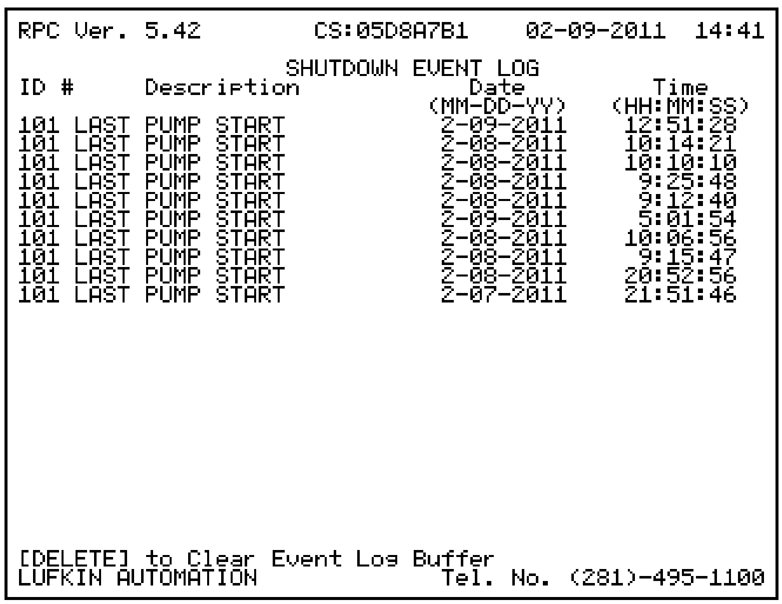
A "No Record" entry in the Date/Time column means that the event has not occurred since the time stamped event buffer was cleared. You can clear the time stamp buffer by pressing <**DELETE**> or by selecting the **RESET TO DEFAULTS** option under the RTU Level menu.

This log is a complement to the maintenance log feature provided in the Diagnostic Menu screen. For more information, see "Event Log" in section 17, "System Diagnostics Tools."

11.8.2 RPC Shutdown Log

MENU 3/4/2

This log screen displays the last 20 times that the Lufkin Well Manager RPC stopped and started the pumping unit with a date/time stamp for each. The reason for the stop or shutdown decision is included. Figure 11-12 is an example. To display this screen, select **2. RPC SHUTDOWN LOG** from the Event Data Menu screen.



```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  14:41
                       SHUTDOWN EVENT LOG
ID #     Description               Date           Time
                                (MM-DD-YY)    (HH:MM:SS)
101 LAST PUMP START              2-09-2011     12:51:28
101 LAST PUMP START              2-08-2011     10:14:21
101 LAST PUMP START              2-08-2011     10:10:10
101 LAST PUMP START              2-08-2011      9:25:48
101 LAST PUMP START              2-08-2011      9:12:40
101 LAST PUMP START              2-09-2011      5:01:54
101 LAST PUMP START              2-08-2011     10:06:56
101 LAST PUMP START              2-08-2011      9:15:47
101 LAST PUMP START              2-08-2011     20:52:56
101 LAST PUMP START              2-07-2011     21:51:46

[DELETE] to Clear Event Log Buffer
LUFKIN AUTOMATION                 Tel. No. (281)-495-1100
```

Figure 11-12. History Shutdown Event Log Screen

11.8.3 Alarm Log

MENU 3/4/3

This log screen can display a maximum of 100 recorded alarm logs with date and time stamps and descriptions of each alarm. Figure 11-13 is an example. To display this screen, select **3. ALARM LOG** from the Event Data Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  14:42
                     ALARM LOG     Total Events:   4
-----------------------------------------------------
   1       2-08-2011    10:14:21
      NO RPM - CLEAR
-----------------------------------------------------
   2       2-08-2011    10:14:21
      DRIVE COMM ERROR - CLEAR
-----------------------------------------------------
   3       2-08-2011    10:10:11
      DRIVE COMM ERROR - SET
-----------------------------------------------------
   4       2-08-2011    10:10:10
      NO RPM - SET
-----------------------------------------------------





[NEXT] NEXT SCREEN                    [DEL]-CLEAR LOG
LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 11-13. History Alarm Log Screen

11.9 Register Log

MENU 3/5

The register log has a buffer with 1440 entries. Because each register log has a varying sample rate based on its particular setting, this buffer can store data for anything from one day (once-a-minute sampling) to 1440 days (once-a-day sampling).

The data displayed is based on parameters specified for the register log in the Register Logging Config screen, such as the category of data (analog input, accumulator, register log, etc.), sample rate, and whether the data is a sample point taken each period or a sample average for the period. For more information about this screen, see “Configuring a Register Log”, in section 9, “Lufkin Parameter Programming.”

Register log data displays in the Register Log screen (Figure 11-14). To display this screen, select **5. REGISTER LOGING** from the Historical Data Menu screen.

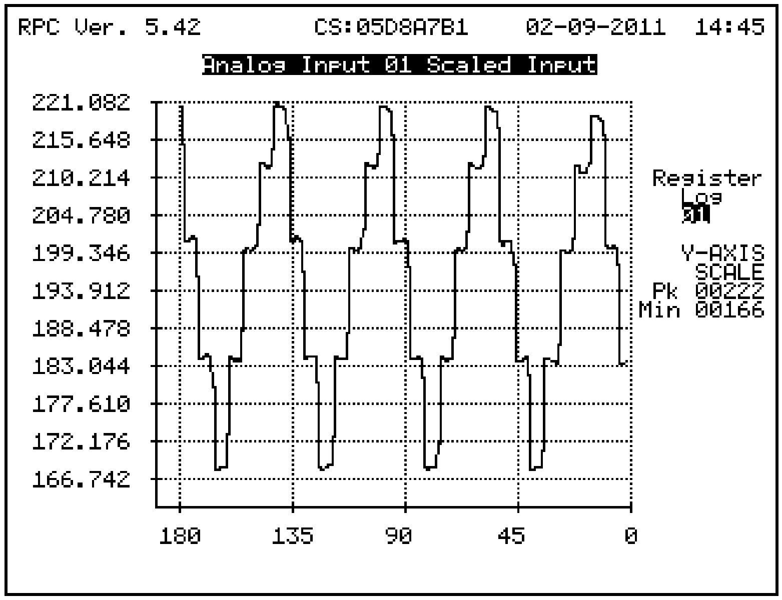


Figure 11-14. Register Log Screen

Selecting a Specific Log for Display

You can select the register log you want plotted. A maximum of 10 logs are available, but the actual number available depends on which register logs were configured with the Register Logging Config screen. The log type displays above the plot. If you select a register log that is not configured, a message displays to inform you that it is not configured.

To select a plot, highlighting the **Register Log** field, press **<EDIT>**, use the number keys to specify the log, and then press **<ENTER>**.

Section 12

Dynagraph Cards

The Lufkin Well Manager RPC stores historical dynagraph cards and also displays a live real-time dynagraph trace.

The topics covered in this section include:

12.1 Overview of Dynagraph Cards

MENU 4

The Lufkin Well Manager RPC stores historical dynagraph cards and also displays a live real-time dynagraph trace. Control parameters related to the dynagraph shape analysis are programmed on dynagraph screens. All card data is available by using the Dynagraph Menu screen (Figure 12-1). To display this screen, select **4. DYNAGRAPHS** from the Main Menu screen.

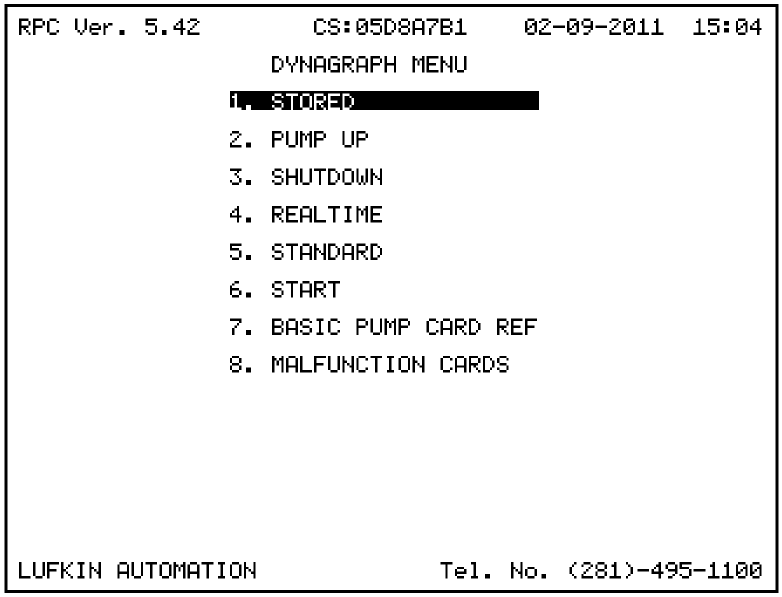


Figure 12-1. Dynagraph Menu

12.2 Dynagraph Card Types

All dynagraph options shown in Figure 12-1 are described below.

12.2.1 Stored

MENU 4/1

This option displays the most-recent five strokes. If the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC is in a downtime or malfunction condition, the stored cards will be duplicates of the Group 1 shutdown cards.

12.2.2 Pump Up

MENU 4/2

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 Lufkin Well Manager RPC goes through a stop/start cycle.

12.2.3 Shutdown

MENU 4/3

The Lufkin Well Manager RPC saves the last five strokes leading up to the last two shutdown decisions. When you select this option, the Shutdown Card Menu screen (Figure 12-2) appears for you to select cards from among two groups.

- Group 1 represents the most recent shutdown
- Group 2 represents the shutdown prior to the most recent

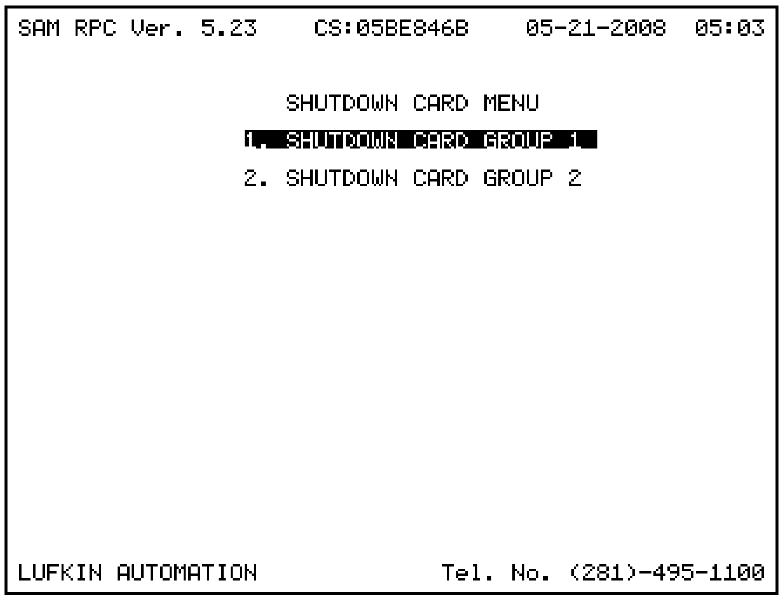


Figure 12-2. Shutdown Card Menu Screen

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.

12.2.4 Realtime

MENU 4/4

The Realtime dynagraph is a live trace of the load and position data obtained by the Lufkin Well Manager RPC. Realtime dynagraph cards can be drawn for surface or downhole activity, or you can display a split screen displaying both card types.

Realtime dynagraphs are the only card types that have programmable data fields you can use to program setpoints for pump off and malfunction limits, and allowed peak and minimum loads. For information about programming these values, see “Control Parameter Programming from Dynagraph Screens” on page 12-6.

12.2.5 Standard

MENU 4/5

The Lufkin Well Manager RPC saves a single card shape that the operator has selected and saved as a standard or reference card shape. To save a Standard card, use the **Savd STD** option available in the **Display Option** field included in all historic dynagraph screens. For more information, see “Historical Dynagraph Cards” on page 12-12.

12.2.6 Start

MENU 4/6

This is a single dynagraph card saved by the Lufkin Well Manager RPC as early in the pumping cycle as possible. This is the dynagraph at the start of minimum pump strokes as opposed to the Pump Up card that is saved at the end of Minimum Pump Strokes.

12.2.7 Basic Pump Card Reference

MENU 4/7

A library of 12 downhole pump card shapes for typical pump conditions are stored in memory and are available on three screens. These cards can be used as a quick analysis tool. Figure 12-3 is an example of the first screen you see when you select this option.

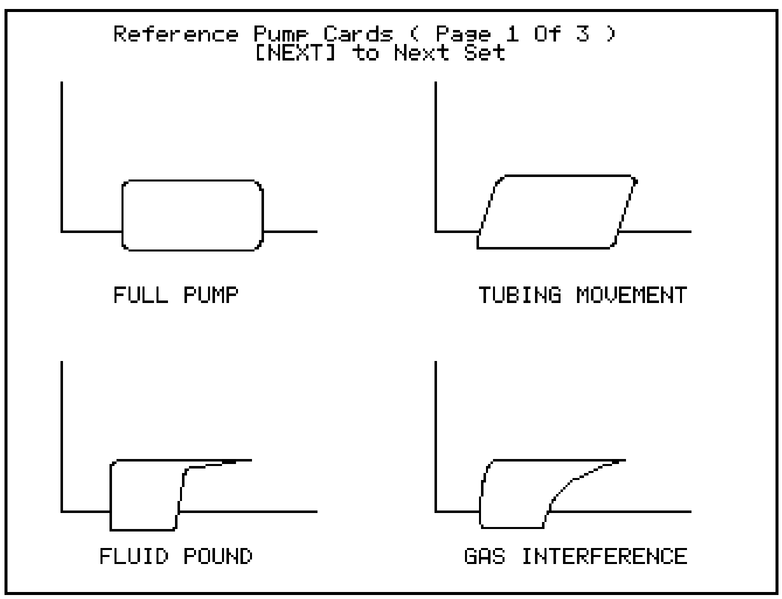


Figure 12-3. Reference Pump Cards Screen (1 of 3)

To scroll through the screens, press **<NEXT>**, and then press **<EXIT>** when you are finished to return to the Dynagraph Menu screen.

12.2.8 Malfunction Cards

MENU 4/8

When a malfunction occurs, the Lufkin Well Manager RPC takes the data obtained during the malfunction and stores it in the malfunction card buffer. The data stored can vary anywhere from complete cards, a partial surface card, or no cards, depending on the malfunction cause.

If the malfunction is based off of a complete card and a downhole card is available, both cards are stored. Figure 12-4 is an example of a complete card.

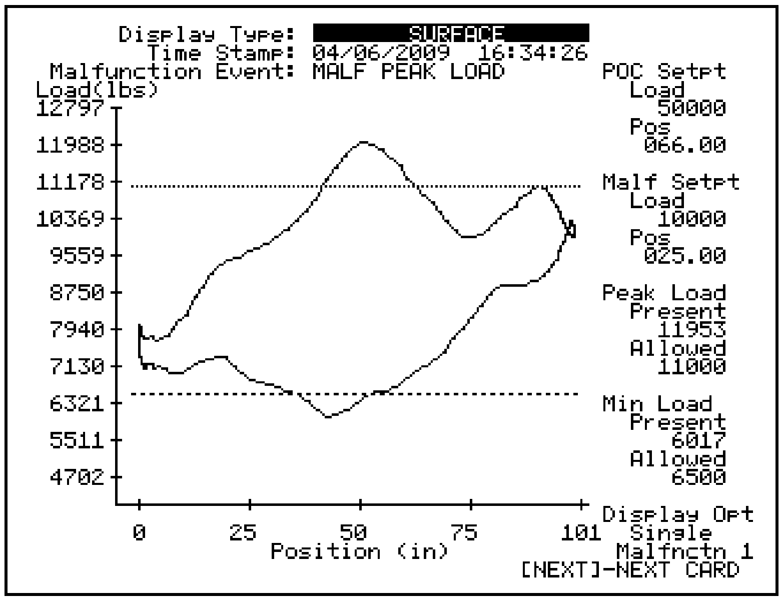


Figure 12-4. Malfunction Dynagraph Card

For other malfunctions, either a partial surface card or no card is stored, depending on the type of malfunction. A partial surface card is stored because the malfunction may be based on an event that happened before the current card was completed. The partial surface card will contain up to a card's worth of data going backward from the malfunction event.

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.

The table below lists the malfunctions and the type of card stored (if one is stored).

Malfunction	Card Type
Malfunction Setpoint	Full Card
Low Fluid Load	Full Card
Peak Load	Partial surface card
Minimum Load	Partial surface card
Low RPM	Partial surface card
Logic Expression	Partial surface card
Peak Torque	Partial surface card
Drive Fault	Partial surface card
No RPM Signal	No Card
No Crank Signal	No Card

The last ten malfunctions are stored. The most-recent malfunction displays when you access this option. Press **<NEXT>** to display the previous malfunction recorded. If the buffer is full, the oldest malfunction is removed when a new malfunction is recorded.

12.3 Control Parameter Programming from Dynagraph Screens

Some of the Lufkin Well Manager RPC controller parameters are programmable only from a dynagraph display. These include the pumpoff limits, either surface setpoint or downhole percent pump fillage, and the surface malfunction setpoint.

Different dynagraph screens offer different fields for data display or control parameter programming. Programming fields can be highlighted by the cursor, whereas the cursor skips over fields that have read-only data. Most of the required programming can be done from a Realtime dynagraph screen. The cursor defaults to the **Display Type** field at the top of the screen when you select the Realtime option.

Display type options are:

- Surface (page 12-7)
- Downhole (page 12-10)
- Surface and Downhole split screen (page 12-13)

Each display type has slightly different fields for programming and data display.

Note: Pressing <**DELETE**> when a Realtime screen is displayed refreshes the screen and allows the Lufkin Well Manager RPC to rescale the dynagraph trace.

12.3.1 Surface Realtime Dynagraph Cards

The Surface Realtime dynagraph screen (Figure 12-5) has two read-only data fields and several programmable parameter fields.

Read-Only Data Field Descriptions

Peak Load — Present

This value is updated at the end of each stroke and is the maximum value for the polished rod load in the stroke just completed.

Minimum Load — Present

This value is updated at the end of each stroke and is the minimum value of the polished rod load in the stroke just completed.

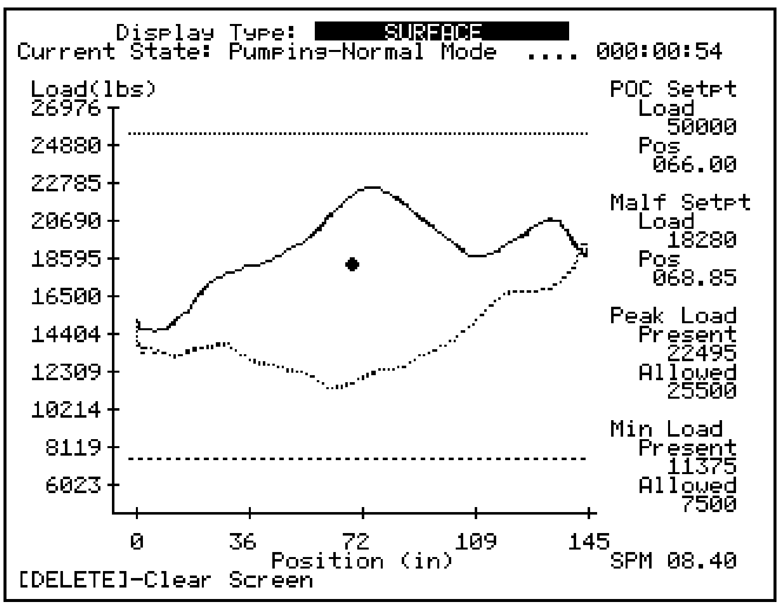


Figure 12-5. Realtime Dynagraph Screen for Surface

Programmable Parameter Field Descriptions

Display Type

This field allows you to select the type of realtime dynagraph displayed. Choices are Surface, Downhole, and Split Screen (displays Surface and Downhole on one screen).

POC Setpoint

This setpoint is the pumpoff "limit" for the Surface control mode. The "*" shown in Figure 12-5 is not shown when the Pumpoff setpoint is disabled. When the load goes above the POC setpoint in the downstroke, the Lufkin Well Manager RPC counts that as a pumpoff stroke. The consecutive number of pumpoff strokes allowed is specified with the RPC Control Parameter programming screen (**MENU: 2/1/1/1**).

To edit the setpoint:

1. Highlight the **POC Setpoint** field with the cursor and press <**EDIT**>. **POC Setpoint** will be placed in brackets indicting that the Lufkin Well Manager RPC is in Edit mode.

2. Use the arrow keys to move the setpoint "*"marker to the desired location and then press <**ENTER**> to complete the programming.

An alternate method for editing the setpoint is to highlight either the **Load** or **Position** field under **POC Setpoint** with the cursor, press <**EDIT**>, use the number keys to enter a new coordinate value, and then press <**ENTER**>. This method allows large coordinate changes to be made quicker than holding down arrow keys. An experienced operator can make initial gross adjustments by editing the coordinate fields directly and then using the arrow keys to fine tune the setpoint location.

Malf Setpoint

This setpoint is used to check for rod parts or other pump malfunctions that cause no fluid load to be picked up by the pump. The small black diamond graphic representation of the setpoint will not be shown if the Malfunction Setpoint control feature is disabled. If the load falls below the Malfunction setpoint in the upstroke, the Lufkin Well Manager RPC counts that as a violation of the setpoint. You can specify the number of consecutive Malfunction Strokes Allowed using the RPC Control Parameter screen (**MENU: 2/1/1/1**).

To edit the setpoint:

1. Highlight the **Malf Setpoint** field with the cursor and press <**EDIT**>. "Malf Setpoint" will be placed in brackets indicting that the Lufkin Well Manager RPC is in the Edit mode.

2. Use the arrow keys to move the setpoint black diamond marker to the desired location and then press <**ENTER**> to complete the programming.

An alternate method for editing the setpoint is to highlight either the **Load** or **Position** field under **Malf Setpoint** with the cursor, press <**EDIT**>, use the number keys to enter a new coordinate value, and then press <**ENTER**>. This method allows large coordinate changes to be made quicker than holding down arrow keys. An experienced operator can make initial gross adjustments by editing the coordinate fields directly and then using the arrow keys to fine tune the setpoint location.

Peak Load Allowed

This value is the maximum allowed value for load input. If the load exceeds this limit, the Lufkin Well Manager RPC instantly shuts down the pumping unit with no consecutive stroke delay.

Min Load Allowed

The lowest allowed value for load input. If the load falls below this value, the Lufkin Well Manager RPC instantly shuts down the pumping unit with no consecutive stroke delay.

Note: The Lufkin Well Manager RPC automatically scales the dynagraph screen to show both Peak and Min Load Allowed. 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, program the Peak and Min Load Allowed to within 15 percent or 25 percent above/below the working loads.

12.3.2 Downhole Realtime Dynagraph Cards

A Downhole Realtime dynagraph screen (Figure 12-6) has several read-only data fields and some programmable parameter fields.

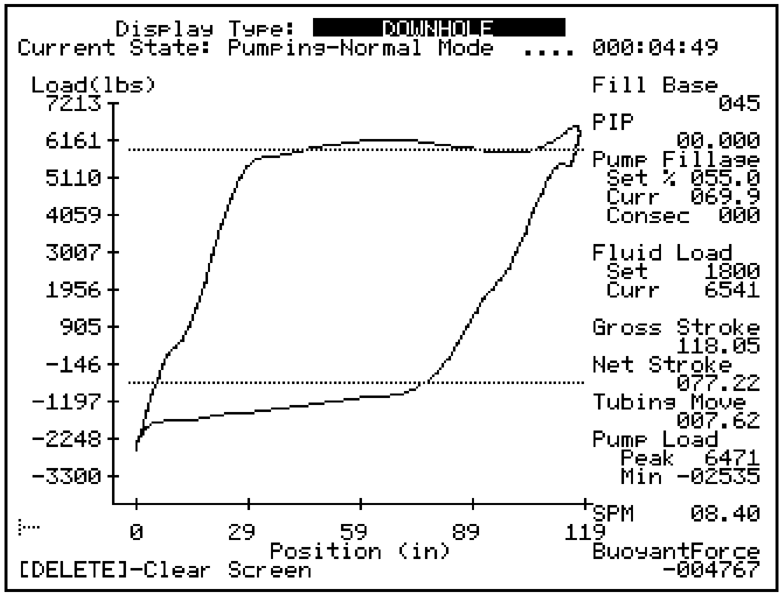


Figure 12-6. Realtime Dynagraph Screen for Downhole with Display Option

Read-Only Data Field Descriptions

Pump Fillage — Current

This 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 pumpoff stroke. You can specify the consecutive number of pump off strokes allowed using the RPC Control Parameter programming screen (**MENU: 2/1/1/1**).

Fluid Load — Current

This value is the difference between the average upstroke load and the average downstroke load of the downhole pump card as calculated by the Lufkin Well Manager RPC. 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 Lufkin Well Manager RPC stops the pumping unit.

Gross Stroke

This value is the maximum possible pump plunger stroke length calculated by the Lufkin Well Manager RPC.

Net Stroke

The Lufkin Well Manager RPC 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.

Pump Load — Pk

This value is the highest value for load in the displayed downhole card.

Pump Load — Min

This value is the lowest value for load in the displayed downhole card.

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.

Programmable Parameter Field Descriptions

Display Type

This field allows you to select the type of realtime dynagraph displayed. Choices are Surface, Downhole, and Split Screen (displays Surface and Downhole on one screen).

Fill Base

This value is the full range load percentage of the downhole card at which the Lufkin Well Manager RPC, 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 Lufkin Well Manager RPC 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.

Pump Fillage — Set %

This value is the pumpoff shutdown level when Downhole Control mode is selected.

Fluid Load — Set

This value is the Low limit for the fluid load control function. See **Fluid Load —Current** above.

12.3.3 Historical Dynagraph Cards

The **Display Opt** field shown in Figure 12-7 is present on any dynagraph screen that displays historical cards with a display type of **Surface** or **Downhole** selected. It is not available for a Realtime dynagraph screen.

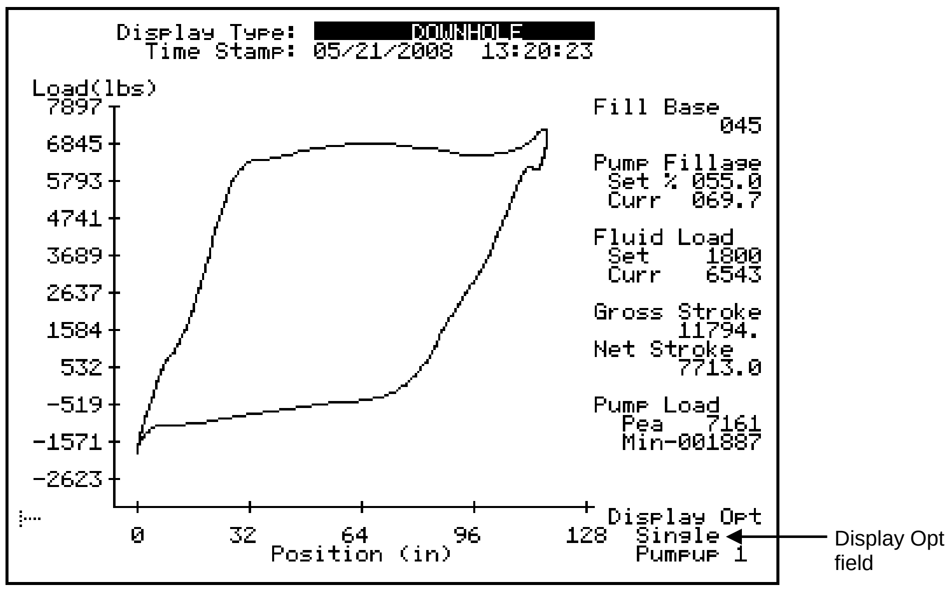


Figure 12-7. Dynagraph Card with Display Opt Field

The display options available include:

- **Single** — For multiple card types of data (Stored and Shutdown), this option displays the cards one at a time. When you press <**ENTER**>, the screen clears and the next card in sequence displays.

- **Overlay** — For multi-card data types, this option lays multiple cards on top of one another. If a single card type of data (Pump Up, Standard, or Start) is selected, the Overlay option is not available.

- **Save Standard** — Select this option to save the card displayed as the Standard card. Only one card can be saved; therefore, if one is already saved, it is overwritten when you use this option.

- **Show Standard** — This option displays the current Standard card, if one was saved. If one is not saved a message briefly appears that reads "Not Available."

12.3.4 Surface and Downhole Realtime Dynagraph Cards

You can display realtime surface and downhole dynagraph card data on the same screen (Figure 12-8). This screen has several read-only data fields and some programmable parameter fields.

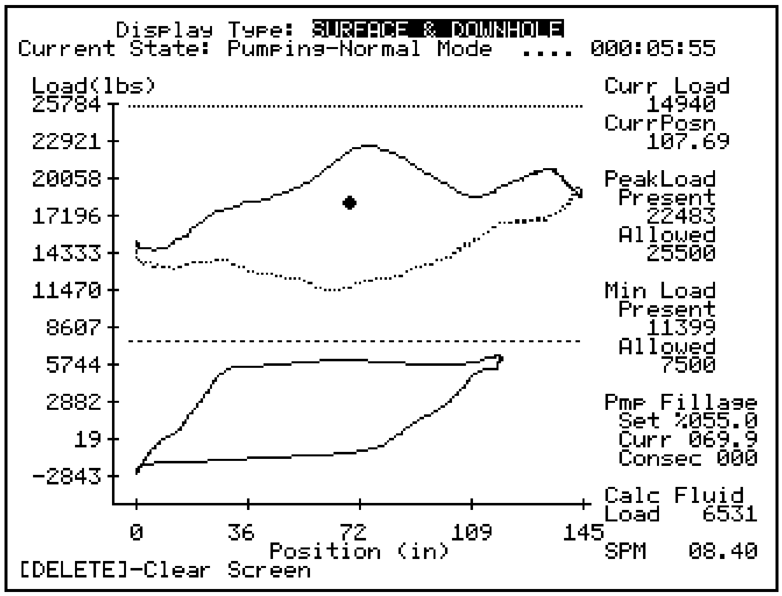


Figure 12-8. Realtime Dynagraph Screen for Surface and Downhole

Read-Only Data Field Descriptions

Current Load

The field displays the dynamic load value. If the load input is working as it should, and the unit is pumping, this value changes so rapidly that it is not of much practical use. However, when the unit is pumping, a static number indicates a problem with the load input signal.

Current Position

The field displays the dynamic position value.

Peak Load — Present

This value is updated at the end of each stroke and was the maximum value for the polished rod load in the stroke just completed.

Minimum Load — Present

This value is updated at the end of each stroke and was the minimum value of the polished rod load in the stroke just completed.

Pump Fillage — Current

This value is updated at the end of each stroke after the Minimum Pump Strokes, and is the calculated percent pump fillage represented by the downhole pump card. When this value falls below the value for **Pump Fillage-Set %**, the stroke is counted as a pumpoff stroke.

Pump Fillage — Consecutive

This value is the number of consecutive strokes that the Lufkin Well Manager RPC has detected a pumpoff condition.

Calculated Fluid Load

This value is updated at the end of each stroke and is the difference between the average upstroke load and the average downstroke load of the downhole pump card for the stroke just completed. The Lufkin Well Manager RPC uses this as the input parameter for the Low Fluid control function.

Programmable Parameter Field Descriptions

Peak Load Allowed

This value is the maximum allowed value for load input. If the load exceeds this limit, the Lufkin Well Manager instantly shuts down the pumping unit with no consecutive stroke delay.

Min Load Allowed

The lowest allowed value for load input. If the load falls below this value, the Lufkin Well Manager instantly shuts down the pumping unit with no consecutive stroke delay.

Pump Fillage — Set %

This value is the pumpoff shutdown level when Downhole Control mode is selected.

Section 13

System Starting and Stopping

MENU
5

The RPC system can be started or stopped at the Lufkin Well Manager RPC using the Start/Stop command available from the Main Menu screen. 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, and if the well is idle, this is a start command.

After you select **5. START/STOP** PUMP from the Main Menu screen, one of the following messages displays for five seconds:

- **MOTOR STOP** appears when the system is operating to notify you that the system is shutting down.

- **MOTOR START** appears when the system is shut down to notify you that the system is starting.

Note: When the system is stopped, the **Current Well State** field in the RPC Status screen reads **DT – Operator Stop**.

Section 14

Reset Malfunctions

MENU
6

When the Lufkin Well Manager RPC is in a malfunction state, the malfunction must be cleared. To reset malfunctions, select **6. RESET MALFUNCTIONS** from the Main Menu screen.

Note: You can also use Reset Malfunctions to reset VSD drive faults and malfunctions.

After you select this command, the malfunctions are reset and the message **Reset Malf Completed** appears.

Section 15

Notepad

MENU 8

The Notepad feature is useful for leaving a note for a relief operator or for referring back to an issue at a later date. Typical notes might include listing the auxiliary device designations configured in the Lufkin Well Manager RPC or noting the date that a new pump was installed (as shown in Figure 15-1). To display Notepad, select **8. NOTEPAD** from the Main Menu screen.

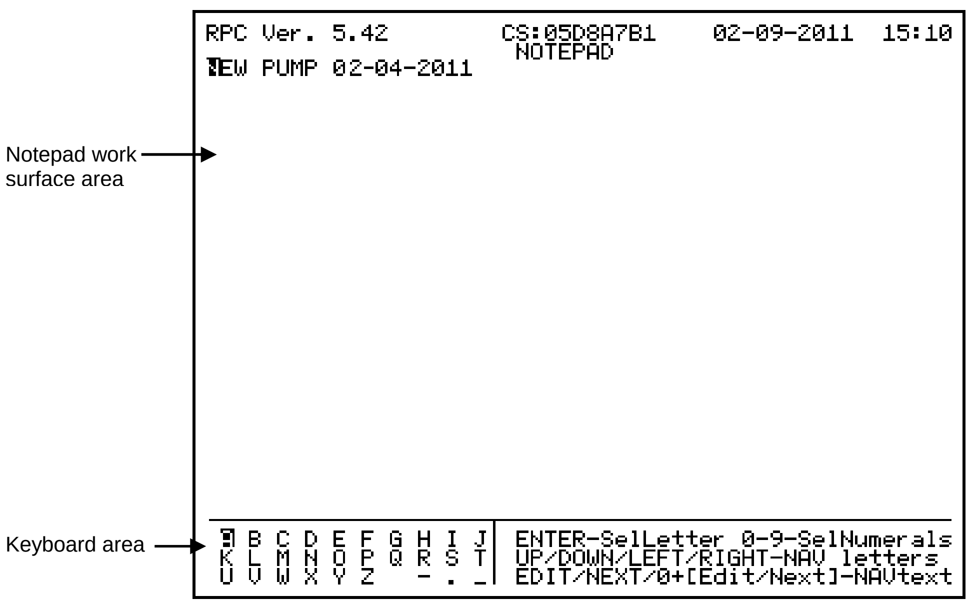


Figure 15-1. Notepad Screen Example

A blank screen displays the first time this feature is accessed. Once a note is written, you can add to it or overwrite it. Only one Notepad screen is available.

Notepad Work Surface Area Hotkeys

Below are the hotkey functions used to move the cursor in the Notepad work surface area.

Key	Function
<EDIT>	Moves the cursor one space to the right.
<0> + **<EDIT>**	Moves the cursor one space to the left.
NEXT	Moves the cursor down one row.
<0> + **<NEXT>**	Moves the cursor up one row.

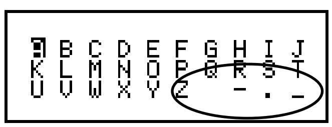
Keyboard Hotkeys

Below are the hotkey functions used to move the cursor in the keyboard area.

Key	Function
<↑>	Moves the cursor up one row.
<↓>	Moves the cursor down one row.
<←>	Moves the cursor to the left.
<→>	Moves the cursor to the right.

Non-alphabetical Characters

In the bottom right corner of the keyboard are four non-alphabetical characters.



Key	Function
Blank	Blank space (below **Q**).
–	Dash (below **R**).
.	Period (below **S**).
_	Underscore (below **T**).

To write numbers 1 through 0, use the number keys on the operator interface keypad.

Character Deletion

To delete a character, press **<DELETE>** on the operator interface keypad. All remaining characters are shifted to the left.

Procedure

Follow the steps below to write a new message or revise an existing one.

1. From the **Main Menu** screen, select **8. NOTEPAD** to display the Notepad screen.

2. Use the Notepad hotkey functions to position the cursor in the Notepad work surface area where you need it.

3. To enter a character, do one of the following:

   - ***For all characters except numbers***, press <↑>, <↓>, <←>, and <→> to highlight the character, and then press **<ENTER>**.

   - ***For numbers***, press the number key on the operator interface keypad.

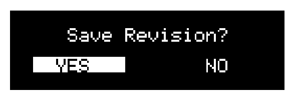
   The character is entered and the cursor in the Notepad work surface area moves one character to the right. If a character was already highlighted it is overwritten by your new choice.

Note: To erase a character, press **<DELETE>** on the operator interface keypad.

---

4. When you are finished writing your notes, press **<EXIT>**.

   A message appears that asks if you want to save the changes you wrote. Yes is the default option.

5. Do one of the following:

   - ***To save the note***, make sure **YES** is highlighted, and then press **<ENTER>**.

   - ***To keep the previous note written and discard your changes***, press <←> or <→> to highlight **NO**, and then press **<ENTER>**.

6. Press **<ENTER>** to return to the Main Menu screen.

Section 16

Alarm Clearing

MENU 9

Alarm conditions in the Lufkin Well Manager RPC that involve basic rod pump control function are typically indicated by the **Current Well State** field on the first RPC Status screen (see Figure 16-1). You can use the Reset Malfunction option (**MENU: 6**) to clear this type of alarm. For more information about resetting malfunctions, see section 14, “Reset Malfunctions.”

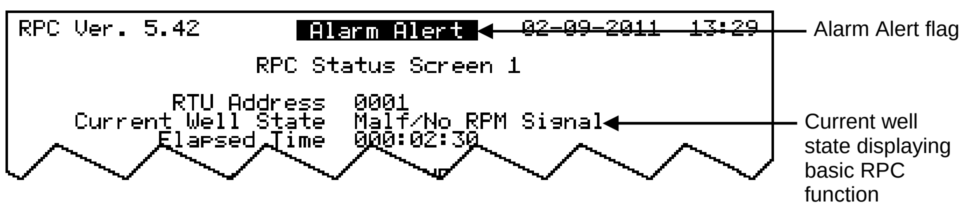


Figure 16-1. Alarm Alert Notification Example

Note: You can also use Reset Malfunctions to reset VSD drive faults and malfunctions.

Other alarm/alert conditions may be generated by auxiliary functions of the Lufkin Well Manager RPC. If this type of dynamic alarm and/or alert condition exists anywhere in the Lufkin Well Manager RPC, an alarm alert flag blinks on and off at the top of every screen. Figure 16-1 is an example of a screen displaying an Alarm/Alert notification.

Clearing Alarms

The Lufkin Well Manager RPC has features you can use to clear all alarms at once or you can clear a specific alarm or a specific group of alarms, such as user-configured alarms, or alarms associated to analog inputs or digital outputs.

If you want to clear all alarms set in the Lufkin Well Manager RPC at once, use the Clear Alarms option (**MENU: 9**).

If you want to investigate the condition causing the Alarm/Alert flag to display, you can use the alarm log screens (**MENU: 7/2**) to see each alarm configured. Nine of these status screens are available. The first screen (similar to Figure 16-2) displays the present status of each configured alarm.

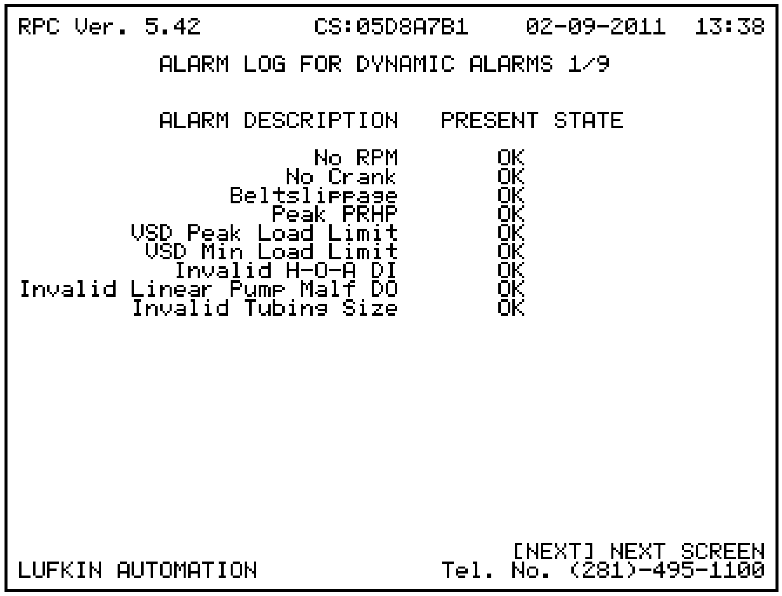


Figure 16-2. Alarm Status Screen Showing Alarm Alert Conditions

Other status screens display the alarm status for analog and digital inputs and outputs, such as the example in Figure 16-3. Press **<NEXT>** to scroll through the alarm status screens.

Many screens include prompts displayed at the bottom of their screens for you to use to clear the alarms displayed on the current screen, similar to Figure 16-3. For example:

- To clear all latched alarms shown on the present screen, press **<DELETE>**.
- To clear all latched alarms displayed on all the screens, press **<0>**.

Note: Dynamic alarms clear themselves when the input associated with the alarm returns to a normal (non-alarm) level.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  15:30
         ALARM LOG FOR ANALOG INPUT ALARMS 3/9
                     LOW                  HIGH
             ALARM        ALERT      ALARM     ALERT
ANALOG IN   D     L    D     L    D     L   D     L

    1       0     0    0     0    0     0   0     0
    2       0     0    0     0    0     0   0     0
    3       0     0    0     0    0     0   0     0
    4       0     0    0     0    0     0   0     0
    5       0     0    0     0    0     0   0     0
    6       0     0    0     0    0     0   0     0
    7       0     0    0     0    0     0   0     0
    8       0     0    0     0    0     0   0     0
    9       0     0    0     0    0     0   0     0
   10       0     0    0     0    0     0   0     0
   11       0     0    0     0    0     0   0     0
   12       0     0    0     0    0     0   0     0
   13       0     0    0     0    0     0   0     0
   14       0     0    0     0    0     0   0     0
   15       0     0    0     0    0     0   0     0
   16       0     0    0     0    0     0   0     0

Note: D = Dynamic       0 = NORMAL
      L = Latched       1 = ALARM/ALERT CONDITION

[DEL] Clear AI Latched Only
[0] Clearr ALL Latched Alarm        [NEXT]Next Scrn
```

Figure 16-3. Alarm Status Screen for Clearing Alarm Conditions

If the alarm condition still exists, the alarm will reset and the alarm flag will resume blinking. Check and correct the problem, and then use the Clear Alarms option (**MENU: 9**) again.

Section 17

System Diagnostics Tools

The Lufkin Well Manager RPC has several diagnostic tools for checking data communications, local keypad integrity, and other operational features in the controller.

The topics covered in this section include:

17.1 Overview of the Diagnostics Tools

Several useful diagnostic tools are available for troubleshooting RPC control system installations. They include::

MENU 2/5/5

- Key events that have occurred, such as power on or off, firmware upgrades, and system overrides
- Main board activities, including I/O performance issues

- Communications performance, including RX/TX messages, and Modbus activity
- Keypad operations
- Verification of firmware versions and checksums

Note: These tools are primarily intended for use by trained Lufkin Automation service technicians. This section only provides a brief overview about them. For more information about these functions, contact your Lufkin Automation representative.

The diagnostic tools are accessed from the Diagnostic Menu screen (Figure 17-1). To display this menu, select **5. DIAGNOSTICS** from the RTU Level Menu screen.

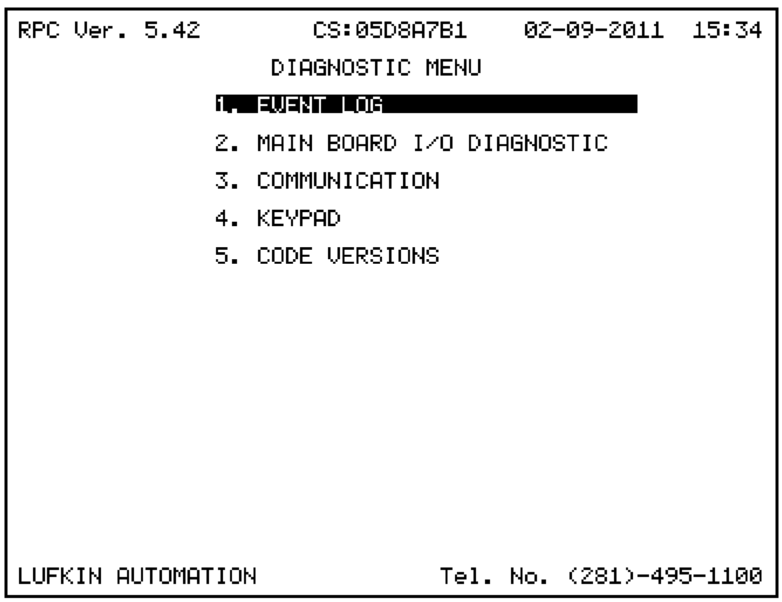


Figure 17-1. Diagnostics Menu Screen

Figure 17-2 shows where the Diagnostic options are located.

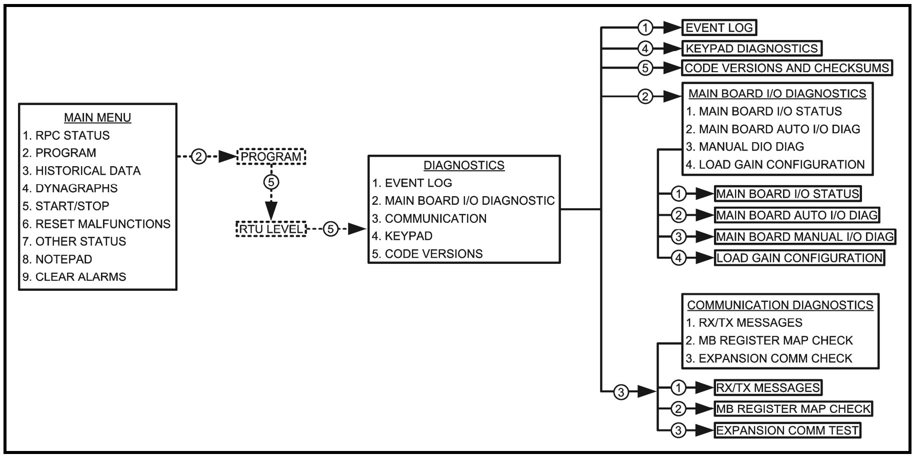


Figure 17-2. Diagnostic Menu Map

17.2 Event Log

MENU 2/5/5/1

The event log feature displays a record of the last 200 significant 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.

This information is displayed in an Event Log screen similar to Figure 17-3. To display this screen, select **1. EVENT LOG** from the Diagnostics Menu screen.

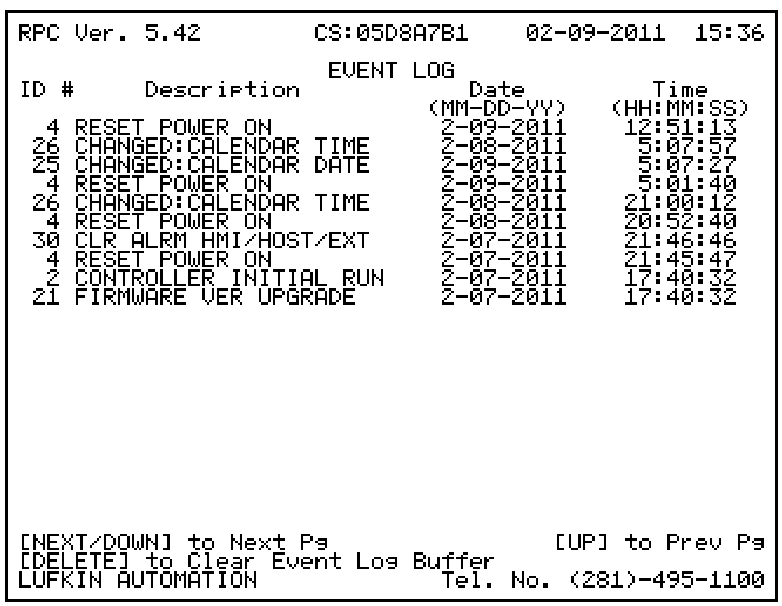


Figure 17-3. Event Log Screen

You can use key commands while viewing the event log data:

Key	Function
NEXT or ↓	Displays the next screen of events.
↑	Returns to the previous screen of events.
ENTER	Returns to the first screen to view the most-recent events.
DELETE	Clears all events from the screen.

After you are finished viewing this screen, do one of the following:

- Press **<EXIT>** to return to the Diagnostics Menu screen.
- Press **<MENU>** to return to the Main Menu screen.

17.3 Board Diagnostics

MENU 2/5/5/2

The Lufkin Well Manager RPC includes a number of diagnostic screens that provide information to help a technician troubleshoot problems, test the motherboard hardware, and recalibrate load inputs. These screens are accessed from the Main Board I/O Diagnostics Menu screen (Figure 17-4). To display this menu, select **2.MAIN BOARD I/O DIAG** from the Diagnostic Menu screen. A brief description of each available screen is provided below.

A brief description of each available screen is provided below. For more information about troubleshooting the Lufkin Well Manager RPC, see “Diagnostics Screens” in section 20, “Troubleshooting.”

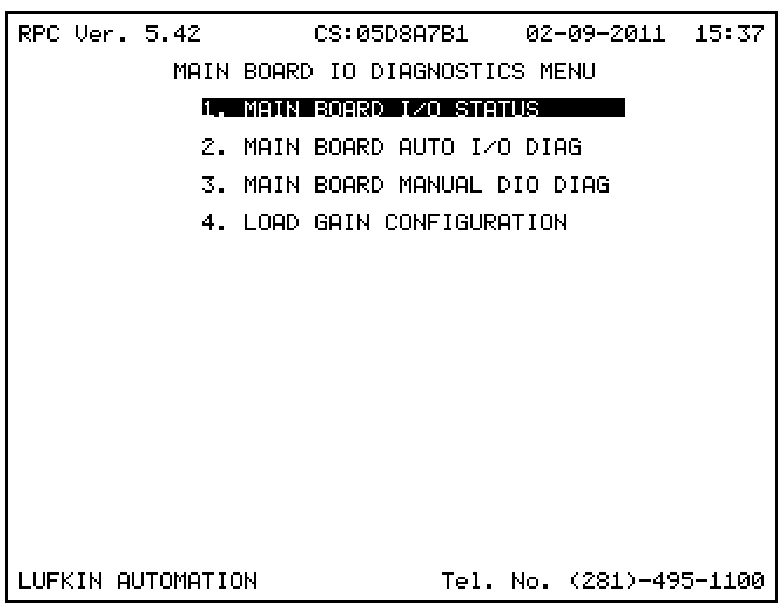


Figure 17-4. Main Board IO Diagnostics Menu

17.3.1 Main Board I/O Status

MENU
2/5/5/2/1

A Main Board I/O Status screen similar to Figure 17-5 shows the present value of the load and position analog inputs, present frequency of the RPM and crank switch digital inputs, and present on/off state of each of the eight discrete points on the Lufkin Well Manager RPC motherboard.

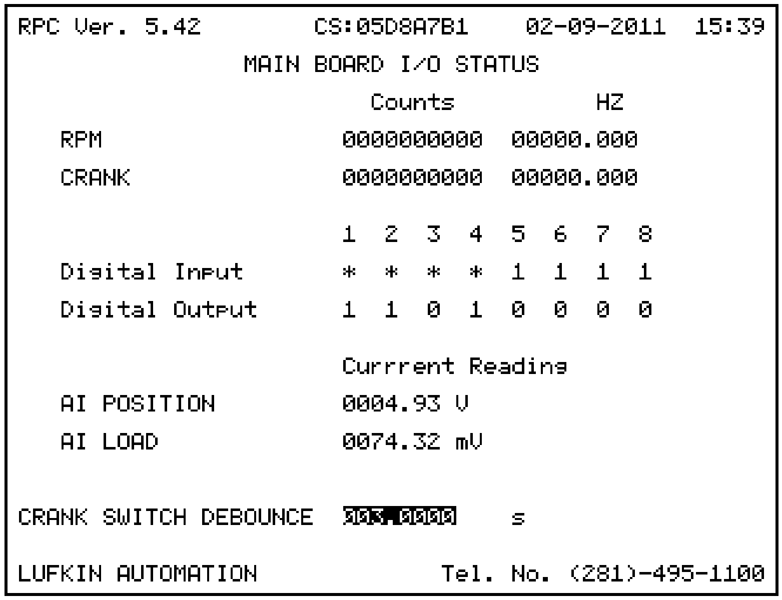


Figure 17-5. Main Board I/O Status Screen

The **Hz** field for the **RPM** and **CRANK** rows indicate a value consistent with pumping cycles (strokes) per second and motor revolutions per second when both sensor inputs are working properly. Divide the strokes per minute pumping speed by 60 to obtain strokes per second. To arrive at motor revolutions per second, divide motor RPM by 60. If the Hall-Effect transducer for that input is not connected and working properly, the field for that input indicates a frequency of zero.

17.3.2 Main Board Auto I/O Diagnostics

MENU
2/5/5/2/2

A Main Board Auto I/O Diag screen (Figure 17-6) is used to check that all circuitry is working properly and to re-calibrate the load signal circuitry. Lufkin Automation offers a signal source circuit board assembly that can be used in the field to check that all motherboard circuitry is working properly. The signal source board can also be used to re-calibrate the load signal circuit.

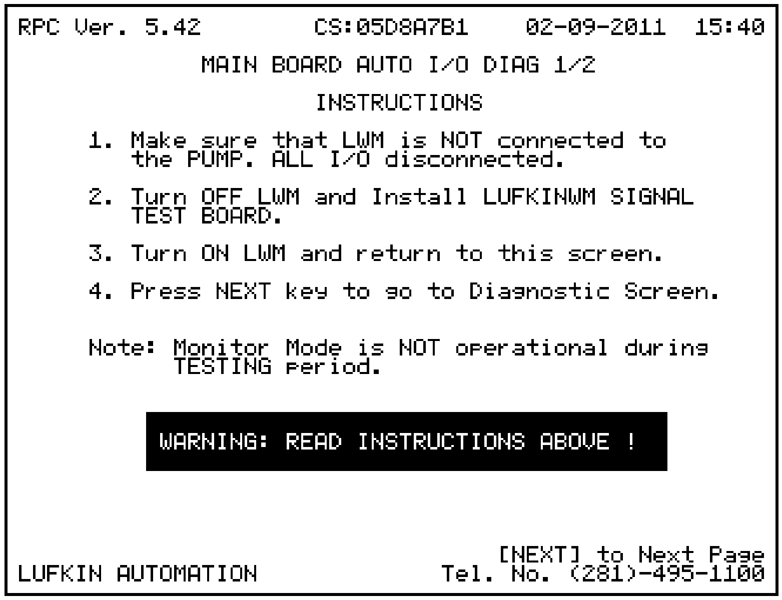


Figure 17-6. Main Board Auto I/O Status Screen 1 of 2

Contact your Lufkin Automation representative about a Lufkin Signal Test Board (Part No. 520.5007). Complete instructions for using the board and the Lufkin Well Manager RPC diagnostic screens is included with the test board.

17.3.3 Main Board Manual DIO Diagnostics

MENU
2/5/5/2/3

The Main Board Manual DIO Diag screen (Figure 17-7) is used to check the status of each discrete point configured as a digital input, and to verify that discrete end devices are properly connected and functioning as desired. Digital outputs can also be manually turned on and off to check interposing relay connections and action.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  15:41
             MAIN BOARD MANUAL DIO DIAG

                       INPUTS
         1    2    3    4    5    6    7    8
         ------------------------------------
         0    0    1    0    1    1    1    1
                      OUTPUTS
         1    2    3    4    5    6    7    8
         ------------------------------------
         1    1    0    1    0    0    0    0


     Warning: When performing this diagnostic, make
              sure that none of Digital Port is
              connected.



        Press 1 thru 8 to turn on digital
     Press (0+1) thru (0+8) to turn off digital
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 17-7. Main Board Manual DIO Diag Screen 1 of 2

17.3.4 Load Gain Configuration

MENU 2/5/5/2/4

The Load Gain Configuration screen (similar to Figure 17-8), in conjunction with the Lufkin Signal Test Board (Part No. 520.5007), makes it easy to field-calibrate the load signal circuit. Complete instructions are provided with the Lufkin Signal Test Board.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  15:42
                LOAD GAIN CONFIGURATION

TEST/CALIBRATION PROCEDURE:
   1. Turn OFF LWM and Disconnect ALL I/O.
   2. Install LWM Signal Test Board.
   3. Return to this screen and press ENTER key
      to Perform Gain Test/Calibration.
   Note: Manual CFG is not operational during
         Gain Test/Calibration.

             [ Perform Gain Test/Calibration ]

  Load Gain Manual Cfg:  001 000 000 000  CALIBRATE

                Status:  WAITING FOR CMD

    Load Gain Register:  001 000 000 000

            Calibrated:  010.00  mV

               Reading:  000.00  mV

           % Tolerance:  000.50  %

               % Error:  000.00  %

                               [ENTER] select option
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 17-8. Load Gain Configuration Screen

If the load/position analog input board needs to be replaced, use this feature to re-calibrate the load values to factory standards. This operation assures that the Lufkin Well Manager RPC accurately reads and scales the load signal from the polished rod load cell (PRLC).

If the PRLC is out of calibration, use the Load and Position Input CFG screen (**MENU: 2/5/6**) to re-calibrate the load transducer. Follow the prompts to mark a zero load and to enter a standing valve load value. Obtaining a good standing valve load value typically requires that the well be "weighed" with a calibrated dynamometer system.

17.4 Communication Diagnostics

MENU 2/5/5/3

The Communication Diagnostics Menu screen (Figure 17-9) provides options for troubleshooting radio network communications problems and for locating memory locations in the Modbus register map. To display this menu, select **3. COMMUNICATIONS** from the Diagnostics Menu screen.

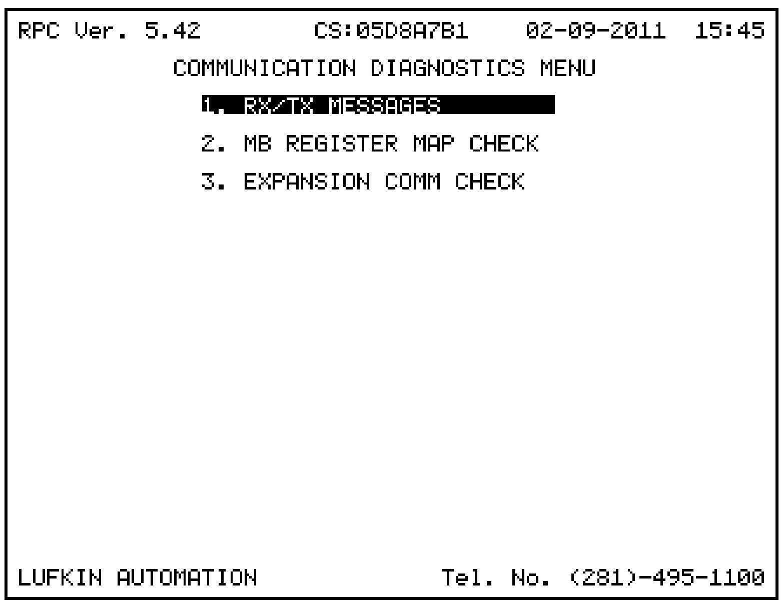


Figure 17-9. Communication Diagnostics Menu Screen

17.4.1 RX/TX Messages

MENU 2/5/5/3/1

The RX/TX Messages screen (Figure 17-10) shows the hexadecimal characters received and transmitted by the Lufkin Well Manager RPC. This information should be useful when troubleshooting radio network communications problems. To display this screen, select **1. RX/TX MESSAGES** from the Communication Diagnostics Menu screen.

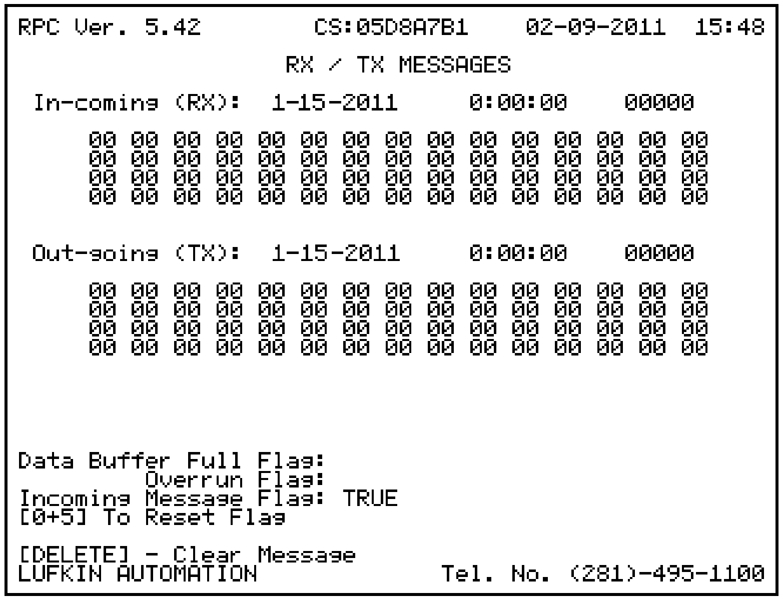


Figure 17-10. RX/TX Messages Screen

17.4.2 Modbus Register Map Check

MENU
2/5/5/3/2

The MB Register Map Check screen (Figure 17-11) is a quick reference for locating memory locations in the Modbus register map for certain types of data. This tool is only useful to a systems integrator that is writing host software for reading and displaying data from the Lufkin Well Manager RPC. For a copy of the complete Modbus register map, contact your Lufkin Automation representative.

To display this screen, select **2. MB REGISTER MAP CHECK** from the Communication Diagnostics Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  15:51
                MB REGISTER MAP CHECK
               30000 Registers - Page 1
     Register Description           MB Address
     Controller Information            30001
     Analog Input Status               30033
     Analog Output Status              30353
     Accumulator Status                30453
     Event Log                         30603
     Alarm Log                         31203
     Common Stamp Event                31505
     App Specific Timestamp            31683
     Shutdown Event Log                31743
     Logic Expr. Syntax Status         31823
     AGA Status Registers              31971
     POC Status Registers              32501
     Consecutive Violations            32528
     Cumulative Violations             32547
     Historical Peak Min Data          32567
     Inferred Production               32603
     Percent Run Time                  32608
     Pump Card Status Regs.            32612

 [NEXT] - 30000 Registers - Page 2
LUFKIN AUTOMATION            Tel. No. (281)-495-1100
```

Figure 17-11. MB Register Map Check Screen

17.4.3 Expansion Comm Check

MENU 2/5/5/3/3

If the Lufkin Well Manager RPC is equipped with an optional RS-485 communication expansion board, this feature provides a way to test the board. Basically, the output of the communication expansion board is looped back to the radio port input, so in effect, the Lufkin Well Manager RPC talks to itself. An RS-232–to–RS-485 converter assembly is required and the Lufkin Well Manager Expansion Comm. Mode option must be configured a certain way. For details about the converter assembly and a copy of the factory test procedure, contact your Lufkin Automation representative.

To display this screen, select **3. EXPANSION COMM CHECK** from the Communication Diagnostics Menu screen. After you select this option, the Expansion Comm Test screen appears (Figure 17-12). Press **<ENTER>** to begin the test.

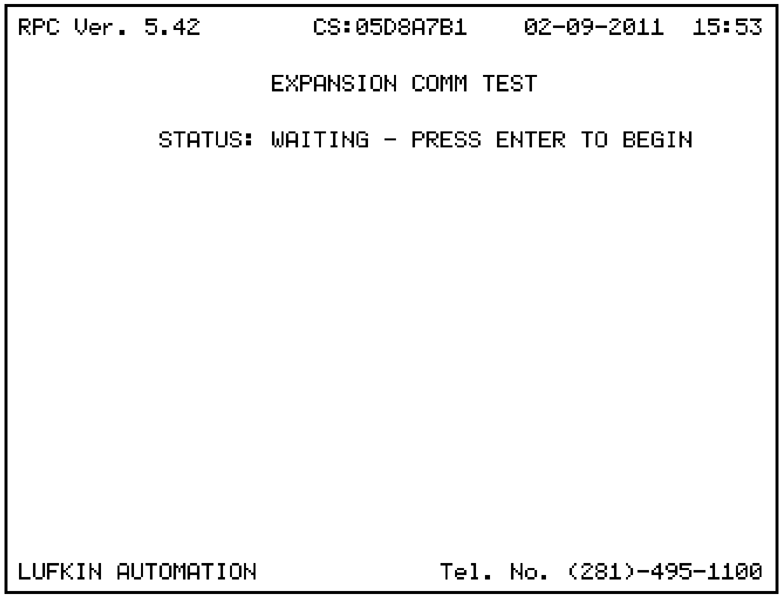


Figure 17-12. Expansion Comm Test Screen

As prompted, press **<ENTER>** to begin the test. The **Status** field displays "Testing" until the test is completed (Figure 17-13).

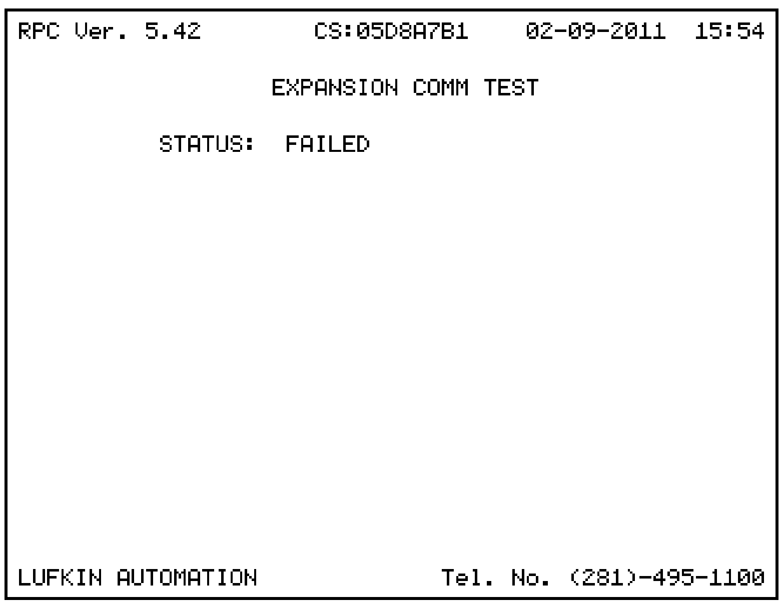


Figure 17-13. Expansion Comm Test in Progress

After the test is completed, either "Passed" or "Failed" will display, according to test results.

17.5 Keypad Diagnostics

MENU 2/5/5/4

The Keypad Diagnostic screen (Figure 17-14) helps you determine if all keys on the Lufkin Well Manager RPC keypad are operating properly. To display this screen, select **4. KEYPAD** from the Diagnostic Menu screen.

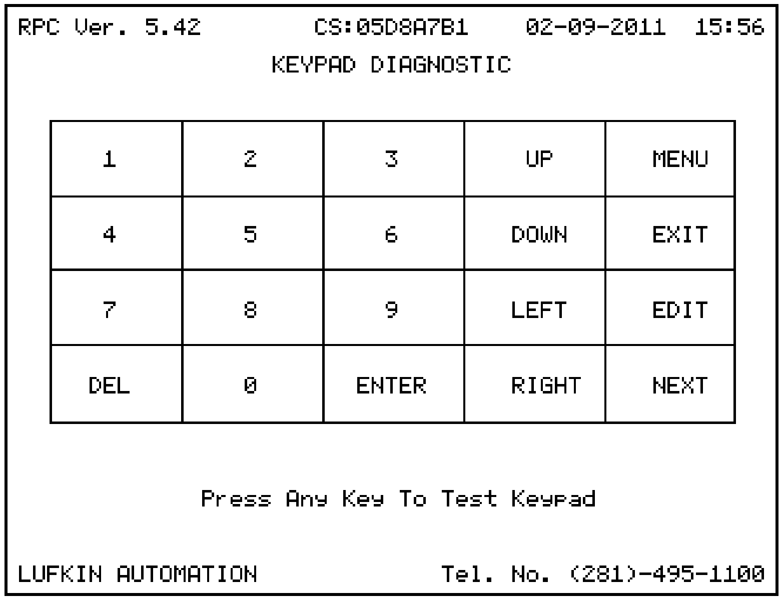


Figure 17-14. Keypad Diagnostic Screen

As you press each key on the membrane keypad, the corresponding square on the Keypad Diagnostic screen darkens. When you press a key and the square representing it does not darken, you need to return the Lufkin Well Manager RPC to Lufkin Automation for service.

When you test the **<EXIT>** key, a message appears below the key squares that asks you to indicate whether you want to continue with the keypad test or actually exit from the test. Do one of the following:

- Press **<1>** to continue testing.
- Press **<2>** to exit from the keypad test and return to the Diagnostics Menu screen.

17.6 Code Versions and Checksums

MENU
2/5/5/5

A Code Versions and Checksum screen similar to Figure 17-15 lists the different firmwares installed in the Lufkin Well Manager RPC and their version numbers and checksums. When you contact technical support with questions, you should either have this screen displayed or write down these numbers. To display this screen, select **5. CODE VERSIONS** from the Diagnostic Menu screen.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  15:59

                CODE VERSIONS AND CHECKSUMS

                   Version             Checksum
                 -----------          ----------

          CPLD:        022

     Bootstrap:        027            0x00125C2E
     Low Level:        072            0x0050F8A9
   Application:  5 Build 42           0x05D8A7B1
      Database:        004            0x0047088A
Serial Number:  0x71D2AADF00000051




LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 17-15. Code Versions and Checksum Screen

Section 18

Quick-Start Feature

The Quick-Start feature is designed to help you quickly enter the basic programming parameters necessary to configure the Lufkin Well Manager RPC and get it into operation. This section shows you typical representations of each configuration screen you will normally see for the load and position end devices and control methods most commonly used.

The topics covered in this appendix include:

18.1 Overview of the Quick-Start Feature

MENU 2/2

The Quick-Start feature was added to the application firmware to make the Lufkin Well Manager RPC more "user friendly." Quick-Start walks you through the screens necessary to program (configure) control parameters that enable the Lufkin Well Manager RPC to work properly. This screen display method simplifies the programming process because only the screens required for the selected end devices and control methods are presented.

The pumping unit must be pumping in order for Quick-Start to work properly. The Lufkin Well Manager RPC calls for the unit to run in a Pumping/HOA in Hand well state. Be sure to place the H-O-A switch in the proper position so that the Lufkin Well Manager RPC has control of the pumping unit.

The exact screens displayed during Quick-Start programming depend on the choices made for the load and position end devices connected to the Lufkin Well Manager RPC and to the control method selected. Below are two examples, which are the most common RPC hardware configurations.

- If you use the Lufkin Well Manager RPC with a combination beam transducer and surface control, as few as 10 of the configuration screens display.

- If you take full advantage of the Lufkin Well Manager RPC capabilities by using the Hall-Effect crank and RPM crank position inputs, a polished rod load cell, and the downhole control method, 12 or more screens display in a logical sequence.

As a result, the Quick-Start screen display method simplifies the programming process because unnecessary screens are not presented.

For demonstration purposes, the end devices used are a beam load transducer and an RPM/crank position transducer.

18.1.1 Quick-Start Flowchart

Figure 18-1 is a flowchart of the Quick-Start feature representing all of the possible screen presentations. This section discusses all of the available screens. However, as previously mentioned, not all screens are presented in a given Quick-Start session. Only those required for the selected end devices and control method are presented.

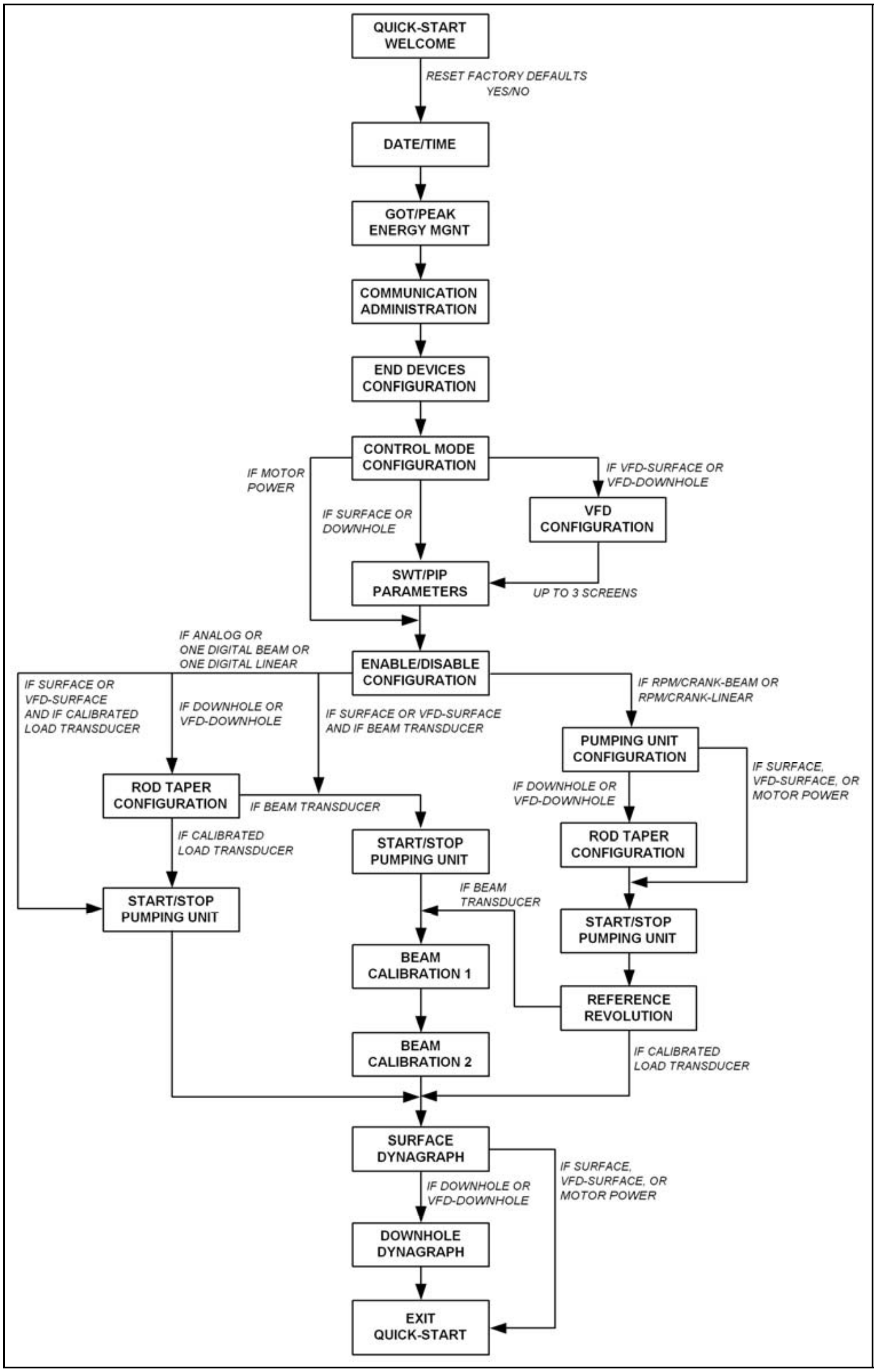
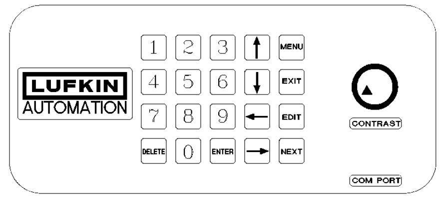


Figure 18-1. Quick-Start Flowchart

18.1.2 Methods for Navigating the Programming Screens

The keys you need to press on the Lufkin Well Manager RPC operator interface keypad and the operations they will perform are provided below.



Moving Between Screens

To move between Quick-Start programming screens:

- Press <**NEXT**> to move forward one step in the Quick-Start process.
- Press <**EXIT**> to move back one step in order to double-check or change a parameter value that was entered.

Editing Parameters

To edit parameters:

1. Press <↑> and/or <↓> to move the cursor to highlight the parameter of interest, press <**EDIT**>, and then do one of the following:
    - Use the number keys to write in the desired value.
    - Press <↑> and/or <↓> to display the options available for the field.
2. When the parameter field reads as desired, press <**ENTER**> to complete the edit/program operation.

18.2 Using the Quick-Start Feature

When the Quick-Start feature begins, you are presented with several screens for you to enter basic programming information. Most screens contain several parameters that require you to enter values specific to your site setup and the end devices installed. The need to complete some tasks depends on the end devices and control method (such as Downhole or VFD-Surface) you select. Below each screen description, you are directed where to find detailed descriptions about the screens and the fields they contain.

18.2.1 Starting the Quick-Start Feature

Note: Before you start the Quick-Start feature, make sure that the pumping unit is running.

To start the Quick-Start feature, from the **Main Menu** screen, select **2. PROGRAM**, and then select **2. RPC QUICK START** to display a Welcome to Lufkin Well Manager RPC Quick-Start Configuration screen similar to Figure 18-2.

```
RPC Ver. 5.42        CS:05D8A7B1    02-10-2011  08:20
            WELCOME TO LUFKIN WELL MANAGER
             QUICK-START CONFIGURATION
   This is a step-by-step configuration of LUFKIN
   WELL MANAGER allowing operators to get started.
   Note: This covers the basic configuration. Other
   parameters should be handled under normal configu-
   ration scheme.
   Press DELETE KEY if you want to Initialize
   the Memory and Reset the Configuration Parameters
   to Default Setting.
   Press NEXT KEY for the Next Configuration Screen.

NOTE: reset to default causes the controller to reset
[EXIT] end of cfg screen    [DELETE] reset to default
[NEXT] next cfg screen
LUFKIN AUTOMATION                Tel. No. (281)-495-1100
```

Figure 18-2. Welcome to Lufkin Well Manager RPC Quick-Start Configuration Screen

18.2.2 Resetting Parameters to Factory-Default Values

Lufkin Automation recommends that you reset the Lufkin Well Manager RPC to the factory-default values. Resetting ensures that any previous programming does not cause problems. This operation is not required.

WARNING: After you execute this operation, the user-defined parameters cannot be easily restored. Each parameter must be re-programmed one field at a time.

From this screen, use one of the following options:

- ***To reset the Lufkin Well Manager RPC to the factory-default values***, press <**DELETE**>.

  After you press <**DELETE**>, a message appears asking you to verify that you want to use the reset operation. By default, the **CANCEL** option highlights. To initiate the reset operation, press **<←>** or **<→>** to highlight **OK**, and then press **<ENTER>**. Be aware that if you wait a few seconds without pressing **<ENTER>**, the message disappears and the highlighted choice goes into effect. The reset-to-default operation reboots the Lufkin Well Manager RPC. After the reboot routine completes, the Main Menu screen displays. Press **<2><2>** to return to the Quick-Start welcome screen, and then press **<NEXT>** to continue the Quick-Start process.

- ***To keep the present values stored in the Lufkin Well Manager RPC***, press <**NEXT**> to continue with the Quick-Start process. Alternatively, if you did press <**DELETE**> and you want to keep the existing programmed values, highlight **CANCEL** and then press **<ENTER>**.

- ***To abort the Quick-Start process***, press <**EXIT**> to display the Quick-Start CFG End screen (Figure 18-20) and then press <**ENTER**>. You are returned to the Programming Menu screen.

18.2.3 Setting Time and Date

After you press <**NEXT**>, a Quick-Start CFG Clock Calendar screen similar to Figure 18-3 displays. The current date and time must be set in order for historical data to be accurate. The **New Date** field is automatically highlighted prompting you to set the current date. For more information about date and time configuration, see “Setting the Controller Date and Time” in section 9, “Lufkin Parameter Programming.”

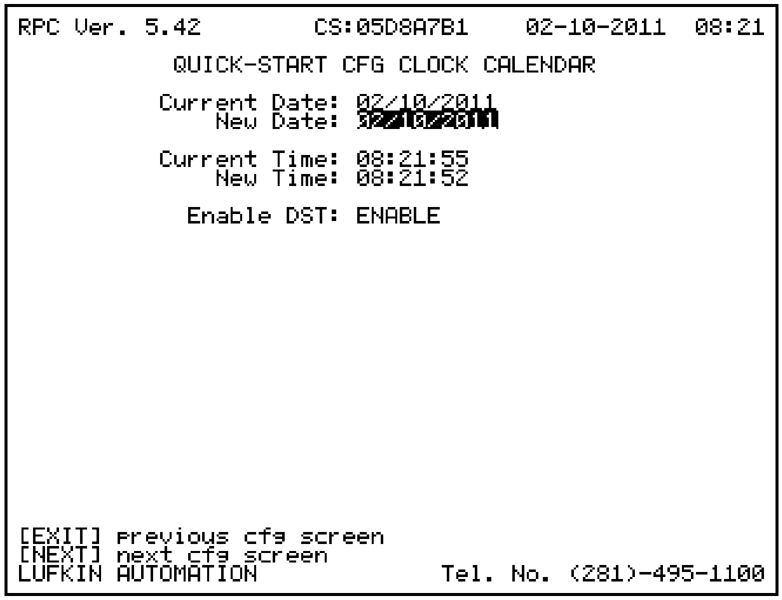


Figure 18-3. CFG Clock Calendar Configuration Screen

18.2.4 Setting Gauge Off Time and Peak Energy Management

After you are finished configuring the current date and time, press <**NEXT**> to display, a CFG Gauge Off Time/Peak Energy Mgnt screen similar to Figure 18-4. Gauge off time (GOT) is the time of day that the Lufkin Well Manager RPC updates all daily historical data buffers. Peak Energy Management is a time period during the day you want the controller to shut down the pump because of contractual agreements with the electric power provider to receive a more economical rate. For information about these features and the parameters on this screen, see "Setting Gauge Off Time and Peak Energy Management" in section 8, "RPC Parameter Programming."

```
RPC Ver. 5.42        CS:05D8A7B1    02-10-2011  08:24
  QUICK-START CFG GAUGE OFF TIME / PEAK ENERGY MGNT
       Gauge Off Time:  07:00
Peak Energy Management: DISABLE











[EXIT] previous cfg screen
[NEXT] next cfg screen
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 18-4. CFG Gauge Off Time/Peak Energy Mgnt Screen

18.2.5 Setting Communications Parameters

After you are finished configuring GOT and Peak Energy Management, press **<NEXT>**. A Quick-Start Communication Port Config screen similar to Figure 18-5 displays for you to begin the Quick-Start setup process. This screen has the communication parameters that you usually need to configure, such as RTU Address, data transmission rate, keying properties, and handshake protocol.

```
RPC Ver. 5.42        CS:05D8A7B1    02-10-2011  08:25
      QUICK-START COMMUNICATION PORT CONFIG
                RTU Address:   0001

        Radio Port Baud Rate:    9600
         Delay before Key Up:  00075  ms
                 Key Up Time:  00300  ms
               Key Down Time:  00050  ms
Enable/Disable Radio RTS/CTS:  DISABLE
    Enable/Disable Radio DCD:  DISABLE
       Character Gap Timeout:  003.5  chars 03.65  ms

       Laptop Port Baud Rate:  115200
   En/Disable Laptop RTS/CTS:  ENABLE
       Character Gap Timeout:  003.5  chars 00.30  ms

 Expansion Comm. Mode Option:  RS485
   Expansion Comm. Baud Rate:    9600
                Key Up Delay:  00075  ms
                 Key Up Time:  00300  ms
               Key Down Time:  00050  ms
      Enable/Disable RTS/CTS:  DISABLE

  Reset Comm Regs to Default:  EXECUTE

[EXIT] previous cfg screen
[NEXT] next cfg screen
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 18-5. Communication Port Config Screen

If the Lufkin Well Manager RPC is a stand-alone control unit and not part of a SCADA system with a central computer and a data telemetry network, skip this screen by pressing <**NEXT**>.

If the Lufkin Well Manager RPC has a radio installed and is part of a SCADA system, three parameters on this screen must be properly programmed for radio communication to be possible.

- **RTU Address** — A unique identifier number that allows the central computer to retrieve data from this particular Lufkin Well Manager RPC. Coordinate with the central computer software configuration group to ensure compatibility.

- **Radio Port Baud Rate** — The rate of data transmission when communicating with a radio. This parameter must also match the software settings in the central computer.

- **Laptop Port Baud Rate** — The rate of data transmission when communicating with software in a laptop computer plugged into the local DB9 Com Port on the front panel of the Lufkin Well Manager RPC.

Other parameters may require fine-tuning later to optimize radio communication efficiency. They can be configured using the Communication Administration screen (**MENU: 2/5/2/1**). For information about these parameters, see “Configuring Communication Parameters” in section 9, “Lufkin Parameter Programming.”

18.2.6 Selecting End Devices

After you press <**NEXT**>, a Quick-Start CFG End Devices Parameters screen similar to Figure 18-6 displays. On this screen you must tell the Lufkin Well Manager RPC what type of load and position input devices are being used at this installation. The actual fields displayed depends on the type of load and position transducer specified. For details about the parameter fields presented, see “Configuring End Device Parameters” in section 8, “RPC Parameter Programming.”

```
RPC Ver. 5.42        CS:05D8A7B1    02-10-2011  08:27
       QUICK-START CFG END DEVICES PARAMETERS
         Load Transducer Type  Beam Transducer

     Position Transducer Type  ANALOG

[NEXT] next cfg screen [EXIT] previous screen
LUFKIN AUTOMATION               Tel. No. (281)-495-1100
```

Figure 18-6. CFG End Devices Parameters Screen

18.2.7 Configuring Rod Pump Control Parameters

After you press <**NEXT**>, a Quick-Start CFG RPC Control Parameter screen similar to Figure 18-7 displays.

```
RPC Ver. 5.42        CS:05D8A7B1    02-10-2011  08:31
        QUICK-START CFG RPC CONTROL PARAMETERS
                 Control Mode  DOWNHOLE
               Operation Mode  NORMAL
         Minimum Pump Strokes     003
                Downtime Mode  Manual
       Manual Downtime(hh:mm)  000:05
           Power ON Delay(sec)   00010
       Start Alert Delay(sec)   00010
   POff/LowFL Strokes Allowed      02
  Malfunction Strokes Allowed      02
                  E/D      Allowed    Consec    Start
 Malfunctions    State     Limit     Allowed    Delay
     Peak Load     E       50000       005       ***
      Min Load     E           0       005       ***
        No RPM     E       *****       003      0001
      No Crank     E       *****       003       ***
Low Motor RPM      E        1050       003      0003
Peak Torque k      D        9999       005       ***
Malf Setpoint      E       *****       004       ***
 Low Fluid Ld      E           0       003       ***

                Start Up Rev    050
               Reference Rev    0141
          Belt Slip Limit(%)     005
           Cutoff Pwr Cfg Mode  Auto

[NEXT]next screen [EXIT]previous screen
LUFKIN AUTOMATION               Tel. No. (281)-495-1100
```

Figure 18-7. CFG RPC Control Parameter Screen

The exact fields presented on this screen depend on the type of load and position transducers selected in the Quick-Start CFG End Devices Parameters screen (Figure 18-6). For descriptions about the control parameters, see “Configuring RPC Control Parameters” in section 8, “RPC Parameter Programming.”

For purposes of getting started, the **Control Mode** field is the only one that must be programmed at this time. The factory-default values for most of the other parameters will work for a majority of applications. If you want to return to this screen later and change control parameters, such as Downtime, Pump Off Strokes Allowed, etc., you can access this programming screen using **MENU: 2/1/1/1**.

After the control parameter fields on this screen read as desired, press<**NEXT**> to continue.

The next screen displayed depends on the control method programmed in the Quick-Start CFG RPC Control Parameter screen.

- If the VFD-SURF or VFD-DH variable speed control method was selected, a Quick-Start VFD/VSD Parameters screen similar to Figure 18-8 (18-12) displays.

- If the Surface or Downhole control method was selected, a LWT/PIP Parameters screen similar to Figure 18-9 (page 18-13) displays.

- If the Motor Power control method was selected, a CFG Violation Enable/Disable screen similar to 18-14 (page 18-14) displays.

18.2.8 Configuring Variable Speed Control Parameters

The Quick-Start VFD/VSD Parameters screen (Figure 18-8) displays only if one of the VFD control methods (VFD-SURF or VFD DH) was selected previously in the Quick Start CFG RPC Control Parameter screen (Figure 18-7).

```
RPC Ver. 5.42        CS:05D8A7B1     02-10-2011  08:34
           QUICK-START VFD/VSD PARAMETERS

                            VFD Drive Type  Lufkin LFKA-1
                              Speed Output  AO1

                        Maximum Speed(  Hz  0090
                        Minimum Speed(  Hz  0000

                               Deadband +/- 005.00
                 Speed Change Stroke Delay  001
           Start Up Speed(% of Full Scale)  020
 Speed Increase Size(% of Full Scale)  005
 Speed Decrease Size(% of Full Scale)  005
    Working Peak Load Limiting(lbs   ) 50000
    Working Min  Load Limiting(lbs   )     0
              Working Peak Speed( Hz)  0060    8.5 SPM
                  Working Min Speed( Hz)  0030    4.3 SPM
    Protection DT/Malfunction Control  RUN LOW SPEED

    VFD Stroke State Detection Option  Single DO 1

 Enable Disable Up/Down Stroke Speed   DISABLED


          Regenerative Torque Control  ENABLED
 [NEXT]-Next Screen
LUFKIN AUTOMATION              Tel. No. (281)-495-1100
```

Figure 18-8. VFD/VSD Parameters Screen

For descriptions about the parameters available on this screen, see "Configuring VFD/VSD Parameters" in section 8, "RPC Parameter Programming."

Note: Lufkin Automation offers a Lufkin VSD controller package that combines the RPC controller function in the same cabinet as a variable speed drive. This user manual does not address the Lufkin RPC Controller/VSD combo product. For information about the combo product, refer to the *Lufkin Well Manager™— Variable Speed Drive Rod Pump Control User Manual* (Part No. 099.5035)

After the parameters on this screen are programmed as desired, press <**NEXT**>.

18.2.9 Configuring LWT/PIP Parameters

The LWT/PIP Parameters screen (Figure 18-9) allows you to use the patented algorithms that can calculate pump intake pressure (PIP) and make automated fluid volume adjustments for pump slippage, fluid shrinkage, and tubing movement determine the pump fluid load (LWT).

```
RPC Ver. 5.42        CS:05D8A7B1    02-10-2011  08:38
                LWT / PIP Parameters 1/3
     Surface Stroke Length   100.00  in
             Pump Diameter   01.00   in
           Pump Depth(TVD)    5280   ft
      Tubing Head Pressure         30psig
           Tubing Gradient   000.40  psi/ft
      Casing Head Pressure   000000.0psig
             LWT Water Cut   20.00
          LWT Pump Leakage   000.0   b/d
        LWT Cutoff Control   ENABLE  1000.0 bbls
      Fluid Load Detection   ADVANCED
     Fluid Load Adjustment   00000.0 lbs
     Consider Shallow Well    NO
Consider Unanchored Tubing   YES
       Tubing Anchor Depth       0   ft
               Tubing Size   2 3/8   in
[NEXT] Next Screen [EXIT] previous screen
```

Figure 18-9. LWT/PIP Parameters Screen

The control method selected determines which LWT/PIP parameter screens display.

- If the Surface or VFD-Surface control method was selected, all required LWT configuration is done on a single screen.
- If the Downhole or VFD-Downhole control method was selected, three screens are required.

For descriptions about the parameters available on the screens, see “Configuring LWT/PIP Parameters” in section 8, “RPC Parameter Programming.” For information about the theories about how the PIP and LWT features work, see appendix E, “Pump Intake Pressure and Lufkin Well Test Theory.”

After the parameters on this screen are programmed as desired, press <**NEXT**> to display a Violation Enable/Disable screen similar to Figure 18-10.

18.2.10 Enabling/Disabling Control Functions

After you press <**NEXT**>, a Quick-Start CFG Violation Enable/Disable screen similar to Figure 18-10 displays. The exact fields presented depend on the position transducer type and control method selected. For example, if Analog Position Transducer and the Surface Control method were selected, several fields such as No Crank, No RPM, Peak Torque, Low Fluid Load, Pump Fillage Setpoint, Motor Power, and Belt Slippage Detection are not offered.

```
RPC Ver. 5.42        CS:05D8A7B1    02-10-2011  08:40
       QUICK-START CFG VIOLATION ENABLE/DISABLE
    Violation/Malfunction      Enable/Disable
                Peak Load      ENABLE
             Minimum Load      ENABLE
         No RPM Detection      ENABLE
       No Crank Detection      ENABLE
            Low Motor RPM      ENABLE
              Peak Torque      DISABLE
     Malfunction Setpoint      ENABLE
           Low Fluid Load      ENABLE

           Control/Alarms      Enable/Disable

   Belt Slippage Detection     ENABLE
              Motor Power      DISABLE
     Pump Fillage Setpoint     ENABLE


DISABLE/ENABLE ALL OPTION      DISABLE

[EXIT] previous cfg screen
[NEXT] next cfg screen
LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 18-10. CFG Violation Enable/Disable Screen

Note: For most users, the defaults are probably adequate. Press <**NEXT**> to move to the next screen in the Quick-Start process.

For more information about the enabling and disabling violations, see “Enabling/Disabling Control Functions” in section 8, “RPC Parameter Programming.” Also, for a description about each of the control and malfunction features, see “Control Capabilities of the Lufkin Well Manager RPC” in section 2, ” Description of the Lufkin Rod Pump Controller System.”

Based on the programmed control method, the Lufkin Well Manager RPC automatically enables the logical control and malfunction features.

When the desired features are enabled/disabled, press <**NEXT**> to access the next screen in the Quick-Start process.

The next screen displayed depends on the combination of selected load transducer type, position transducer type, and control method specified. Use the table below to determine the screen that will display. This section describes the screens in numerical order below. If your selection of input transducers and control method does not require you to use the described programming screens between the ones that you need, go to the figure number indicated in this table.

Position Transducer	Load Transducer	Control Method	Screen
Analog or One Digital-Beam or One Digital-Linear	Calibrated	Surface or VFD-Surface	Start/Stop (Figure 18-14 , page 18-19)
Analog or One Digital-Beam or One Digital-Linear	Beam Transducer	Surface or VFD-Surface	Start/Stop (Figure 18-14 , page 18-19)
Analog or One Digital-Beam or One Digital-Linear	Calibrated or Beam Transducer	Downhole or VFD-DH	Rod taper (Figure 18-13 , page 18-18)
RPM/Crank-Beam or RPM/Crank – Linear	Calibrated or Beam Transducer	Motor Power	Cfg Pumping Unit (Figure 18-11 , page 18-16)
RPM/Crank-Beam	Calibrated or Beam Transducer	Any other than motor power	Cfg Pumping Unit (Figure 18-11 , page 18-16)
RPM/Crank-Linear	Calibrated or Beam transducer	Any other than Motor power	Cfg Pumping Unit. (Figure 18-12 , page 18-17)

18.2.11 Configuring Pumping Unit Parameters

A Pumping Unit Setup screen similar to Figure 18-11 displays only if the RPM/Crank-Beam option for position transducer was selected earlier in the Quick-Start process.

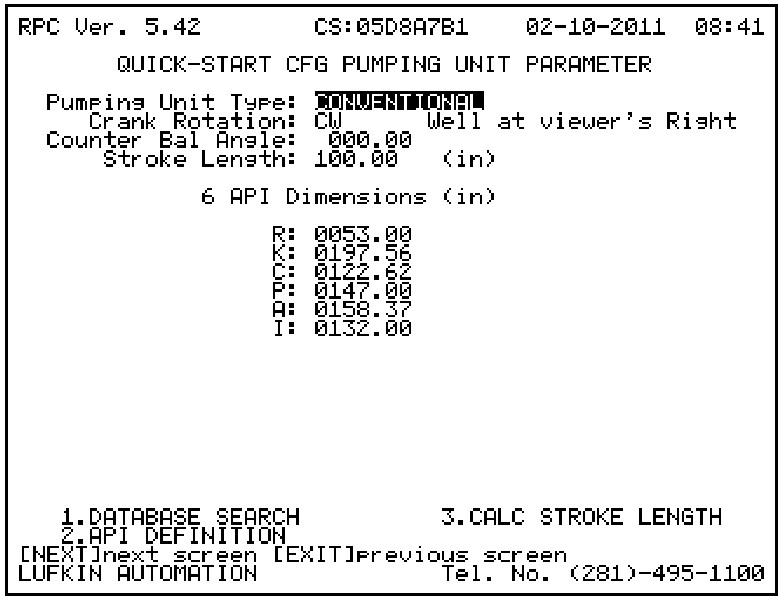


Figure 18-11. Pumping Unit Setup Screen (Beam Unit)

At this point in the Quick-Start process you can either select a pumping unit from the Lufkin Well Manager RPC database or enter pumping unit dimensions data manually.

- To use the selections from data base feature of the Lufkin Well Manager RPC, select **1**. **Database Search**. The steps to perform the database selection are discussed in “Configuring Beam Pumping Unit Data” in section 8, “RPC Parameter Programming.” In the interest of brevity, those steps are not discussed here.

- To enter data manually, highlight each parameter field in turn, press <**EDIT**>, and then enter new data or make a selection from the available options that can be presented by pressing <↑> and <↓>. When a parameter field reads as desired, press <**ENTER**> to complete the edit process for that field and move the cursor to the next field.

  Select **2**. **API Definition** to display a screen defining the six API dimensions required.

  The A and C dimensions may vary from the manufacturers “nominal” values for a given pumping unit installation. This will cause the actual stroke length to vary from the manufacturers nominal values. The Lufkin Well Manager RPC is able to calculate stroke length from unit dimensions.

After the data is correct in all fields, select **3. Calc. Stroke Length** if you want the Lufkin Well Manager RPC to calculate the surface stroke length from the pumping unit dimensions just entered. If the calculated stroke length is different than the measured stroke length, the values for dimensions A and C may be adjusted to get the calculated stroke length to agree with the measured stroke length.

A CFG Pumping Unit Parameter screen similar to Figure 18-12 displays if the RPM/Crank-Linear position transducer option was selected. This pumping unit dimension screen is for a Rotaflex™ type of linear pumping unit. For information about the Rotaflex pumping unit application, see appendix F, “Linear Pumping Unit Application.”

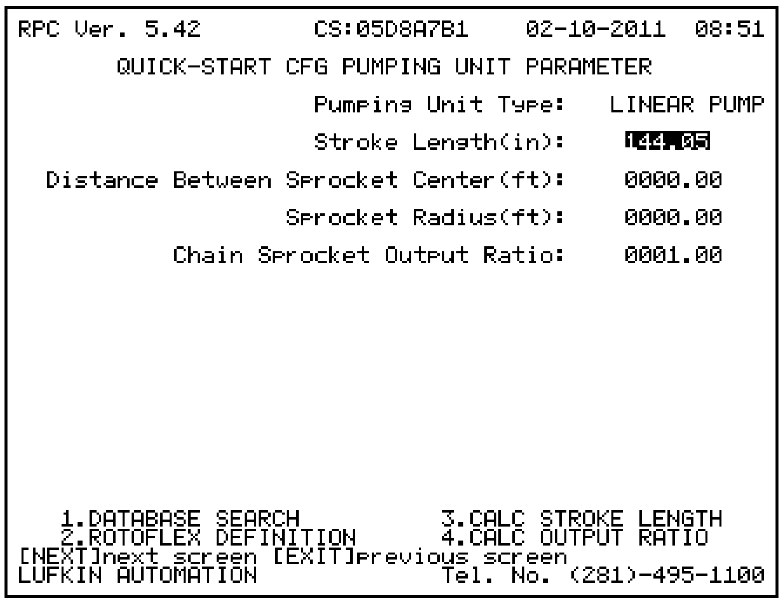


Figure 18-12. CFG Pumping Unit Parameter Screen

Data can be entered in this parameter screen manually or by using the database selection feature.

After the required pumping unit dimensions are entered, press <**NEXT**> to display the next screen. The screen presented depends on the selections made earlier in the Quick-Start process.

- If the Downhole or VFD-Downhole control method was selected, a screen similar to Figure 18-13 (Rod Taper Parameter Configuration, page 18-18) displays.

- If the Surface or VFD-Surface control method was selected and a calibrated load cell is being used, a screen similar to Figure 18-18 (Start/Stop The Pump, page 18-19) displays.

18.2.12 Configuring Rod String Parameters

The Lufkin Well Manager RPC requires rod string design data to calculate the downhole pump card. Therefore, if either Downhole or VFD-Downhole was selected as the control method, a CFG Rod Taper Parameter screen similar to Figure 18-13 displays.

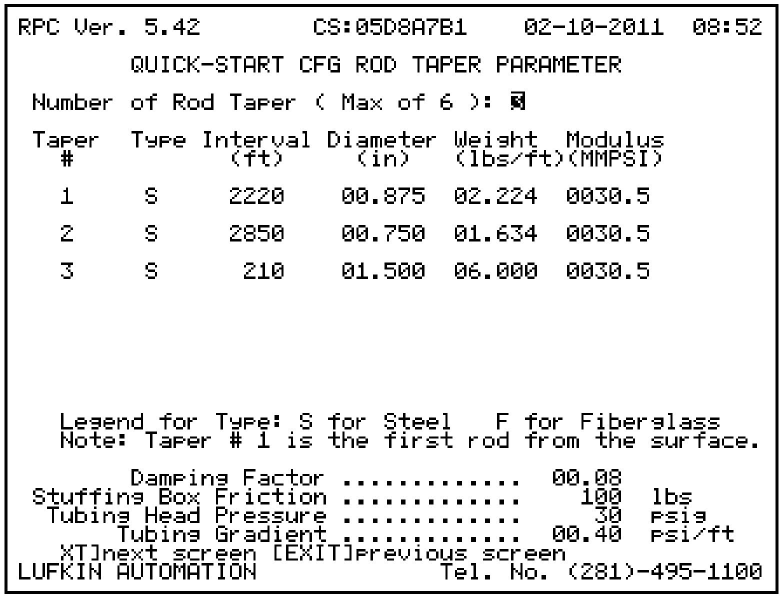


Figure 18-13. CFG Rod Taper Parameter Screen

For details about entering rod string design information, see “Configuring Rod Tapers for Downhole Control” in section 8, “RPC Parameter Programming.”

When data fields on this screen are programmed as desired, press <**NEXT**> to continue.

18.2.13 Starting and Stopping the Pump

The Start/Stop The Pump screen (Figure 18-14) prompts you to start the pumping unit if it is shut down for any reason. The Lufkin Well Manager RPC must be in a run state and the pumping unit must be pumping for the remaining Quick-Starting programming. This screen displays even if the system is already running.

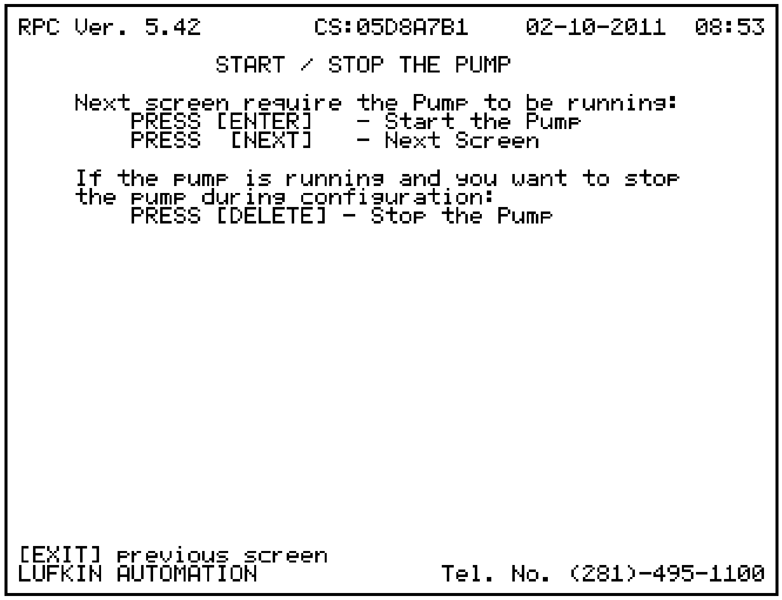


Figure 18-14. Start/Stop The Pump Screen

Press **<ENTER>** to put the Lufkin Well Manager RPC in a run well state and start the pumping unit. If the unit does not start pumping, check the position of the H-O-A switch to ensure that the Lufkin Well manager RPC has control of the well.

Once the unit is pumping, press **<NEXT>** to continue the Quick-Start process.

18.2.14 Configuring Reference Revolutions

If one of the RPM/Crank position transducer types was selected in the Quick-Start CFG End Devices Parameters screen (Figure 18-6) a Quick-Start Reference Revolution Calibration screen similar to Figure 18-15 displays.

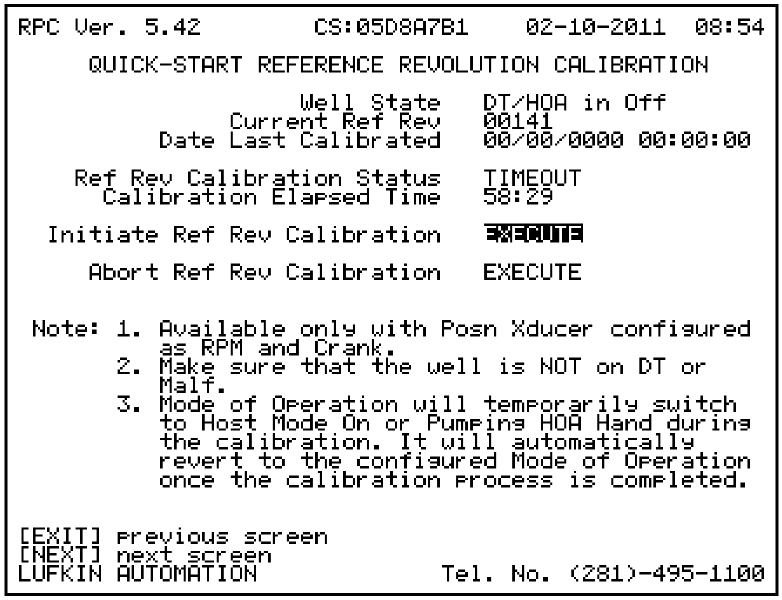


Figure 18-15. Reference Revolution Calibration Screen

When this screen appears, the **Initiate Ref Rev Calibration** field is highlighted. 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**.

For more information about reference revolution, see "Configuring Reference Revolution Calibration" in section 8, "RPC Parameter Programming."

18.2.15 Calibration of Beam Load Transducer

A Quick-Start CFG Beam Transducer and Load Calibration Setup screen similar to Figure 18-16 displays only if a non-calibrated beam transducer was selected earlier as the load transducer type.

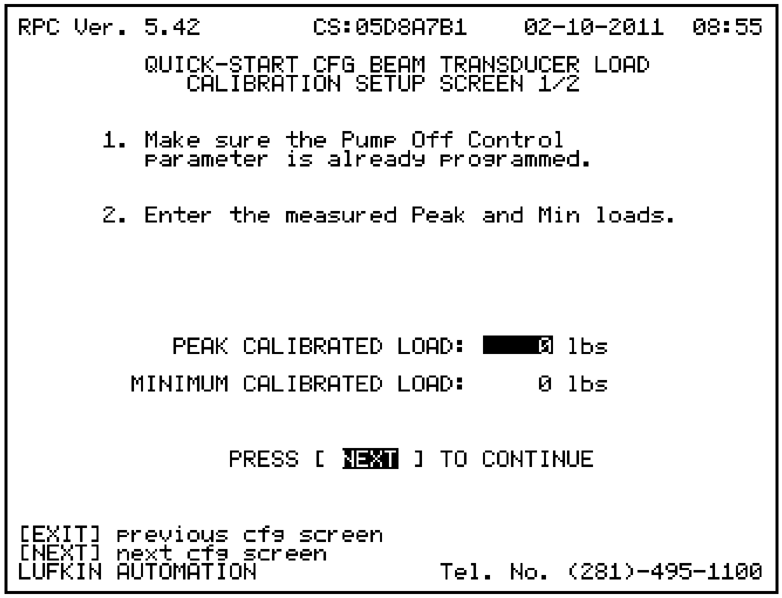


Figure 18-16. CFG Beam Transducer and Load Calibration Setup Screen (1 of 2)

For information about calibrating the beam transducer, see “Calibrating Loads” in section 8, “Lufkin Parameter Programming.”

When the load calibration routine is completed, press <**NEXT**> to display a second Quick-Start CFG Beam Transducer and Load Calibration Setup screen similar to Figure 18-17. The horizontal dotted lines represent the peak and minimum calibration loads just entered in the previous screen. A notice of **INITIALIZING** displays, and after one or two strokes of the pumping unit, a **Strokes Remaining** countdown from 3 displays.

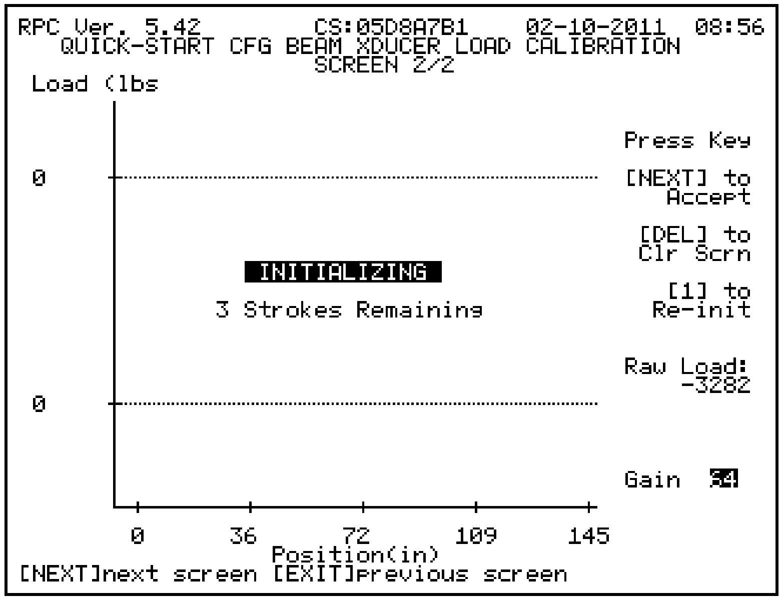


Figure 18-17. CFG Beam Transducer and Load Calibration Setup Screen (2 of 2)

After the three-stroke countdown completes, a surface dynagraph trace starts to appear between the dotted calibration load lines. Within a few strokes, the card trace should automatically scale to just touch the Peak load line and the Min load line.

Press **<NEXT>** to accept the calibration and continue the Quick-Start process.

18.2.16 Configuring Surface Dynagraph Control Parameters

After you press **<NEXT>**, a Surface Dynagraph Card screen similar to Figure 18-18 displays. You can use this screen to set the POC and malfunction setpoints (if those functions were enabled) and program the allowed peak and minimum load limits.

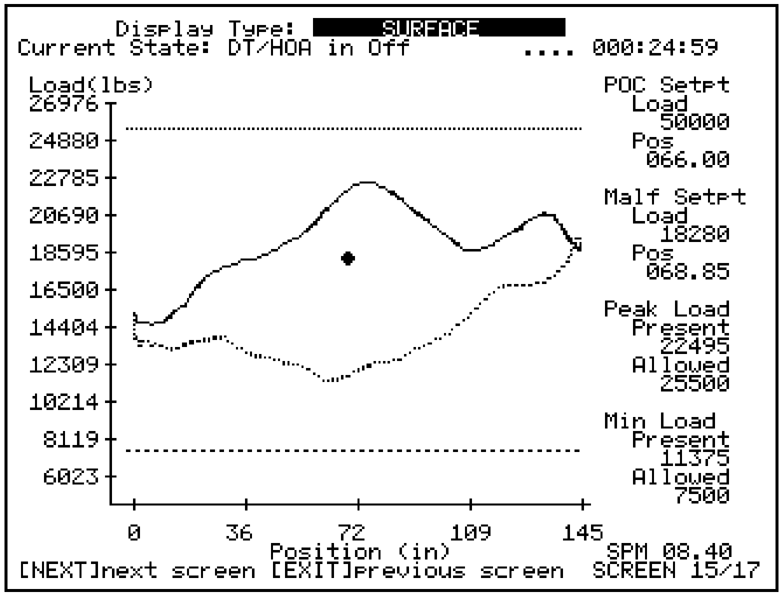


Figure 18-18. Surface Dynagraph Card Display Screen

For information about programming control parameters from a surface dynagraph card screen, see “Surface Realtime Dynagraph” section 12, “Dynagraph Cards.”

When you are satisfied with the parameter values, press <**NEXT**> to access a screen for finishing the Quick-Start process.

18.2.17 Configuring Downhole Dynagraph Control Parameters

If one of the downhole control methods was selected earlier in the Quick-Start process, a Downhole Dynagraph Card display screen similar to Figure 18-19 displays.

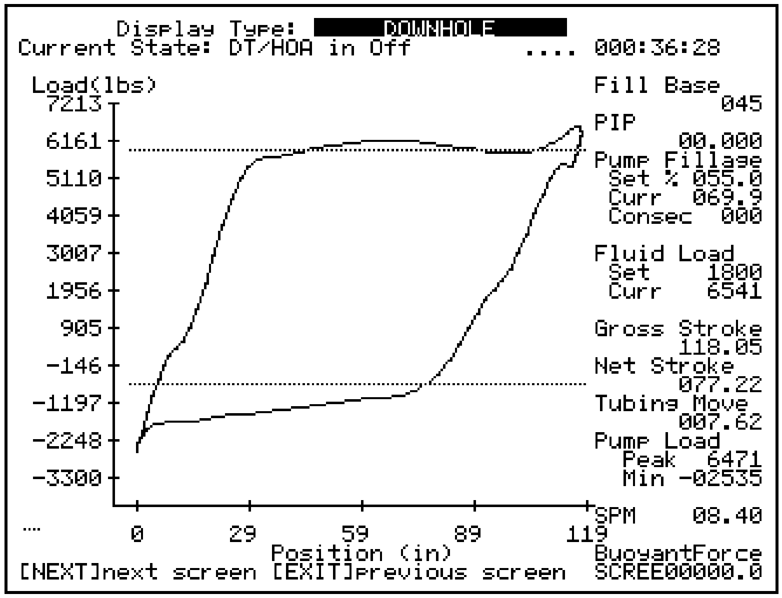


Figure 18-19. Downhole Dynagraph Card Display Screen

For descriptions about the parameters that can be programmed on a Downhole Dynagraph Card screen, see “Downhole Realtime Dynagraph Cards” in section 12, “Dynagraph Cards.”

When you are satisfied with the parameter values, press <**NEXT**> to access a screen for completing the Quick-Start process.

18.2.18 Completing the Quick-Start Feature

A Quick-Start CFG End screen similar to Figure 18-20 is used to complete the Quick-Start process.

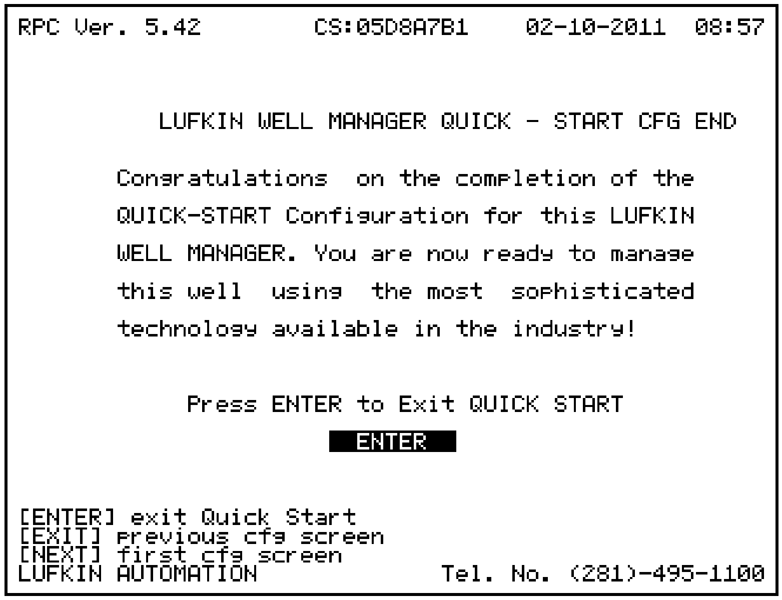


Figure 18-20. CFG End Screen

Press <**ENTER**> to complete programming and exit Quick-Start. You are returned to the Programming Menu screen.

Section 19

LWM Flash Upgrade Utility Software

Lufkin Automation offers a utility software that can help you easily and quickly program one or more Lufkin Well Manager RPCs at the wellsite, create backup files storing these parameters, and upgrade the application firmware in the controller.

The topics covered in this section include:

19.1 Software Overview

Programming the Lufkin Well Manager RPC with the local keypad at the wellsite involves several steps and takes considerable time. To expedite the programming process, especially when you need to program several controllers, you can use the *LWM Flash Upgrade Utility* software available from Lufkin Automation. This software can be used to download all programming parameters from one Lufkin Well Manager RPC to a laptop computer file. You can then upload this "template" file with the complete block of parameters to a new Lufkin Well Manager RPC. After the file is uploaded, you can selectively reprogram specific parameters using the local keypad.

You can also keep this file as a backup in case the controller programming is lost or corrupted or you need to upgrade the application firmware.

19.2 LWM Flash Upgrade Utility Screen

The LWM Flash Upgrade Utility screen (Figure 19-1) is the interface used to:

- Download (save) the configuration parameters to a configuration file prior to a flash upgrade
- Upload the saved configuration file to the Lufkin Well Manager RPC following a flash upgrade
- Upgrade application firmware

All operations are performed through this single screen. It is accessed after you launch the *LWM Flash Upgrade Utility* software.

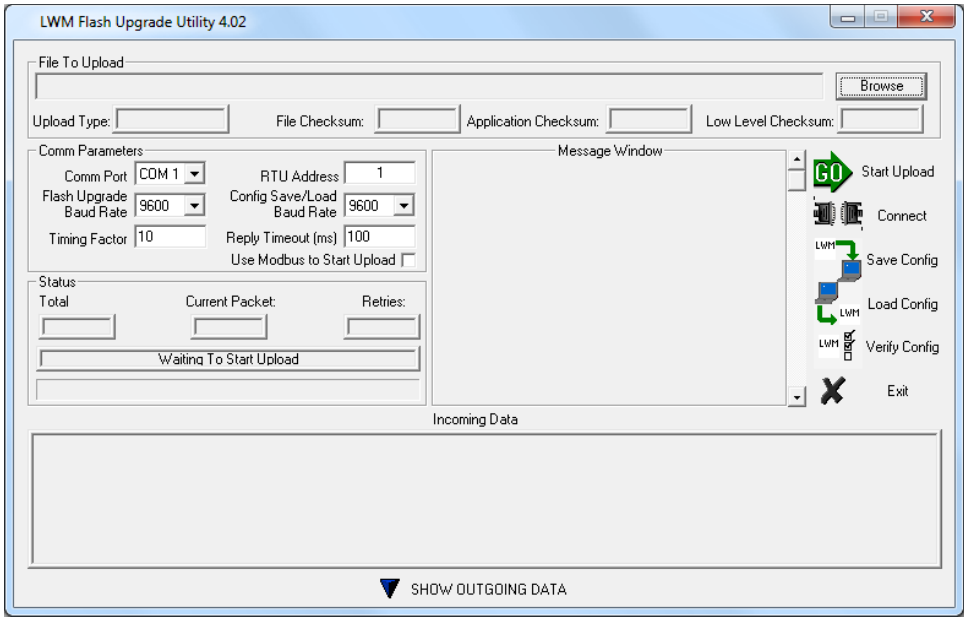


Figure 19-1. LWM Flash Upgrade Utility Screen

If you do not have the *LWM Flash Upgrade Utility* software installed on your laptop computer or you do not know how to display it, see “Installing the Software on a Laptop Computer” on page 19-9.

This utility screen is divided into seven sections.

- File To Upload
- Comm Parameters
- Status
- Message Window
- Command Buttons
- Incoming Data
- Outgoing Data

Each section is described below.

19.2.1 File To Upload Section

This section has fields used to select the application code you want uploaded to the Lufkin Well Manager RPC. You also can verify the upload file type and that the correct file will be uploaded by viewing its checksum number. Figure 19-2 is an example.

Figure 19-2. File To Upload Section Example

Data Field Descriptions

Information about each field is provided below.

Filename

Name of the file selected for uploading.

Browse Button

Click this button to open a dialog box used to select the file for upload to the Lufkin Well Manager RPC. After a file is selected, its file name and path display in the **Filename** field and its type (Application, Low Level, or Table/Database displays in the **Upload Type** field.

Upload Type

The current type of firmware code file to be uploaded to the Lufkin Well Manager RPC. The type is selected using the **Browse** button. The supported upload types are:

- Application
- Low Level
- Table/Database

File Checksum

The checksum for the *.lwm file selected.

Application Checksum

The checksum for the Application (App) file selected. A checksum value (other than 00000000) only displays in this field if **Application** displays in the **Upload Type** field.

Low Level Checksum

The checksum for the low level (LL) file selected. A checksum value (other than 00000000) only displays in this filed if **Low Level** displays in the **Upload Type** field.

19.2.2 Comm Parameters Section

This section has fields for specifying the RTU address of the Lufkin Well Manager RPC and communication parameters, such as timeout values and baud rates. These communication values are necessary in order for the *LWM Flash Upgrade Utility* software to communicate with the Lufkin Well Manager RPC, retrieve the existing configuration parameters, and download the upgraded programming. Figure 19-3 is an example of the Comm Parameters section.

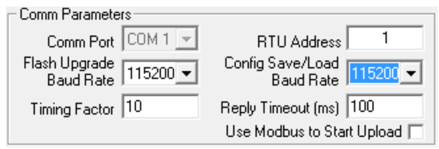


Figure 19-3. Comm Parameters Section Example

Data Field Descriptions

Information about each field is provided below.

Comm Port

The communication port on the laptop computer where the RS-232 cable is connected.

Flash Upgrade Baud Rate

Baud rate of the laptop computer. Allowable baud rates are:

- 1200
- 2400
- 4800
- 9600
- 19200
- 38400
- 57600
- 115200

Most new laptop computer models can use 115200.

Timing Factor

The timing factor is only used for flash upgrades and must be adjusted for each user's system. A lower value results in faster uploads. Too low a value can cause a communication failure when the upgrade is attempted. The default value works for most newer laptop computers.

RTU Address

The Lufkin Well Manager RPC address. This is necessary for transferring data between the Lufkin Well Manager RPC and laptop.

Config Save/Load Baud Rate

The baud rate used for reading and writing the Lufkin Well Manager RPC configuration parameters. The allowable baud rates are:

- 1200
- 2400
- 4800
- 9600
- 19200
- 38400
- 57600
- 115200

Note: **RTU Address** and **Config Save/Load Baud Rate** must be set with the same values as the values in the Lufkin Well Manager RPC. These values are set using the Communication Administration screen. For information about setting these parameters, see "Configuring Communication Parameters" in section 9, "Lufkin Parameter Programming."

Reply Timeout

The timeout between the computer sending a modbus request to the Lufkin Well Manager RPC and the response from the Lufkin Well Manager RPC. The default value works for most situations.

Use Modbus to Start Upload

You can enable this feature to allow an upload to be performed automatically. The *LWM Flash Upgrade Utility* software uses Modbus communications to switch the controller into flash upload mode and start the uploading process automatically.

19.2.3 Status Section

This section provides status information about the data being transferred between the Lufkin Well Manager RPC and the laptop computer. Figure 19-4 is an example of the Status section.

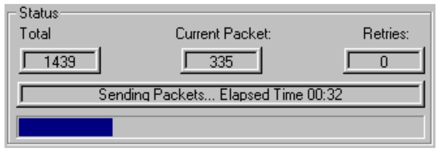


Figure 19-4. Status Section Example

Data Field Descriptions

Information about each field is provided below.

Total

The total number of packets to transfer.

Current Packet

The current packet being transferred.

Retries

The number of retries attempted for the current packet.

Status Window

This window displays the current message pertaining to the system status.

Progress Indicator

This bar is active for any communications to the Lufkin Well Manager RPC. It provides a graphical representation of the time remaining until the task is completed.

19.2.4 Message Window Section

This section is a scrollable window used to view the last 100 messages from the system. System messages allow you to track the success or failure of any task, such as a successful or unsuccessful configuration file upload, notification that the configuration file is being sent, or configuration verification failure. Error messages display in red text. Figure 19-5 is an example.

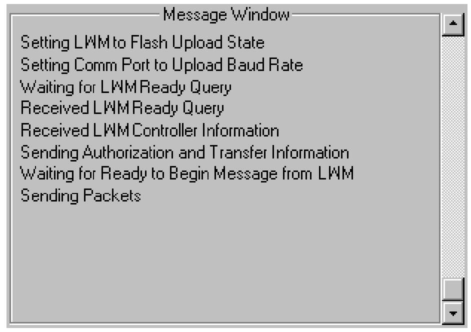


Figure 19-5. Message Window Example

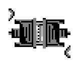
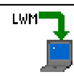
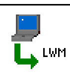
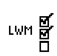
19.2.5 Command Buttons

Command buttons are clicked to perform the necessary operations that the upgrade utility software can offer. These operations include the following:

- Starting and stopping the upload process
- Connecting (establishing communications) and disconnecting with the Lufkin Well Manager RPC
- Retrieving (downloading) the configuration parameters presently defined in the Lufkin Well Manager RPC and restoring (uploading) them to it

Note: Before you use the command buttons, make sure that the laptop computer is connected to the Lufkin Well Manager RPC. For information about properly connecting both components, see “Connecting the Controller to the Laptop” on page 19-13.

Information about each button is described below.

Button	Name	Description
	**Start Upload**	Starts the process for uploading the application firmware. Messages display in the Message window during the uploading process. After this button is clicked, it is replaced with the **Abort Upload** button.
	**Connect**	Opens (connects) the software access to the laptop computer communications port. After this button is clicked, the **Comm Port** field is grayed out and the **Connect** button is replaced with the **Disconnect** button.
	**Disconnect**	Closes (disconnects) the software access to the laptop computer communications port. After this button is clicked, it is replaced with the **Connect** button.
	**Save Config**	Downloads the configuration parameters in the Lufkin Well Manager RPC and saves them to a *.cfg file.
	**Load Config**	Uploads the configuration parameters to the Lufkin Well Manager RPC that are saved to a *.cfg file.
	**Verify Config**	Confirms that the configuration parameters in the Lufkin Well Manager RPC match the parameters saved to the *.cfg file.
	**Exit**	Closes the LWM Flash Upgrade Utility screen and the software. If any upgrading process (Start, Save, Load, Verify) is in progress, it is immediately terminated.

19.3 Installing the Software on a Laptop Computer

The *LWM Flash Upgrade Utility* software must be installed on your laptop computer before you can upgrade the application firmware or upload/download control parameter data. The software operates in the Windows 2000 and XP operating systems. This software is available from your Lufkin Automation representative.

Procedure

Use the steps below to install the *LWM Flash Upgrade Utility* software on the laptop computer.

1. Insert the diskette or CD ROM distribution disk(s) that has the *LWM Flash Upgrade Utility* software into the laptop computer.

2. Copy the installation file (FlashUpgrade4.02.exe) to a folder on you laptop computer.

3. Double-click the installation file. An Install Wizard opens.

4. Follow the instructions provided in the Install Wizard.

5. After the installation is completed, the Flash Upgrade icon ( ) should exist on your desktop.

6. Run the software to ensure that it executes by doing either of the following:

   - Double-click located on your laptop desktop.

   - Click the **Start** button and then select **Programs/Lufkin Automation/Lufkin Utilities/Flash Upgrade**.

   A LWM Flash Upgrade Utility screen similar to Figure 19-1 (page 19-3) opens.

7. Click to close the screen.

The *LWM Flash Upgrade Utility* software is now ready for use. You can now connect your laptop computer to a Lufkin Well Manager RPC and use the software to upgrade the flash ROM in the Lufkin Well Manager RPC.

19.4 Specifying Communications Between the Controller and Laptop

Specifying and synchronizing communication parameters between the Lufkin Well Manager RPC and the laptop computer is required to upload and download files. Two tasks are required to complete this process.

- Specifying the communication baud rate in the Lufkin Well Manager RPC

- Specifying communication parameters in the laptop computer

Each task is described separately below.

19.4.1 Specifying the Communication Baud Rate in the Lufkin Well Manager RPC

MENU 2/5/2/1

Lufkin Automation recommends that the Lufkin Well Manager RPC communicate with the laptop computer port at 115,200 baud. The Lufkin Well Manager RPC defaults to 115,200 baud on the laptop computer port. You can change the baud rate setting using the Communication Configuration screen in the Lufkin Well Manager RPC. For detailed information about this screen and specifying baud rate, see “Configuring Communication Parameters” in section 9, “Lufkin Parameter Programming.”

Procedure

Use the steps below to change the laptop computer port baud rate in the Lufkin Well Manager RPC.

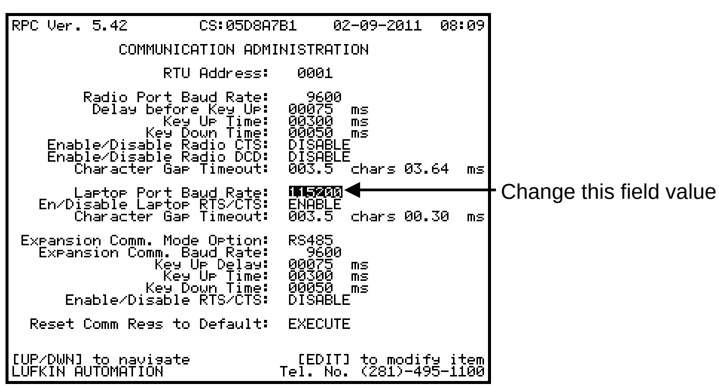
1. From the **Main Menu** screen, select **2. PROGRAM CONTROLLER**, and then select **5. RTU LEVEL** to display the RTU Level Menu screen.

Note: If another screen is displayed, press **<MENU>** to instantly return to the Main Menu screen.

---

2. Select **2. COMMUNICATION PARAMETERS** and then select **1. COMMUNICATION PORT CFG** to display the Communication Administration screen.

3. Press <↓> to highlight the **Laptop Port Baud Rate** field, and then press **<EDIT>**.



4. Press <↑> or <↓> to change the baud rate until **115200** displays, and then press **<ENTER>** to save the setting.

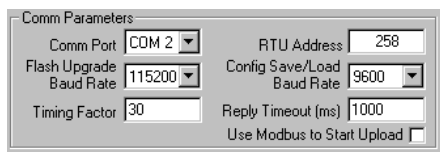
5. Press **<MENU>** to return to the Main Menu screen.

The laptop computer port baud rate in the Lufkin Well Manager RPC is now changed.

Note: While you are at this screen, note the address specified in the **RTU Address** field for use later when you are configuring the laptop computer software.

19.4.2 Specifying Communication Parameters in the Laptop Computer

Lufkin Automation recommends that the Lufkin Well Manager RPC communicate with the laptop computer port at 115,200 baud. Other parameters, such as the correct RTU address and reply times, must be properly configured in order to communicate with a specific controller and upload the application firmware to it. All parameters are specified in the Comm Parameters section of the LWM Flash Upgrade Utility screen.



Procedure

Use the steps below to specify communication parameters in the laptop computer.

1. Start the *LWM Flash Upgrade Utility* software using one of the following methods:

   - Double-click  located on the laptop desktop.

   - Click the **Start** button and then select **Programs/Lufkin Automation/Lufkin Utilities/Flash Upgrade**.

   The LWM Flash Upgrade Utility screen should display.

2. In the **Comm Parameters** section, click the down arrow in the **Comm Port** field and then click the Comm port you are using on your laptop.

3. Click the down arrow in the **Flash Upgrade Baud Rate** field and click **115200**.

4. If necessary, change the value in the **Timing Factor** field.

Timing factor is usually set to 20. It is primarily used to upload upgrade application firmware to flash memory. You may need to set it to a higher value, such as 100, for slower laptop computers. Try 20 first and determine if it is sufficient.

5. In the **RTU Address** field, type the RTU address to the same Modbus address used for the Lufkin Well Manager RPC as noted while performing the steps for specifying RPC baud rate (see page 19-11).

6. In the **Config Save/Load Baud Rate** field, make sure the value specified is 115200.

7. In the **Reply Timeout** field, specify 100.

8. Select the **Use Modbus To Start Upload** check box.

The communication parameters are now specified for communicating with the Lufkin Well Manager RPC.

19.5 Connecting the Controller to the Laptop Computer

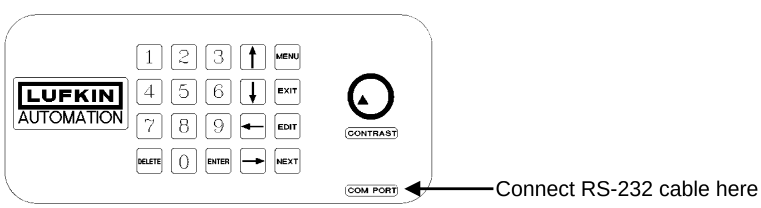
A standard nine-pin RS-232 cable is required to transfer the data from the laptop computer to the Lufkin Well Manager RPC. If your laptop computer has only USB ports, a USB to serial converter is required. Contact your Lufkin Automation representative for assistance.

Procedure

Use the steps below to connect the laptop computer to the Lufkin Well Manager RPC.

1. Connect one end of the RS-232 cable to the DB-9 communications port on your laptop computer.

2. Connect the other end of the RS-232 cable to the DB-9 communications port on the front of the Lufkin Well Manager RPC. This port is located to the right of the 20-key keypad and below where labeled **COM PORT**.



The controller is now connected to the laptop computer.

19.6 Establishing Communications Between the Controller and Laptop Computer

After all communication parameters are correctly specified in the Lufkin Well Manager RPC and laptop computer, and both devices are physically connected, you need to instruct the *LWM Flash Upgrade Utility* software to establish communication with the laptop computer.

Procedure

Follow the step below to establish communications between the Lufkin Well Manager RPC and your laptop computer.

1. Make sure the *LWM Flash Upgrade Utility* software is running and that the LWM Flash Upgrade Utility screen is displayed.
2. In the LWM Flash Upgrade Utility screen, click  to connect the software access to the laptop computer communications port.
3. Select the **Use Config Save/Load Baud Rate** option from the drop-down list.

Communications is now established between the controller and laptop computer. You can now upload and download configuration parameter data.

19.7 Saving the Controller Configuration to a File

The configuration parameters programmed in a Lufkin Well Manager RPC can be downloaded to your laptop computer and saved to a configuration (*.cfg) file. After this file is saved, you can keep it as a backup, and you can also download the parameters to other Lufkin Well Manager RPCs.

Procedure

Use the steps below to download the configuration parameters and save them to a *.cfg file on your laptop computer.

1. Make sure the laptop computer is connected to the Lufkin Well Manager RPC. For this procedure, see “Connecting the Controller to the Laptop” on page 19-13.

2. Start the *LWM Flash Upgrade Utility* software using one of the following methods:

   - Double-click located on the laptop computer desktop.

   - Click the **Start** button and then select **Programs/Lufkin Automation/Lufkin Utilities/Flash Upgrade**.

   The LWM Flash Upgrade Utility screen should display.

3. Click to connect the software access to the laptop computer communications port.

   A shortcut menu appears with two options.

4. Select the **Use Config Save/Load Baud Rat**e option.

5. In the **LWM Flash Upgrade Utility** screen, click .

   The Save File As dialog box appears.

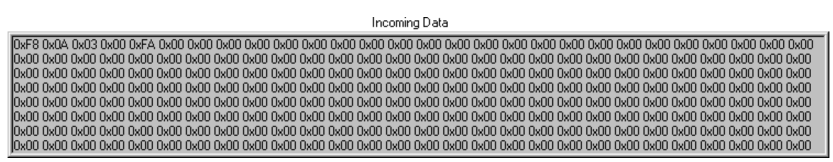
6. In the **Save in** field, select a folder where you want the file saved.

7. In the **File name** field, type over “Well Name” with the name you want used for the file.

8. Click the **Save** command button.

   The dialog box closes and the configuration parameters are saved to a *.cfg file on your laptop computer.

   The Incoming Data window shows the actual data in hexadecimal format being transmitted from the Lufkin Well Manager RPC to the laptop computer.



19.8 Uploading a Saved Configuration File into the Lufkin Well Manager RPC

You can upload from your laptop computer a configuration (*.cfg) file containing the configuration parameters for a Lufkin Well Manager RPC to another Lufkin Well Manager RPC. Uploading is a quick and easy method for programming a Lufkin Well Manager RPC at the wellsite. After the file is uploaded, you can selectively reprogram specific parameters using the local keypad on the Lufkin Well Manager RPC.

Uploading also allows you to use a *.cfg file as a backup when controller programming is lost or corrupted. You will also need to create a backup file before you upgrade the application firmware in the controller because all programming is lost during an upgrade.

Note: You can only successfully upload a *.cfg file for a Lufkin Well Manager RPC to another Lufkin Well Manager RPC. The *LWM Flash Upgrade Utility* software warns you from uploading the file to another type of Lufkin controller, such as an PCP or Injection Well unit.

Procedure

Use the steps below to upload configuration parameters to a Lufkin Well Manager RPC.

WARNING: When you upload a configuration file, all configuration parameters stored in the Lufkin Well Manager RPC are lost and overwritten with the parameters in the configuration file. If you do not already have a backup configuration (*.cfg) file for the controller, create one now for possible use later. For information about creating a file, see “Saving the Controller Configuration to a File” on page 19-14.

---

1. Make sure the laptop computer is connected to the Lufkin Well Manager RPC. For this procedure, see “Connecting the Controller to the Laptop” on page 19-13.

2. Start the *LWM Flash Upgrade Utility* software using one of the following methods:

   - Double-click located on the laptop computer desktop.

   - Click the **Start** button and then select **Programs/Lufkin Automation/Lufkin Utilities/Flash Upgrade**.

   The LWM Flash Upgrade Utility screen should display.

3. Click to connect the software access to the laptop computer communications port.

   A shortcut menu appears with two options.

4. Select the **Use Config Save/Load Baud Rat**e option.

5. In the **LWM Flash Upgrade Utility** screen, click LWM.

   The Configuration File to Restore dialog box appears.

6. In the **Look in** field, select the folder where the *.cfg file is stored.

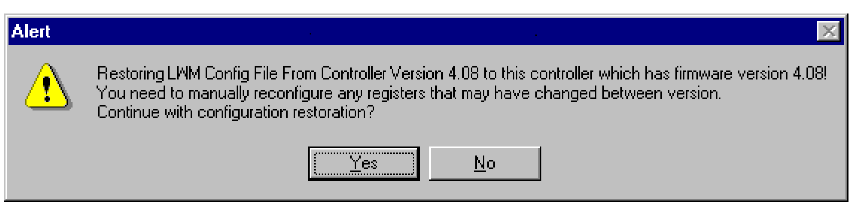
   All *.cfg files stored in the folder are displayed.

7. Do one of the following to select the file you need:

   - Double-click the file name you need.

   - In the **File name** field, type over "Well Name" with the file name you need, and then click **Open**.

   An alert dialog box similar to the one shown below appears informing you that some configuration parameters may need to be manually reconfigured by you after you uploaded the *.cfg file.



8. Do one of the following:

   - ***To continue the uploading process***, click **Yes**.

   - ***To discontinue the uploading process***, click **No**.

You can click ▼ SHOW OUTGOING DATA if you want to display a window showing in hexadecimal format the data being uploaded to the controller.

Click ▲ HIDE OUTGOING DATA when you want to close this window.

9. When finished, click to verify that the configuration parameters in the controller match the parameters saved to the *.cfg file.

   - "Register Values in Lufkin Match File Values" displays in the Message window when they match.

   - If an Unable to Verify message displays, double-check the Comm. Parameter settings and the RS-232 cable connection to the Lufkin Well Manager RPC.

   The Lufkin Well Manager RPC now operates in its normal operation mode.

The Lufkin Well Manager RPC is now operating with the configuration parameters you uploaded. You many need to use the local keypad to check the parameters, and you may need to manually edit some of them.

19.9 Automatically Upgrading Application Firmware

The primary purpose of the *LWM Flash Upgrade Utility* software is to upgrade the application firmware in the Lufkin Well Manager RPC. Flash upgrade files have the "*.lwm" file extension. You can obtain these files from your Lufkin Automation representative.

Note: If you are upgrading both Low Level and Application files, the Low Level file should be upgraded first. After it is successfully upgraded, upgrade the Application file.

Procedure

Use the steps below to upload the updated controller firmware.

WARNING: All configuration programming in the controller is lost during the firmware upgrade. If you do not already have a backup configuration (*.cfg) file for the controller, create one now. For information about creating a file, see "Saving the Controller Configuration to a File" on page 19-14.

---

1. Copy the new application firmware file(s) to a folder on your laptop computer.

2. Make sure the laptop computer is connected to the Lufkin Well Manager RPC. For this procedure, see "Connecting the Controller to the Laptop" on page 19-13.

3. Start the *LWM Flash Upgrade Utility* software using one of the following methods:

   - Double-click 

 located on the laptop computer desktop.

   - Click the **Start** button and then select **Programs/Lufkin Automation/Lufkin Utilities/Flash Upgrade**.

   The LWM Flash Upgrade Utility screen should display.

4. Click  to connect the software access to the laptop computer communications port.

   A shortcut menu appears with two options.

5. Select the **Use Flash Upgrade Baud Rate** option.

6. In the **LWM Flash Upgrade Utility** screen, click 

.

   The File to Upload dialog box appears.

7. In the **Look in** field, select the folder where the *.lwm file is stored.

   All *.lwm files stored in the folder are displayed.

8. Do one of the following to select the file you need:

   - Double-click the file name you need.

- In the **File name** field, type the file name you need, and then click **Open**.

9. Click  to start the uploading process.

   Messages display during the uploading process in the Message window and the actual data being transmitted displays in the Outgoing Data window.

Note: If you do not see messages display, the flash files are not uploading. Repeat steps 6 through 9. If you still do not see messages, you will need to manually upload the files. For instructions about how to manually upload, see “Manually Uploading the Flash Upgrade” on page 19-20.

After the uploading process completes, the Lufkin Well Manager RPC reinitializes (reboots). Its operator interface reads “Reinitializing” during this process. After reinitializing is completed, the operator interface displays the first of the RPC Status screens.

The application firmware is now updated and operational.

The application firmware overwrites the programmed configuration parameters with factory-default values. You need to program the controller-specific configuration parameters into the Lufkin Well Manager RPC. You can program them manually, or if you have a backup *.cfg file containing them, use it.

- For information about uploading the *.cfg file, see “Uploading a Saved Configuration File into the Lufkin Well Manager RPC” on page 19-16.
- For information about manually programming the configuration parameters, see section 8, “RPC Parameter Programming,” and section 9, “Lufkin Parameter Programming.”

19.10 Manually Uploading the Flash Upgrade

Note: If you are upgrading both Low Level and Application files, the Low Level file should be upgraded first. After it is successfully upgraded, upgrade the Application file.

Occasionally conflicts occur that do not allow the *LWM Flash Upgrade Utility* software to automatically load the flash upgrade. If you do not see messages display after you start the automatic upload process, you will need to manually upload the flash files. Manual uploading requires you to perform the uploading process three times, once for each upload type file (App, LL, and db).

Procedure

Use the steps below to perform the manual flash upload process.

1. Start the *LWM Flash Upgrade Utility* software using one of the following methods:

   a. Click 

   located on the laptop desktop.

   b. Click the **Start** button and then select **Programs/Lufkin Automation/Lufkin Utilities/Flash Upgrade**.

2. In the **Comm Parameters** section, fill in the fields.

   - In the **Comm Port** field, select the comm. port where the RS-232 cable is connected.
   - In the **Flash Upgrade Baud Rate** field, enter the highest baud rate value that your laptop will support.
   - In the **RTU Address** field, type in the RTU address of the Lufkin Well Manager. The RTU address is displayed in the RPC Status screen **S_A_M: 1**.
   - In the **Config Save/Load Baud Rate** field, select the baud rate used by the Lufkin Well Manager RPC. Use **S_A_M: 2/3/2/1** to locate the laptop port baud rate of the Lufkin Well Manager RPC.
   - In the **Timing Factor** field, accept the default value of 30.
   - Make sure the **Use Modbus to Start Upload** check box is not marked.

3. Click  to connect the software access to the laptop communications port. Select the Use **Flash Upgrade Baud Rate** option from the drop down menu.

4. Select the firmware upgrade file (App, LL, or db) that you want downloaded.

a. Click the **Browse** command button to open the file selection dialog.

b. Locate the upload file you want and then click **OK**. This file will have the *.lwm extension. File names generally indicate the type of file. Database files will be named “Dbxxxx.lwm” where the “xxxx” string will be a version number. Low level files will be named “LLxxx.lwm”, and Application files will be named “Lufkin xxx.lwm”.

The dialog box closes and the file name and path are written to the **Filename** field. The checksum value for the upload type is written to its respective field.

5. Go to the Lufkin Well Manager RPC, press in and hold **<MENU>**, turn off the power, turn on the power and wait until the Lufkin Well Manager initializes. Continue to press **<MENU>** until a display screen similar to Figure 19-6 with a menu across the lower half of the screen is presented on the Lufkin Well Manager operator interface.

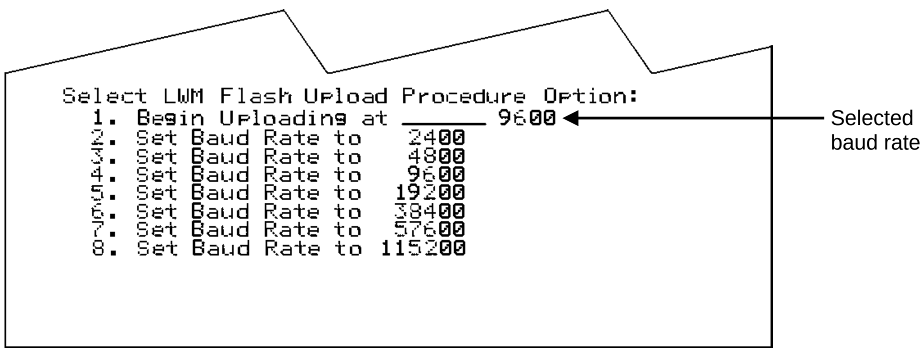


Figure 19-6. Select Lufkin Flash Upload Procedure Option Screen

6. Press the number (2 through 8) representing the baud rate displayed in the **Flash Upgrade Baud Rate** field of the LWM Flash Upgrade Utility screen.

   After you press the number, line 1 displays the value selected.

7. Click  to start the upload process.

   The message ***Waiting for Lufkin Ready Query*** displays in the **Status** field.

8. Press **<1>** on the Lufkin Well Manager RPC keypad.

The Message window in the LWM Flash Upgrade Utility screen reads ***Received Lufkin Ready Query*** and the upgrade process begins. Messages display during the uploading process in the Message window and the actual data being transmitted displays in the Outgoing Data window.

9. After the upload is completed, repeat steps 4 through 8 for each upload type file.

Note: The Lufkin Well Manager RPC automatically tries to reboot after all three upload type files are uploaded. The reboot will probably not be successful until all three of the new files are uploaded. Repeat steps 5 through 10 for each file to be uploaded and the Lufkin Well Manager RPC will successfully reboot after the third file is uploaded.

10. Click to close (disconnect) the software access to the laptop communication port.

11. Click to close the LWM Flash Upgrade Utility screen.

The flash upgrade process is finished. You now need to check the Lufkin Well Manager RPC programming described in the next subsection.

19.11 Disconnecting Communications Between the Controller and Laptop Computer

After you are finished communicating with the Lufkin Well Manager RPC, you need to disconnect communications with the controller and laptop computer and close the *LWM Flash Upgrade Utility* software.

Procedure

Use the steps below to disconnect the software access to the Lufkin Well Manager RPC and laptop computer and close the software.

1. Click to close (disconnect) the software access to the laptop computer communication port.

2. Click to close the LWM Flash Upgrade Utility screen.

You can now disconnect the cable connecting the Lufkin Well Manager RPC to the laptop computer.

Section 20

Troubleshooting

This section attempts to provide a field technician with sufficient information to help determine which major component of the Lufkin Well Manager RPC system needs to be replaced. It does not attempt to assist in circuit board–level repairs.

The topics covered in this section include:

20.1 General Approach

For troubleshooting purposes, the Lufkin Well Manager RPC system should be thought of as being made up of the following major components:

- **Lufkin Well Manager RPC**
  - Power supply
  - Motherboard
  - Load and analog position input board
- **End Devices**
  - Load input devices (polished rod load cell, beam transducer)
  - Position input devices (inclinometer, Hall-Effect RPM and crank)
  - End device cables
- **Output Devices**
  - Radio communication equipment
  - Relays

This section does not attempt to assist in circuit board–level repairs. If the input and output checks listed in this section indicate a circuit board assembly failure, that assembly must be returned to a Lufkin Automation authorized repair shop for repair. With basic hand tools and a reasonable stock of spare parts, an electronics technician with minimum experience should be able to identify and replace failed components and return a Lufkin Well Manager RPC system to normal operation.

20.2 Lufkin Well Manager RPC Diagnostic Tools

The Lufkin Well Manager RPC has several tools available to detect and report a problem, and to help diagnose the cause of the problem. These tools include:

- Well state information on the RPC Status screens (page 20-3)
- Historical load and dynagraph card data (page 20-3)
- Diagnostic screens at the RTU Level (page 20-3)

20.2.1 Well States

The present well state in many cases will be the first indicator that a problem exists with the Lufkin Well Manager RPC system. The well state can point you to the part of the system that should be checked.

Well State	Possible Problem Source
• Unable to Run • Unable to Stop	Check for problem with the Lufkin Well Manager RPC 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

20.2.2 Load/Position Data and Dynagraphs

The Last 400 Load Plot historical screen (**MENU: 3/1/4**) or the shutdown cards (**MENU: 4/3**) in the dynagraph area may give insight into a Bad Load well state. If the 400 Load plot is flat line at either full scale or zero, a lose 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.

20.2.3 Diagnostic Screens

The Lufkin Well Manager RPC has screens available under the RTU Level Menu screen that provide a number of diagnostic and calibration features. These include

- Main board I/O diagnostics
- Communication (page 20-7)

- Keypad (page 20-8)
- Code versions (page 20-8)

Each feature is described separately below.

Main Board I/O Diagnostics

Use the Main Board I/O Diagnostics Menu (**MENU: 2/5/5/2**) to help diagnose main board issues. The diagnostic and calibration features offered include:

- **1. MAIN BOARD I/O STATUS**
  A Main Board I/O Status screen similar to Figure 20-1 shows the present value of the load and position analog inputs, present frequency of the RPM and crank switch digital inputs, and present on/off state of each of the eight discrete points on the Lufkin Well Manager RPC motherboard.

MENU 2/5/5/2/1

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  15:39
                MAIN BOARD I/O STATUS
                         Counts          HZ
   RPM                 0000000000  00000.000
   CRANK               0000000000  00000.000

                       1  2  3  4  5  6  7  8
   Digital Input       *  *  *  *  1  1  1  1
   Digital Output      1  1  0  1  0  0  0  0

                       Currrent Reading
   AI POSITION         0004.93 V
   AI LOAD             0074.32 mV

CRANK SWITCH DEBOUNCE  003.0000    s

LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 20-1. Main Board I/O Status Screen

The **Hz** field for the **RPM** and **CRANK** inputs indicate a value consistent with pumping cycles (strokes) per second and motor revolutions per second when both sensor inputs are working properly. Divide the strokes per minute pumping speed by 60 to obtain strokes per second. To arrive at motor revolutions per second, divide motor RPM by 60. If the Hall-Effect transducer for that input is not connected and working properly, the field for that input indicates a frequency of zero.

The RPM frequency is recalculated and updated every time a motor shaft pulse input is received. Since the motor shaft speed slows and speeds up during a pump cycle in response to the cyclical rod loading, some fluctuation is expected in the displayed RPM **Hz** field. The Crank **Hz** field is typically much more stable.

2. MAIN BOARD AUTO I/O DIAG

MENU 2/5/5/2/2

A Main Board Auto I/O Diag screen (Figure 20-2) used to check that all circuitry is working properly and to re-calibrate the load signal circuitry. Lufkin Automation offers a signal source circuit board assembly that can be used in the field to check that all motherboard circuitry is working properly. The signal source board can also be used to re-calibrate the load signal circuit.

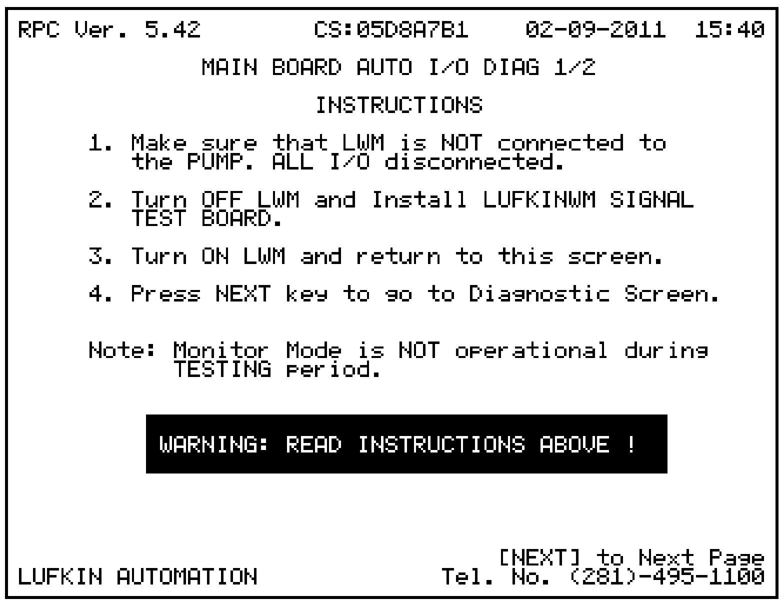


Figure 20-2. Main Board Auto I/O Status Screen 1 of 2

Contact your Lufkin Automation representative about a Lufkin Signal Test Board (Part No. 520.5007). Complete instructions for using the board and the Lufkin Well Manager RPC diagnostic screens is included with the test board.

- **3. MAIN BOARD MANUAL DIO DIAG**

MENU 2/5/5/2/3

The Manual DIO Diag screen (Figure 20-3) used to check the status of each discrete point configured as a digital input, and to verify that discrete end devices are properly connected and functioning as desired. Digital outputs can also be manually turned on and off to check interposing relay connections and action.

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  15:41
             MAIN BOARD MANUAL DIO DIAG

                      INPUTS
        1    2    3    4    5    6    7    8
        ------------------------------------
        0    0    1    0    1    1    1    1
                     OUTPUTS
        1    2    3    4    5    6    7    8
        ------------------------------------
        1    1    0    1    0    0    0    0


     Warning: When performing this diagnostic, make
              sure that none of Digital Port is
              connected.



         Press 1 thru 8 to turn on digital
     Press (0+1) thru (0+8) to turn off digital
LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 20-3. Main Board Manual DIO Diag Screen

- **4. LOAD GAIN CONFIGURATION**
  The Load Gain Configuration screen, (Figure 20-4) in conjunction with the Lufkin Signal Test Board (Part No. 520.5007), makes it easy to field calibrate the load signal circuit. Complete instructions are provided with the Lufkin Signal Test Board.

MENU 2/5/5/2/4

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  15:42
                LOAD GAIN CONFIGURATION
TEST/CALIBRATION PROCEDURE:
   1. Turn OFF LWM and Disconnect ALL I/O.
   2. Install LWM Signal Test Board.
   3. Return to this screen and press ENTER key
      to Perform Gain Test/Calibration.
   Note: Manual CFG is not operational during
         Gain Test/Calibration.

            [ Perform Gain Test/Calibration ]

  Load Gain Manual Cfg:  001 000 000 000  CALIBRATE

                Status:  WAITING FOR CMD

    Load Gain Register:  001 000 000 000

            Calibrated:  010.00  mV

               Reading:  000.00  mV

           % Tolerance:  000.50  %

               % Error:  000.00  %

                                 [ENTER] select option
LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 20-4. Load Gain Configuration Screen

If the load/position analog input board needs to be replaced, use this feature to re-calibrate the load values to factory standards. This operation assures that the Lufkin Well Manager RPC accurately reads and scales the load signal from the polished rod load cell (PRLC).

If the PRLC is out of calibration, use a Load and Position Input Cfg screen (**MENU: 2/5/6**) to access a programming screen similar to Figure 20-8 on page 20-11. It offers an option to re-calibrate the load transducer. Follow the prompts to mark a zero load and to enter a standing valve load value. Obtaining a good standing valve load value typically requires that the well be "weighed" with a calibrated dynamometer system.

Communication

MENU
2/5/5/3

Use the Communications Diagnostic Menu screen (Figure 20-5) to display the most recently received and transmitted data stream in hexadecimal format. Pressing **<Delete>** clears the display and allows you to observe the next communication attempt.

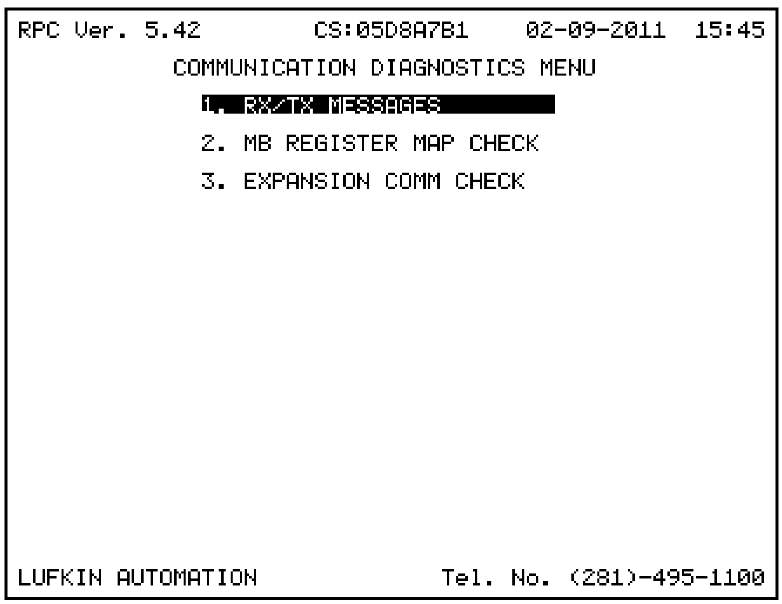


Figure 20-5. Communications Diagnostics Menu Screen

Keypad

Use the Keypad Diagnostic screen (Figure 20-6) to test each key on the keypad.

MENU 2/5/5/4

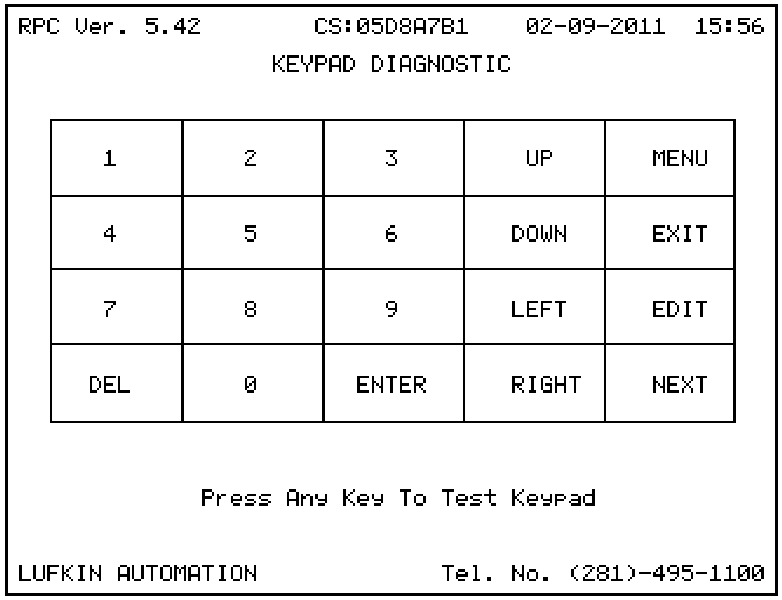


Figure 20-6. Keypad Diagnostic Screen

To exit this screen you must press **<EXIT>** then **<2>** to let the Lufkin Well Manager RPC know that you want to exit this area and not test the **EXIT** key.

For more information about using this screen, see “Keypad Diagnostics” in section 17, “System Diagnostics Tools.”

Code Versions

MENU 2/5/5/5

Use the Code Versions and Checksum screen, similar to Figure 20-7, to display the firmware version number and checksum data for each of the five parts of the Lufkin Well Manager RPC firmware suite presently installed in the unit. A control unit serial number is also displayed on this screen. This information should be collected before calling in a trouble report to Lufkin Automation Technical Services. For more information about the firmware suite components, see “LWM Flash Upgrade Utility Screen” in section 9, “Flash Upgrade.”

```
RPC Ver. 5.42        CS:05D8A7B1    02-09-2011  15:59

              CODE VERSIONS AND CHECKSUMS

                     Version            Checksum
                   -----------         ----------

        CPLD:          022
   Bootstrap:          027             0x00125C2E
   Low Level:          072             0x0050F8A9
 Application:   5 Build 42             0x05D8A7B1
    Database:          004             0x0047088A
Serial Number:  0x71D2AADF00000051




LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 20-7. Code Versions and Checksum Screen

20.3 Inputs to the Lufkin Well Manager RPC

Information is provided for troubleshooting the following input problems:

- Power (page 20-9)
- Load signals (page 20-10)
- Load cells and cables (page 20-12)
- Analog and digital position signals (page 20-13)

20.3.1 Power Input

Power for the Lufkin Well Manager RPC board comes in through the TB1 terminal strip on the upper right corner of the Lufkin Well Manager RPC motherboard. TB1 is also labeled +12V and GND.

Input voltage should measure +13.8 VDC with the red lead on terminal +12 V with respect to the black lead on the GND terminal. The 13.8 VDC comes from the switching power supply on the back panel of the Lufkin Well Manager RPC through the J2 connector on the right edge of the power supply.

The power supply has a two-amp fuse soldered in and located to the right of the AC power input connector on the left edge of the power supply.

The switching power supply is rated for an input voltage range of 85 VAC to 264 VAC.

The hot (black) AC power lead is switched by the On/Off switch mounted on the Lufkin Well Manager RPC front panel and is fused by the 1.5-Amp Slo-Blo fuse mounted next to the power switch..

The primary AC power connects to the Lufkin Well Manager RPC on the LIN (line) and NEU (neutral) terminals on the lower left of the back panel. Primary AC power must be supplied from the motor starter panel, typically from a stepdown control transformer.

20.3.2 Load Signal Input

The load signal input for the Lufkin Well Manager RPC is on terminal strip TB3 on the lower right corner of the motherboard. The load signal conditioning circuit is on a separate analog input circuit board assembly that plugs into the motherboard. 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**
  On terminal strip TB3, terminal **LD1** must read +5.0 VDC with respect to terminal **LD4**. Note that this 5.0-VDC excitation is isolated from the motherboard, so the negative probe of your meter must be on terminal **LD4** of TB3. If the 5.0 VDC 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 **LD2** and **LD3** on terminal strip TB3. Terminal LD2 should be a few MVDC positive with respect to terminal **LD3**. The magnitude of the signal depends on the type of load device used.

  - 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.

Highest Signal Level	Gain Setting
<20 MV	64
>19MV but <75 MV	32
>74 MV	1 or 2

Use the Load and Position Input CFG screen (**MENU: 2/5/6**) similar to Figure 20-8.

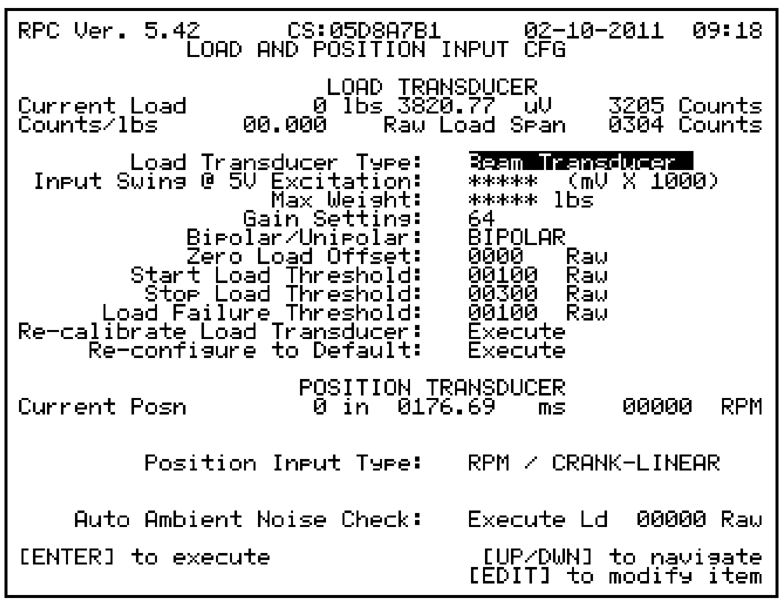


Figure 20-8. Load and Position Input CFG Screen

To change the gain setting,

1. Move the cursor down to that field, and then press <**EDIT**>.
2. Press <↑> and <↓> to view the available options.
3. Press <**ENTER**> when the desired option is displayed.

20.3.3 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 Lufkin Well Manager RPC before taking any readings.

2. Leave the connection in place at the load device end.

3. From the Lufkin Well Manager RPC end of the cable, measure the resistance between wire color pairs as shown below.

   Ohmmeter readings depend on the load cell type in use.

   - **Beam mounted transducer**
     - Red to Black — 350 ±5 Ω
     - Green to White — 350 ±5 Ω
     - Red to Green, Red to White, Black to Green, and Black to White — Should all read 262 ±5 Ω
     - Each wire to earth ground — Ohmmeter on the highest scale; open circuit or infinite resistance
   - **Polished Rod Load Cell**
     - Red to Black — 693 Ω to 770 Ω
     - Green to White — 693 Ω to 707 Ω

For both types of load devices, each wire to earth ground should read greater than 10 MΩ.

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 above 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.

For the PRLC, the pin equivalent of the wire colors listed above is shown in Figure 20-9.

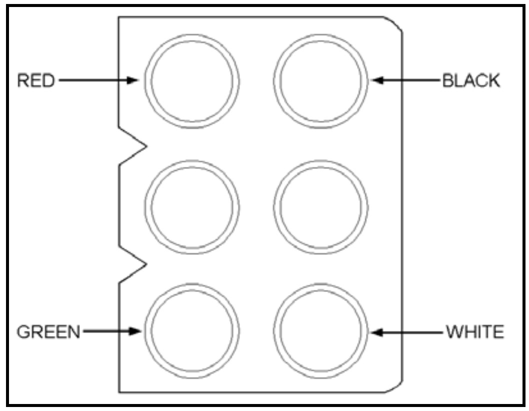


Figure 20-9. Polished Rod Load Cell Connector Diagram

20.3.4 Analog and Digital Position Signal Inputs

The position input to the Lufkin Well Manager RPC can be either analog or digital.

Analog Position Signal

The analog position signal from an inclinometer is connected to terminal strip TB2 on the analog input board. The Analog position signal is a single-ended input in the 0-to-8 VDC range. Analog input must be a smoothly varying signal that increases in the upstroke. Terminal **PO2** should be positive with respect to terminal **PO3**. Voltage levels to check are as follows:

- **Excitation Voltage**
  Terminal PO1 should be +8.0 VDC with respect to terminal **PO3**. If the 8.0 VDC 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 inclinometer cable leads and check the excitation voltage again.

- **Signal Voltage**
  Terminal **PO2** should be positive with respect to terminal **PO3**. The signal magnitude will be 4 VDC with the walking beam horizontal and the inclinometer properly positioned on the beam. Signal level will change at the rate of approximately 30 MV per degree of inclination, increasing in the upstroke. Exact voltage level is not critical as long as it does not go to zero at the bottom of the stroke, or to 8 VDC at the top of stroke, and it is consistent from stroke to stroke. Voltage signal saturated high or low, or an erratic signal, indicates a signal cable problem. With the unit pumping, a static voltage that is not saturated high or low generally indicates an inclinometer failure. The configuration jumper on the inclinometer, having not been removed, may cause an erratic surface dynagraph trace near the top and bottom of the stroke. For more information about the configuration jumper, see “Wiring the Inclinometer” in section 6, “Wiring the System.”

Digital Signal Input

The digital position input is actually two discrete inputs from the Hall-Effect transducers. The Hall-Effect inputs are connected to terminal strip TB4 on the bottom edge of the motherboard. The motherboard has a voltage regulator that provides excitation voltage for the Hall-Effect transducers. Indicator LEDs are provided for both RPM and CSW (crank switch) on the left edge of the motherboard. The RPM LED should blink on and off at a high rate (100 to 200 pulses per pump cycle). The CSW LED should blink on briefly at the bottom of each pump stroke. Voltage levels are as follows:

- **Excitation Voltage**
  Terminal 1 (labeled **+5V**) of terminal strip TB4 must measure +5.0 VDC with respect to terminal 4 of TB4. If the excitation voltage is not correct, either the voltage regulator on the motherboard 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 2 and the CSW signal on terminal 3 of TB4 are pulled up to the motherboard +5 VDC reference voltage through a 150-ohm resistor. Therefore, the voltage level on these terminals should be at about +4 VDC with respect to terminal 4 of TB4 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.

20.4 Outputs from the Lufkin Well Manager RPC

The digital outputs of the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC 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 Lufkin Well Manager RPC turns off an output, the voltage level at the associated terminal on TB5 will be pulled up to about 11 VDC. When the Lufkin Well Manager RPC turns on an output, the voltage level at that terminal will be pulled down to less than 1 VDC.

Digital points 1 through 4 are dedicated as outputs with specific functions.

- **DIO1 —** Error lamp driver for optional indicator lamp. Lamp remains on when the Lufkin Well Manager RPC is in a normal operating mode, and blinks off and on to alert you when an abnormal condition exists.

- **DIO2 —** Motor control output. Pulled low to run the pumping unit, and allowed to pull up high to stop the pumping unit. Normally open contacts on the interposing relay would therefore close to run, and open to stop the pumping unit.

- **DIO3 —** Start alert output that will be held low for the programmed amount of Start Alert Delay time prior to a start of the pumping unit. Designed for use with an audio or visual device to alert an operator that the pumping unit is about to start.

- **DIO4 —** A fault output that is held low at any time that power is on and the Lufkin Well Manager RPC firmware is running properly. In the event of a hardware or firmware fault, the output turns off. By using an interposing relay with normally closed contacts, well control can be automatically switched over to a time clock device when the Lufkin Well Manager RPC experiences a failure.

Use the Main Board Manual DIO Diag screen (see Figure 20-3 on page 20-6) to switch on and off each digital output and to observe the state of each digital input.

20.5 Communications

MENU
2/5/2/1

The Lufkin Well Manager RPC provides two ports to access the primary serial communication channel of the microprocessor. A group of LED indicators is provided on the motherboard adjacent to each port to show activity on the RS-232 signal lines for that port. All firmware-controlled communication-related parameters are programmed from a Communications Administration screen similar to Figure 20-10.

```
RPC Ver. 5.42        CS:05D8A7B1    02-08-2011  13:00
             COMMUNICATION ADMINISTRATION
                  RTU Address:    0001

         Radio Port Baud Rate:    9600
          Delay before Key Up:   00075  ms
                  Key Up Time:   00300  ms
                Key Down Time:   00050  ms
     Enable/Disable Radio CTS:   DISABLE
     Enable/Disable Radio DCD:   DISABLE
        Character Gap Timeout:   003.5  chars 03.65  ms

        Laptop Port Baud Rate:   115200
    En/Disable Laptop RTS/CTS:   ENABLE
        Character Gap Timeout:   003.5  chars 00.30  ms

  Expansion Comm. Mode Option:   RS485
    Expansion Comm. Baud Rate:    9600
                 Key Up Delay:   00075  ms
                  Key Up Time:   00300  ms
                Key Down Time:   00050  ms
       Enable/Disable RTS/CTS:   DISABLE

   Reset Comm Regs to Default:   EXECUTE

[UP/DWN] to navigate            [EDIT] to modify item
LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure 20-10. Communication Administration Screen

The RJ11 port on the left edge of the motherboard shown in Figure 20-11 is designed for use as a radio port.

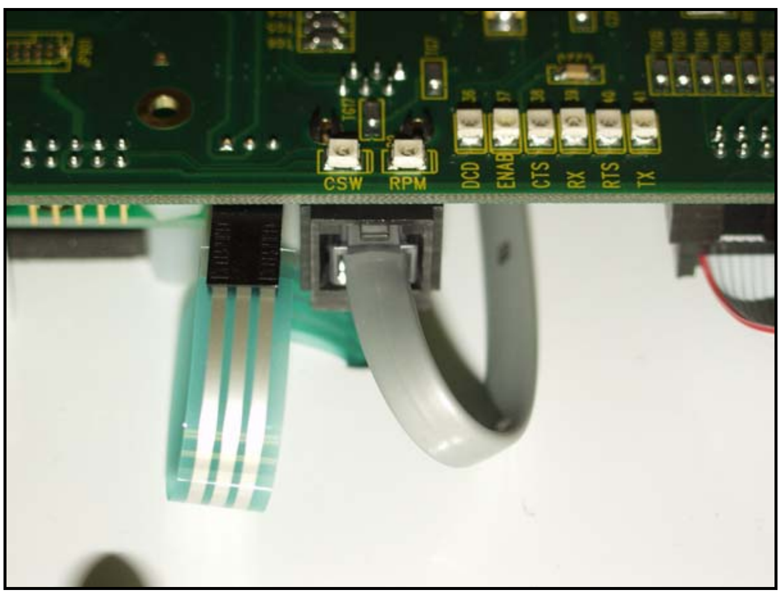


Figure 20-11. RJ11 Port on Motherboard

The table below lists the pin-out function for that port. Pin 1 is on the end nearest the RPM LED.

Pin #	Function
1	Data Carrier Detect (DCD)
2	Transmit Data (TD)
3	Receive Data (RD)
4	Signal Common (GND)
5	Request to Send (RTS)
6	Clear to Send (CTS)

Note on Figure 20-10 that the radio port has several programmable functions including baud rate, key up and key down times, and enable/disable of DCD and RTS/CTS functions as desired to be compatible with the data transmission device used.

The DB9 port on the front panel is intended as the laptop computer port. Pin out for active functions on the DB9 port are provided in the table below.

Pin #	Function
1	Data Carrier Detect (DCD)
2	Transmit Data (TD)
3	Receive Data (RD)
4	Data Terminal Ready (DTR)
5	Signal Common (GND)
6	Data Set Ready (DSR)
7	Request to Send (RTS)
8	Clear To Send (CTS)
9	Ring Indicator (RI)

Laptop computer software must raise the DTR line to switch the Lufkin Well Manager RPC to the laptop port. Note on Figure 20-10 that the Lufkin Well Manager RPC can be programmed to work with or without an RTS/CTS handshake.

The communication protocol for the Lufkin Well Manager RPC is RTU Modbus with a default data format of eight data bits, no parity, and one stop bit. For information about how to modify this data format, see “Configuring Modbus Transmission Mode” in section 9, “Lufkin Parameter Programming.” The Lufkin Automation ELAM protocol builds on the standard Gould Modicon Modbus to allow more RTU addresses, larger data blocks, and multiple message transmission.

If you are interested in developing interrogation software, contact your Lufkin Automation representative for a copy of the ELAM specification and a Modbus register map for the Lufkin Well Manager RPC.

Appendix A

Auto Downtime Feature

This appendix describes the purpose of the Auto Downtime feature and how to program for an auto downtime test.

The topics covered in this appendix include:

A.1 Overview

When rod pump control is used on a well, the most important consideration is properly detecting the pumped-down condition. You do not want to stop pumping action too early and thereby lose fluid production. You also do not want to over pump the well and shorten the life of the pumping equipment.

A secondary important consideration is how long should the well be left idle? In other words, what value should be used for the downtime? Long idle times (downtimes) can allow enough fluid to accumulate in the well bore to start restricting inflow from the reservoir. This results in a loss of fluid production. On the other hand, if the downtime is too short, the pumping unit will cycle on/off very frequently with possible penalties on electrical power costs and excess wear on motor starter equipment.

A plot of pumping time (runtime) versus downtime for any well will have a shape similar to Figure A-1. If the downtime is made long enough, the fluid level in the well bore stabilizes at the static fluid level. From that fluid level, the time to pump the well back down to the producing fluid level depends solely on the lift capacity of the pumping system. Further downtime increases will not affect the pumping/runtime. Operating a well with a downtime that long results in lost fluid production.

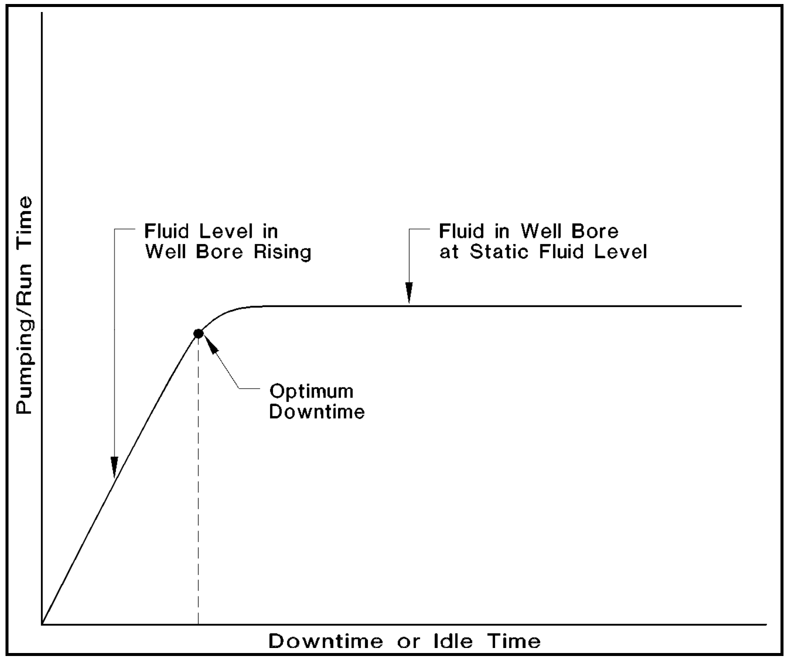


Figure A-1. Runtime vs. Downtime Curve

Optimum downtime for a given well is the point in the curve of Figure A-1 where the up-to-the-right portion of the curve at the left-hand end begins to roll over into the horizontal flat portion to the right.

The Lufkin Well Manager RPC is capable of developing the runtime/downtime curve for a well and selecting the optimum downtime from that curve. This feature is referred to as “auto downtime.”

The Lufkin Well Manager RPC algorithm steps through a progression of incrementing downtimes and records the runtime associated with each downtime interval to develop the runtime/downtime plot. The user programs the desired increment size in minutes and decides to either run the full algorithm of 15 steps or to only run as far as necessary to find the rollover knee.

A.2 Auto Downtime Algorithm

MENU 2/1/1/1

You initiate the auto downtime routine when you select the **Automatic** option for **Downtime Mode** on the RPC Control Parameter screen (Figure A-2).

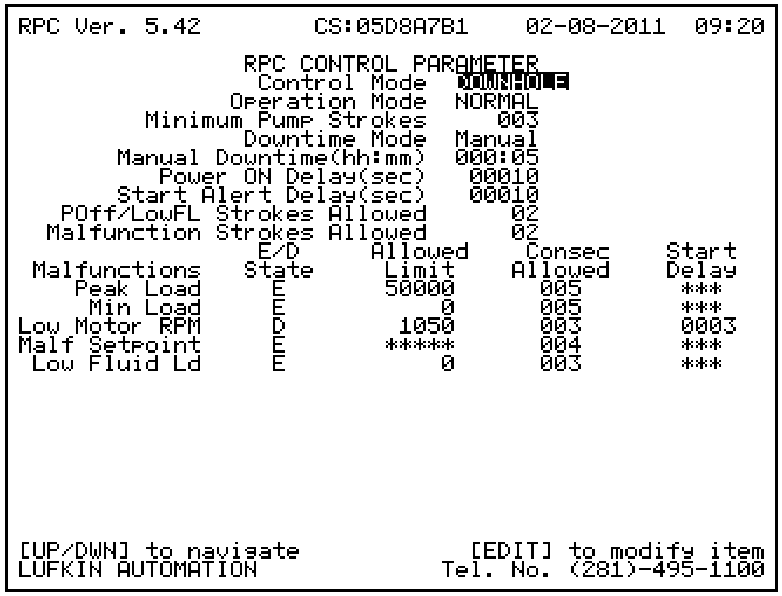


Figure A-2. RPC Control Parameter Screen

When the Automatic mode is selected, fields appear for you to specify the auto downtime step size (**Auto DT Step**) and to select a Yes or No response for **Run to Max**.

- **YES** produces a more complete plot of 15 downtime steps, but at the cost of a longer test time to develop the curve and possible loss of fluid production due to the longer downtimes in the latter part of the test cycle.

- **NO** usually works best since as few as six steps may be all that are necessary to find the rollover point on the curve.

If the pumping unit is running when the programming steps are completed, the pump will continue to run until the next pumpoff. If the pumping unit is in a Downtime well state when you complete the programming, the unit will remain down for the previously programmed manual downtime, then the pump will start and pump until the next pumpoff.

The next time the well shuts down for pumpoff, the downtime value is set equal to the Auto DT Step programmed. After this downtime elapses, the pumping unit starts and runs until pumpoff occurs. Runtime is recorded. This step is repeated to obtain four samples of runtime with this downtime value. The average of the four runtime samples is recorded as Runtime1. Figure A-3 illustrates Runtime 1 as point 1.

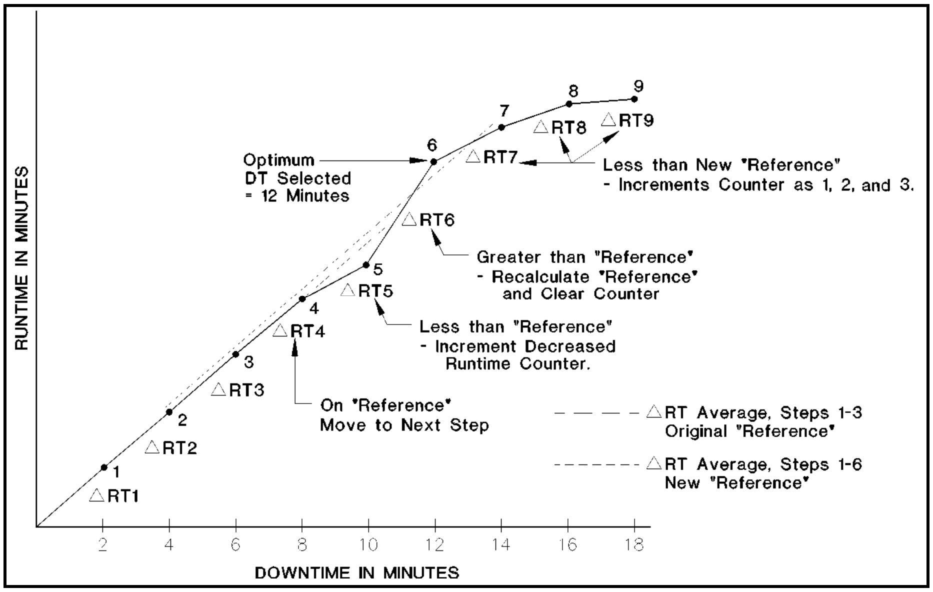


Figure A-3. Runtime/Downtime Curve Plot Illustrating Nine Runtime Steps

The downtime value is then incremented by one step size (that is, DT Step times 2), and the well is allowed to operate four cycles with the new downtime. The average runtime for this second downtime is calculated and recorded as Runtime 2 (point 2 in Figure A-3).

The Downtime is then incremented to a value of DT Step times three and the average runtime for four cycles is calculated and recorded as Runtime 3 (point 3 in Figure A-3).

At this point in the process, the average runtime difference is calculated using the formula:

$$\frac{(\,Runtime\ 1 - 0\,) + (\,Runtime\ 2 - Runtime\ 1\,) + (\,Runtime\ 3 - Runtime\ 2\,)}{3}$$

The average value is saved as the “reference” for best downtime determination.

The process of incrementing downtime by the DT Step amount and calculating the average runtime of four pumping cycles for each downtime value is repeated to obtain additional points for the plot.

After each successive step, before initiating the next step, the runtime difference (ΔRT) between that step and the previous step is compared to the “reference” average runtime difference for the first three steps.

If the runtime difference between a step and the previous step is less than the reference but greater than or equal to the reference minus 15 seconds, the algorithm moves to the next step. This difference is illustrated as ΔRT4 in Figure A-3.

If the runtime difference between a step and the previous step is less than (“reference” – 15 seconds), a counter of decreasing runtime differences is incremented and the next step is initiated. This difference is illustrated as ΔRT5 in Figure A-3.

If however, the runtime difference for a given step is greater than or equal to the “reference” (illustrated as ΔRT6 in Figure A-3), a new “reference” is calculated as the average for all samples up to and including the runtime difference for that step. Any time that the “reference” is recalculated, the counter of decreasing runtime differences is reset to zero. The next step is initiated after the new “reference” is calculated.

This process of taking a step and analyzing the results for that step is repeated until either the decreasing runtime difference counter reaches a count of three or the maximum downtime step is completed. The maximum downtime would be the DT Step value times 15 possible steps. When the counter reaches a count of three, the downtime associated with the step-3 points before is selected as the optimum downtime.

To complete the process, the auto downtime algorithm then sets the Downtime mode back to Manual. If the decreasing runtime difference counter had reached a count of three (i.e., a rollover knee was found), the downtime is set for the value selected as the optimum downtime. If the auto downtime algorithm ran all 15 steps without finding a rollover knee, the downtime value is set for the maximum value of DT Step times 15.

A.3 Auto Downtime Interrupts

The following occurrences will cause the auto downtime algorithm to pause or stop completely:

- If a runtime for a step exceeds 420 minutes (7 hours), the auto downtime test stops and a status flag of “Maximum Run” is set. The Lufkin Well Manager RPC is reset to the Manual Downtime mode with the original manual downtime value.

- If any malfunction event occurs (peak load, peak torque, malfunction set point, etc.), the test stops. The control is reset to the Manual Downtime mode with the original manual downtime value. The regular well state message on the RPC Status screen alerts the operator to the condition.

- If the Lufkin Well Manager RPC is unable to run or unable to stop the pumping unit, the auto downtime algorithm pauses until the cause of the problem is corrected. The test will then proceed with adding new points to the previously collected data.

A.4 Practical Considerations

Consider the following recommendations before trying to perform an auto downtime test.

- The Lufkin Well Manager RPC should be installed, programmed, and allowed to control the well for at least one day to be sure that the well is in a stable pumped-down condition.

- Review the 24-hour history of the Off/On cycles of the well to determine if the auto downtime algorithm has a chance of working with a particular well. Access the plot using **MENU: 3/1/1**.

  If the runtimes are fairly consistent for the manually programmed downtime, a fairly stable well bore condition is indicated and the auto downtime algorithm should reach a logical conclusion.

  If however the run cycles are very erratic (such as some short cycles, followed by a long cycle, and then more short cycles), the well bore response is very erratic and the auto downtime algorithm will probably not be able to arrive at a logical decision regarding optimum downtime. Erratic well bore response is typically due to free gas in the pump barrel interfering with good pump action.

- If conditions seem favorable for a valid auto downtime test, program a fairly small DT Step for a first attempt. A step of five to ten minutes is recommended. It is further recommended that **NO** be selected in the **Run to Max** field.

The auto downtime algorithm will not initiate another test session on its own. You must manually initiate another test by accessing the RPC Control Parameter programming screen (Figure A-2).

A.5 Viewing Auto Downtime Results

MENU
3/1/6

The plot of runtime versus downtime developed by the auto downtime algorithm can be viewed on the Lufkin Well Manager RPC LCD screen. Use the Auto Downtime Plot option (**MENU: 3/1/6**) after the auto downtime algorithm is executed to access the plot.

A.6 Programming for an Auto Downtime Test

MENU
2/1/1/1

Before you attempt an auto downtime test, the Lufkin Well Manager RPC pumpoff control parameters must all be programmed. Also, you must verify that the well is actually cycling off and on as a result of the pump off control parameter settings.

To program for the auto downtime test, follow the steps below.

1. From the **Main Menu** screen, select **2. PROGRAM** to display the Programming Menu screen, and then select **1. RPC APPLICATION** to display the RPC Parameters Menu screen.

Note: If you have another screen displayed, press **<MENU>** to instantly return to the Main Menu screen.

---

2. Select **1. RPC PARAMETERS** and then select **1. CONTROL PARAMETERS** to display a RPC Control Parameter screen similar to Figure A-2. (page A-3).

3. Press <↑> and <↓> to highlight the **Downtime Mode** field.

4. Press <**EDIT**>, press <↑> and <↓> to highlight the **Automatic** option, and then press <**ENTER**>.

5. Move the cursor to the **DT Step** field, press <**EDIT**>, and then use the number keys to enter the desired value.

6. When the value is correct, press <**ENTER**>.

7. Move the cursor to the **Run to Max** field, press <**EDIT**>, press <↑> and <↓> to display the desired option, and then press <**ENTER**>.

8. Press <**MENU**> to return to the MAIN menu.

The auto downtime algorithm starts the test session after the next pumpoff occurs.

Appendix B

Valve Checks, Counter Balance Effect, and Residual Friction

This appendix explains how to record reference and work data sets, mark standing valve and traveling valve loads, residual friction, and counterbalance effect, and store this data for analysis.

The topics covered in this appendix include:

B.1 About Reference Data and Working Data

MENU 3/1/5

The Lufkin Well Manager RPC is capable of storing two sets of records that contain up to 1,200 load and position samples versus time. These records can be analyzed to measure traveling valve (TV) and standing valve (SV) loads, residual friction (RF), and counterbalance effect (CBE). Two data sets are available at any time. The data sets are:

- Reference Data (REF DATA) saved from a previous valve check analysis operation
- Working Data (WRK DATA) from a data gathering session just completed

REF DATA can be overwritten with a new analysis of the WRK DATA at any time. Date and time stamps are provided on both data sets to help you choose the desired data for analysis or viewing.

The Lufkin Well Manager RPC samples load and position values five times per second when recording valve check data. The valve check data gathering and analysis features are accessed from the RPC Valve Check Menu screen (Figure B-1).

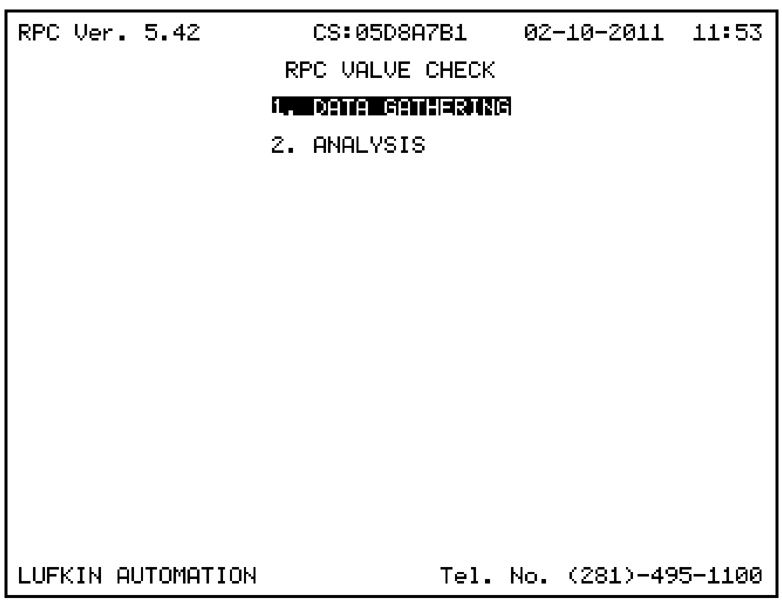


Figure B-1. RPC Valve Check Menu Screen

B.2 Data Gathering

MENU 3/1/5/1

To begin recording valve check data, select **1. DATA GATHERING** from the RPC Valve Check Menu screen to display a Valve Check Data Gathering screen similar to Figure B-2.

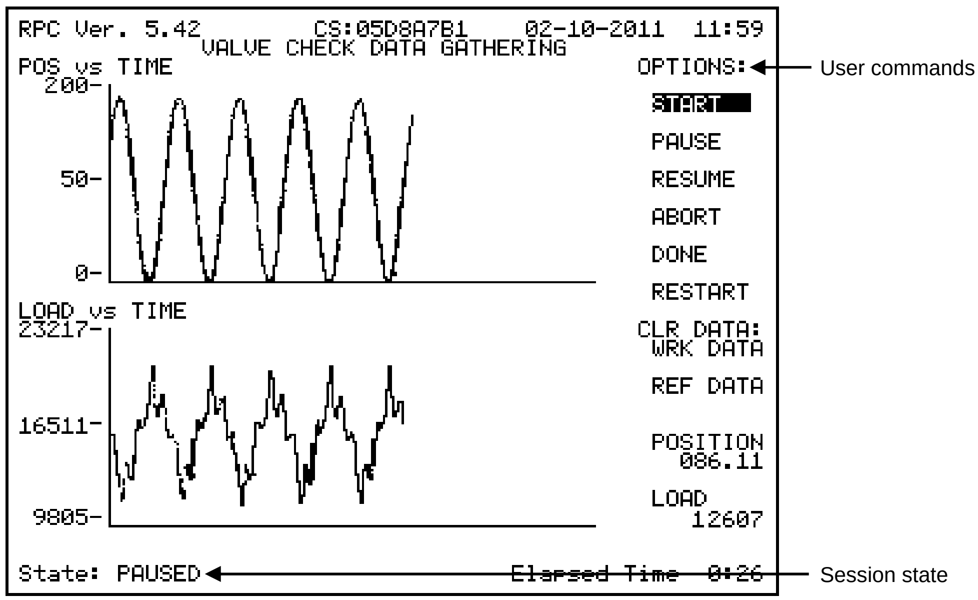


Figure B-2. Valve Check Data Gathering Screen

The Lufkin Well Manager RPC immediately starts displaying load and position–versus–time data, but a data gathering session is not started until you select the **START** option.

Note: The position trace is not available if Hall-Effect transducers are used for position input since the unit may reverse direction at any time causing the Lufkin Well Manager RPC to lose its position reference.

B.2.1 Session States

The “state” of the data gathering session is displayed in the lower left corner of the screen. You will most likely see one of the following data gathering session states on the lower left corner of the screen:

- **IDLE STATE** — User must select **START** option to initiate a data recording session.

- **WAITING-CMD** — User must select the appropriate command option; i.e., **START**, **SAVE**, or **EXIT**.

- **DATA GATHERING** — Recording session is in process.
- **PAUSED** — User must select **RESUME** to continue session.
- **TIMEOUT** — The 1,200-point buffer is full. User may elect to save data or start a new session.

B.2.2 Data Gathering User Options

To select a command option or to clear data, press <↑> and <↓> to highlight your choice with the cursor, and then press <**ENTER**>. The options available include:

- **START** — Begins the recording session.
- **PAUSE** — Conserves the four minutes of actual data time available.
- **RESUME** — Continues the present session after a **Pause**.
- **ABORT** — Ends the present session and clears the data screen.
- **DONE** — Stores the displayed data to the working data set file. This action overwrites working data from the previous session.
- **RESTART** — Ends the present session and starts a new session.

From the Valve Check Data Gathering screen, you also have the option to clear data (**CLR DATA**). This function clears from memory the reference data and/or working data presently stored. Saving new data overwrites any existing data, so a clearing is not required.

B.2.3 Starting a Recording Session

Use the procedure below to start a data recording session. You can record a total of four minute's worth of data.

Note: To end a session without saving data, press <**EXIT**> at any time during the session.

1. At the Valve Check and Data Gathering screen (**MENU: 3/1/5/1**), press <↑> and <↓> to highlight the **START** option, and then press <**ENTER**>.

   The screen clears and the load and position traces begin drawing from the left hand edge.

2. At this time you can record a total of four minute's worth of data. The **PAUSE** and **RESUME** options give you the flexibility to take more than four minutes of actual time to record the four minutes of data. If the data gathering buffer reaches the full 1,200 points before you finish, the session state switches to TIMEOUT. At this point you can save the data recorded by selecting the **DONE** option, or start a new recording session by selecting **RESTART**.

3. When the state reads **DATA GATHERING**, move promptly to the pumping unit H-O-A switch and brake to stop the unit at different points in the stroke to record load values for traveling valve (TV), standing valve (SV), counterbalance effect (CBE), and residual friction (RF).

4. For recording valve loads and CBE, consider the following tips:

   - Stop the pumping unit as gently as possible near the top of the upstroke for traveling valve checks, and near the bottom of the downstroke for standing valve checks. Multiple stops can be made on each upstroke and downstroke if the counterbalance of the pumping unit does not cause a reversal of direction when you release the brake. Hold the pumping unit with the brake for approximately one pump cycle time (for example, 6 seconds at 10 SPM) for each valve check.

   - To record data for pump leakage calculations, stop the pumping unit on the upstroke for a TV or plunger/barrel measurement, and on the downstroke for a SV leak measurement. Allow enough time to record the load change, usually 5 to 10 seconds.

   - Weigh the counterbalance with the cranks within about 30 degrees of horizontal on either the upstroke or downstroke. The brake must be fully released with the unit at rest. If the unit is engine-driven, the clutch must not be dragging.

     If the unit will not remain at rest on the upstroke, try weighing the counterbalance on the downstroke (and vice versa). If the pumping unit is stopped on the upstroke and the rods tend to fall back into the hole (under-balanced condition), hold the unit with the brake and wait for the fluid load on the pump to leak off. Eventually the unit may remain at rest after the brake is released. Use the **PAUSE** and **RESUME** commands to conserve recording time.

In extreme over-balanced cases, it may be necessary to chain the pumping unit on the downstroke. Stop the unit near the middle of the downstroke stroke and set the brake. Connect the chain from the wellhead to the polished rod below the carrier bar; use a polished rod clamp if necessary. Do not chain to the carrier bar. Release the brake slowly to transfer the load to the chain. The chain can be easily removed by momentarily turning on the motor to create slack in the chain and then resetting the brake.

In extreme under-balance cases, measure counterbalance on the upstroke. Stop the unit near the middle of the upstroke stroke and set the brake. It may be necessary to clamp the polished rod above the stuffing box. If a polished rod liner is installed, place a clamp above the liner head and prop up the rods with knock-off spacer(s) between the stuffing box and liner head. Slowly release the brake to transfer the load to the wellhead. The knock-off spacer(s) can be easily removed by momentarily turning on the motor to create a space between the stuffing box and liner head.

- Use the **PAUSE** and **RESUME** commands to avoid recording needless data while connecting and disconnecting the chain (over-balanced condition) or installing and removing the polished rod clamp or knock-off spacer(s) (under-balanced condition).

Note: If Hall-Effect position input is used, it is important to note if CBE was measured in the upstroke or the downstroke, as well as the position of the polished rod from the bottom of the stroke. That data is needed for analysis.

---

5. To measure residual friction (RF), stop the pumping unit on the upstroke and set the brake. RF is defined as the load difference between the lowest SV measurement and a leaked off TV measurement. Use the **PAUSE** option to conserve available data space. About once a minute, briefly use the **RESUME** option to see if the load is still decreasing. If the load is decreasing, use **PAUSE** and wait another minute. The indicated load in the lower right corner can also be monitored. When the load stops decreasing, the fluid load has completely leaked off. Typically the RF, in pounds, will be about 10 percent of the pump depth in feet; i.e., 500 pounds of RF for a 5,000-foot well would be considered normal.

6. To analyze the data easier, consider using the same sequence of actions each time that valve check data is recorded. For example, you might stop the unit at 60 percent and then 90 percent of the way into the upstroke to record two TV loads, and then stop twice on the next downstroke to record two SV loads. This method assures consistency. The CBE load could then be recorded with the final step being the measurement for RF. RF is usually the last step performed during the data gathering process. This routine sequence helps locate the correct part of the load-versus-time trace when doing the analysis. This is particularly helpful when the Lufkin Well Manager RPC system has Hall-Effect position transducer input, since no position-versus-time plot is available.

   When the pumping unit balance makes it difficult to record CBE, use the **PAUSE** option to conserve the available four minutes of session time and then use **RESUME** when you are ready to begin recording again.

7. If you are not satisfied with the results obtained from the recording session, do either of the following to start a recording session over again:

   - Press <↑> and <↓> to highlight **RESTART** and then press **<ENTER>** to clear the screen and start a new four-minute session.

   - Press <↑> and <↓> to highlight **ABORT** and then press **<ENTER>**to end the session and clear the screen. You must, however, select either **START** or **RESTART** to initiate the new session.

B.2.4 Ending a Recording Session

After you are satisfied with the load data that is recorded, you need to save it as the current working data set (WRK DATA).

Note: To end a session without saving data, press <**EXIT**> on the operator interface keypad at any time during the session.

Use the procedure below to save the data and end the recording session.

1. When the load data that you want to save is recorded, press <↑> and <↓> to highlight **DONE** and then press **<ENTER>** to save the recorded data as the current working data set.

   Notice that the session state changes to **WAITING-CMD** after **DONE** is selected.

2. Press <**EXIT**> on the operator interface keypad to return to the RPC Valve Check Menu screen.

You can now use this data for valve check analysis

B.3 Valve Check Analysis

MENU 3/1/5/2

To display the recorded valve check data for analysis, select **2. ANALYSIS** from the RPC Valve Check Menu screen to display a Valve Check Analysis screen similar to Figure B-3. This screen displays all of the data from the working data set.

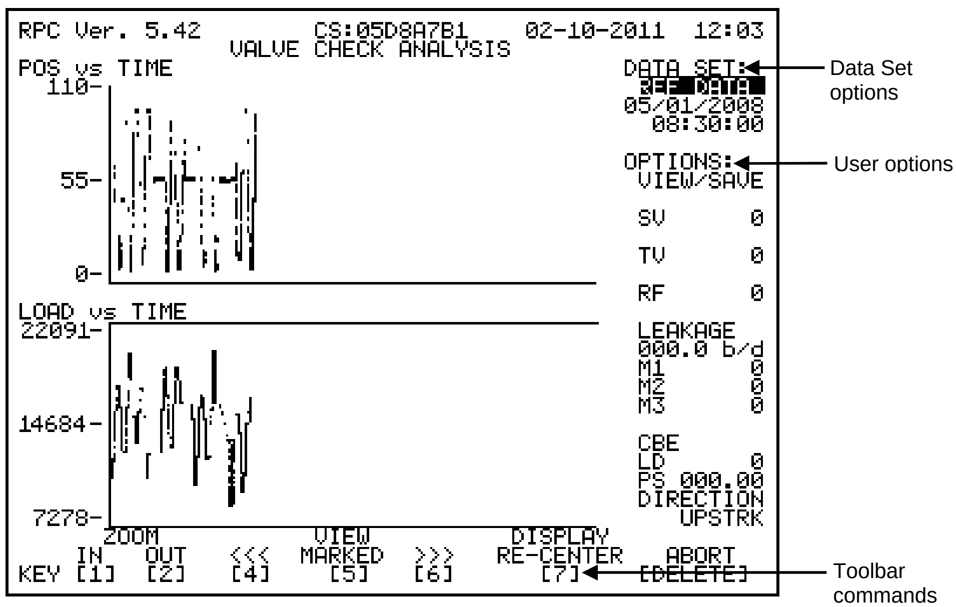


Figure B-3. Valve Check Analysis Screen

If the full 1,200 points were saved in the previous recording session, this display will be very compressed on the time axis and will therefore be difficult to analyze. Use the zoom-in feature (**[1]**) available in the toolbar at the bottom of the screen to expand the trace for easier analysis. The toolbar is described on page B-10.

To analyze the SV, TV, CBE, and data gathered, you will need to perform the following procedures:

- Marking standing valve load
- Marking traveling valve load (page B-12)
- Marking residual friction load (page B-12)

- Calculating traveling valve leakage (page B-13)
- Marking counter balance effect load (page B-13)
- Saving the analysis as reference data (page B-14)
- Returning to normal operation (page B-14)

Each procedure is described separately below, but before you begin these operations, familiarize yourself with the user options described below.

B.3.1 Data Analysis User Options

Three types of user options are available on this screen:

- Data set options
- User options
- Toolbar commands

Data Set Options

The data set allows you to select either the working data set (**WRK DATA**) for a new analysis, or the reference data set (**REF DATA**) to view a previous analysis.

Use the procedure below to select a data set.

1. Press <↑> and <↓> to highlight the **DATA SET** field, press <**EDIT**>, and then press <↑> and <↓> to toggle between **WRK DATA** and **REF DATA**.
2. After the desired choice is displayed, press <**ENTER**> to select that data set and display it on the screen.

Notice that the date/time stamp for the selected data set is displayed when the selection process is completed.

Note: A new analysis cannot be performed on REF DATA. It is only available for viewing.

B.3.2 User Options

The options available include:

- **VIEW** — Select to view the REF DATA set.

- **SAVE** — Select after completing an analysis of the WRK DATA, overwrite REF DATA set with the current analysis.
- **SV** — Select to mark the standing valve load.
- **TV** — Select to mark the traveling valve load.
- **RF** — Select to mark residual friction.
- **LEAKAGE – M1** — Select to mark the first valve leakage point.
- **LEAKAGE – M2** — Select to mark the second valve leakage point.
- **LEAKAGE – M3** — Select to mark the third valve leakage point.
- **CBE** — Select to mark the counterbalance effect load.

Note: Selecting any user option except **VIEW** and **SAVE** accesses the toolbar at the bottom of the screen as indicated by the cursor.

To select a user option, press <↑> and <↓> to highlight the option you want under **OPTIONS** and then press <**ENTER**>.

Toolbar Commands

The toolbar is located across the bottom of the Valve Check Analysis screen and is used to identify the "hot" number keys that you can press on the operator interface keypad to execute certain operations. For example, to zoom in on a portion of the data record, press <**1**>. The toolbar is accessible after you select any user option except **View** and **Save**.

Toolbar functions and their respective hot keys are shown in the table below.

Hot Key	Function
<**1**>	Zoom in
<**2**>	Zoom OUT
<**4**>	<<< (move crosshairs to the left)
<**5**>	Marked (capture marked value)
<**6**>	>>> (move crosshairs to the right)
<**7**>	Re-center display
<**DELETE**>	Abort (exit tool bar without marking)

If you press and hold **<4>** or **<6>**, the crosshairs will continue to move to the left or right until the key is released.

B.3.3 Marking Standing Valve Load

Use the procedure below to mark the standing valve (SV) load.

1. Press <↑> and <↓> to highlight the **SV** option and then press <**ENTER**>. The cursor moves to the toolbar and highlights the **Zoom In** function.

2. Press <**1**> to expand the x-axis of the display. A screen similar to Figure B-4 displays. Notice that the crosshairs indicate the load/time coordinates on the load trace.

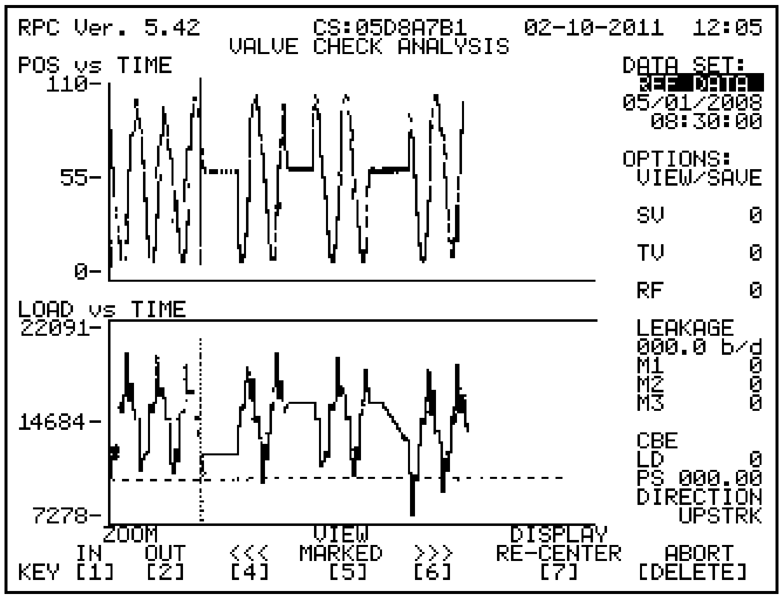


Figure B-4. Toolbar Active in Valve Analysis Screen

3. Press <**4**> or <**6**> to move the crosshairs to the part of the record that contains the loads at the point where the SV load was measured. Notice that the load value shown in the SV field tracks motion of the cross hairs.

4. When the crosshairs are located where desired, press <**5**> to mark the SV load and exit the toolbar. The SV load is generally considered the minimum load with the pumping unit stopped (ignoring any transient dynamic loads). If the unit is stopped too abruptly, a higher load may be recorded which is not the true SV load.

B.3.4 Marking Traveling Valve Load

Use the procedure below to mark the traveling valve (TV) load.

1. Press <↑> and <↓> to highlight the **TV** option and then press <**ENTER**>. The cursor moves down to the toolbar.

2. Press <**1**> to expand the x-axis of the display. A screen similar to Figure B-4 displays. Notice the crosshairs that indicate the load/time coordinates on the load trace.

3. Press <**4**> or <**6**> to move the crosshairs to the part of the record that contains the loads at the point where the TV load was measured. Notice that the load value shown in the **TV** field tracks motion of the cross hairs.

4. When the crosshairs are located where desired, press <**5**> to mark the TV load and exit the toolbar. The TV load is generally considered the maximum load with the pumping unit stopped (ignoring any transient dynamic loads). If the unit is stopped to abruptly, some of the load may be lost resulting in a lower recorded load than the true TV load.

B.3.5 Marking Residual Friction Load

Use the procedure below to mark the residual friction (RF) load.

1. Press <↑> and <↓> to highlight the **RF** option and then press <**ENTER**>. The cursor moves down to the toolbar.

2. Press <**1**> to expand the x-axis of the display. A screen similar to Figure B-4 (page B-11) displays with a horizontal dashed line added at the marked standing valve load level. Notice that the crosshairs indicate the load/time coordinates on the load trace. The cross hairs are positioned at the end of the load trace, since the marking of RF is usually the last procedure performed during the data gathering session.

3. Press <**4**> or <**6**> to move the crosshairs to the part of the record that contains the loads at the point where the RF load was measured. Remember that the RF load is typically a few hundred pounds greater than the SV load. Notice that the load value shown in the RF field tracks motion of the cross hairs.

4. When the cross hairs are located where desired, press <**5**> to mark the RF load and exit the toolbar.

B.3.6 Calculating Traveling Valve Leakage

Use the procedure below to calculate the traveling valve leakage.

Note: In order for the leakage calculation to work properly, a value must be entered for the **Pump Depth** field on the LWT/PIP Parameters screen. Use **MENU: 2/1/3** to access the LWT/PIP Parameters screen. For information about this field, see "Configuring LWT/PIP Parameters" in section 8, "RPC Parameters Programming."

---

1. Press <↑> and <↓> to highlight the **M1** option under the **LEAKAGE** heading and press <**ENTER**>. The cursor moves down to the toolbar.

2. Press <**1**> to expand the x-axis of the display. A screen similar to Figure B-4 (page B-11) displays. Notice that the crosshairs indicate the load/time coordinates on the load trace.

3. Press the <**4**> or <**6**> to move the crosshairs to the part of the record that contains the load data at the point where the traveling valve leak was recorded. Notice that the load value shown in the M1 field tracks motion of the crosshairs. The **M1** point should be at the start of the TV check period where the unit was stopped and the load first starts to drop off due to the leak.

4. When the crosshairs are located where desired, press <**5**> to mark the M1 load and exit the toolbar.

5. Mark points **M2** and **M3** using the same steps as used to mark **M1**. Points **M2** and **M3** will normally be marked to the right of M1, at a lower load value than **M1**, and at approximately equal time intervals.

6. After marking point **M3** observe the calculated traveling valve leakage rate in Barrels per Day (B/D) under the **LEAKAGE** heading.

B.3.7 Marking Counterbalance Effect Load

Use the procedure below to mark the counterbalance effect load.

1. Press <↑> and <↓> to highlight the **CBE** section and then press <**ENTER**>. The cursor moves down to the toolbar.

2. Press <**1**> to expand the x-axis of the display. A screen similar to Figure B-4 (page B-11) displays with a horizontal dashed line added at the marked standing valve load level. Notice that the crosshairs indicate the load/time coordinates on the load trace.

3. Press <**4**> or <**6**> to move the cross hairs to the part of the record that contains the loads at the point where the CBE load was recorded. Notice that the load value shown in the **CBE Load** field tracks motion of the crosshairs.

4. When the crosshairs are located where desired, press <**5**> to mark the CBE load and exit the toolbar.

5. If an analog position input is used, the corresponding position is also recorded when the CBE load is marked. If the Hall-Effect position input is used, the position must be manually entered, which is done by editing the **CBE-PS** field and entering the correct value. To assure accuracy, the CBE position should be measured during the recording session. If that is not feasible, the position can be estimated; for example, one half of the surface stroke length plus or minus a few inches as observed during the recording session.

6. You must also enter the correct Upstroke/Downstroke selection in the **DIRECTION** field. That field is not shown on Figure B-3 (page B-8) but will be added by the Lufkin Well Manager RPC firmware as appropriate. The **DIRECTION** field is added just below the **PS** field in the CBE part of the screen.

B.3.8 Saving the Analysis as Reference Data

Use the procedure below to save your analysis as a new reference data set (RF).

1. Review the results of the analysis.

2. If you are satisfied that they are reasonable, Press <↑> and <↓> to highlight the **SAVE** option and then press <**ENTER**>.

The analysis is saved as the new REF DATA set and an **Analysis Saved** message appears on the screen for a few seconds.

B.3.9 Returning to Normal RPC Operation

Press <**EXIT**> and then <**MENU**> to return to the Main Menu screen and resume normal RPC operation.

Appendix C

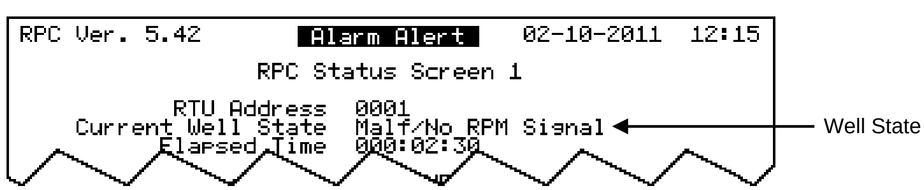
Well State List

This appendix defines the well states that the Lufkin Well Manager RPC can be in at any given time.

The topics covered in this appendix include:

C.1 Overview of the Well State Types

The Lufkin Well Manager RPC 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 the RPC Status screen along with the time that has elapsed since being in that well state.



A well state can indicate a phase of normal operation, or it may alert the user to a problem with the Lufkin Well Manager RPC input devices or the pumping equipment.

C.1.1 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 Lufkin Well Manager RPC 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 Lufkin Well Manager RPC receives a Global Off command, it keeps the pumping unit shut down until told to do otherwise.

- **Downtime Peak Energy Management well state** — The Lufkin Well Manager RPC keeps the pumping unit in a downtime state for the entire period programmed for Peak Energy Management.

C.1.2 Well States Involved in Malfunctions

The word Malfunction (Malf) in a well state means that the Lufkin Well Manager RPC detected a malfunction with equipment and that an operator must take action to return the unit to a pumping condition.

C.1.3 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 and Valve/CBE Check.

C.2 Well State Descriptions

Fonts are used in the well state list below to indicate whether the well state is a normal operation or if it is a problem. For example,

- Bold type (**Well State**) indicates a problem with the pumping equipment or the Lufkin Well Manager RPC system components, or it may indicate that someone has bypassed the Lufkin Well Manager RPC. The user should check the Lufkin Well Manager RPC installation and programming.

- Italics type (*Well State*) indicates a normal state and the unit should not be pumping.

- Normal type (Well State) indicates normal operation and the unit should be pumping.

The well states that can be displayed are described below.

Loss of Programming
Lufkin Well Manager RPC has lost the programmed parameters and has therefore returned to default conditions.

Initializing
Well state during boot-up period when power is first turned on or the re-set button has been pushed.

DT/Power-On Delay
Initial well state following *Initializing*. The Lufkin Well Manager RPC 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.

Starting Unit
Lufkin Well Manager RPC 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
Lufkin Well Manager RPC will pump for the programmed number of strokes with no analysis of dynagraph data.

Pumping-Normal Mode
Lufkin Well Manager RPC is performing all enabled functions.

Pumping-Host Mode
Lufkin Well Manager RPC has been user-programmed to operate in Host Operation mode and is currently programmed to run the pumping unit.

Pumping-Timed Mode
Lufkin Well Manager RPC has been user-programmed to operate in the Timed Operation mode.

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 Lufkin Well Manager RPC.

Unable to Run
Lufkin Well Manager RPC 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
Lufkin Well Manager RPC has detected a problem with the load input signal. In the event of a load signal input problem, the Lufkin Well Manager RPC 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 Lufkin Well Manager RPC has detected a problem with the position input. In the event of an analog position signal input problem, the Lufkin Well Manager RPC 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.

Stopping Unit
One of the enabled Lufkin Well Manager RPC control functions 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.

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.

Load Calibration
The operator is presently calibrating the beam mounted transducer inputs to the Lufkin Well Manager RPC.

Load Uncalibrated
The Lufkin Well Manager RPC has not been properly calibrated for use with a beam transducer.

Valve/CBE Check
The operator is presently using the Lufkin Well Manager RPC to record and/or analyze valve check or counterbalance effect data.

BS Calibration.
The operator is presently performing a bottom of stroke adjustment on the crank arm Hall-Effect transducer.

DT/Pumpoff
The Lufkin Well Manager RPC detected a pumped off condition and was successfully able to stop the pumping unit.

DT/Malf Setpt
The Malfunction setpoint in the surface dynagraph has been violated and the Lufkin Well Manager RPC has successfully stopped the pumping unit. Lufkin Well Manager RPC 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 Lufkin Well Manager RPC will arrive at the **Malf/Setpoint** well state.

DT/Peak Load
Peak Load Allowed Limit in the surface dynagraph has been violated and the Lufkin Well Manager RPC has successfully stopped the pumping unit. The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC will arrive at the **Malf/Peak Load** well state.

DT/Min Load
Min. Load Allowed Limit in the surface dynagraph has been violated and the Lufkin Well Manager RPC has successfully stopped the pumping unit. The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC will arrive at **Malf/Minimum Load** well state.

DT/HOA in Off
This well state does not indicate any trouble with Lufkin Well Manager RPC 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. Only if digital inputs have been wired to H-O-A switch contacts and programmed for Hand and Auto use.

DT/Host Mode
Indicates that Lufkin Well Manager RPC has been deliberately programmed to keep the pumping unit shut down until further operator action.

DT/Timed Mode
Indicates that Lufkin Well Manager RPC 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.

DT/Bad Pos Signal
The Lufkin Well Manager RPC 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.

DT/Bad Load Signal
Only with analog position input, the Lufkin Well Manager RPC 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.

DT/Low RPM
Low RPM Allowed Limit has been violated and the Lufkin Well Manager RPC has successfully stopped the pumping unit. The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC will arrive at **Malf/Low RPM** well state.

DT/Global Off CMD
An all-call Global Off command has been received from the host software to stop the pumping unit. The Lufkin Well Manager RPC will remain in the downtime mode until an operator programs otherwise.

DT/Valves Measure
A local user has programmed the Lufkin Well Manager RPC 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.

DT/LogicExpression (number)
One of the programmed logic expressions has been proved True and the Lufkin Well Manager RPC has successfully stopped the pumping unit. The Lufkin Well Manager RPC will start the pumping unit after the programmed downtime elapses. If the logic expression violation was due to a transient condition, the consecutive malfunction counter will be cleared and normal operation will continue. If the logic expression violation occurs repeatedly for the number of Consecutive Allowed violations, the Lufkin Well Manager RPC will arrive at **Malf/Logic Expression (number)** well state. The number indicates which of a possible eight logic expressions has proved True.

DT/Low Fluid Load
The Fluid Load Allowed Limit has been violated and the Lufkin Well Manager RPC has successfully stopped the pumping unit. The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC will arrive at **Malf/Low Fluid Load** well state.

DT/Peak Torque
Peak Torque Allowed Limit has been violated and the Lufkin Well Manager RPC has successfully stopped the pumping unit. The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC will arrive at **Malf/Peak Torque** well state.

DT/Low Power
The Lufkin Well Manager RPC is operating in the Motor Power Control Mode, and has stopped the pumping unit because the present average downstroke pseudo motor power dropped below the set reference power. The operator should check if the switch to motor power was intentionally programmed or was due to a load signal input failure.

DT/No RPM Signal
The Lufkin Well Manager RPC lost input pulses from the motor RPM Hall-Effect transducer and has successfully stopped the pumping unit. The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC will arrive at **Malf/No RPM Signal** well state.

DT/No Crank Sig
The Lufkin Well Manager RPC lost input pulses from the crank arm Hall-Effect transducer and has successfully stopped the pumping unit. The Lufkin Well Manager RPC 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 Lufkin Well Manager RPC will arrive at **Malf/No Crank Signal** well state.

DT/Peak Energy
Peak Energy management function has been enabled and the Lufkin Well Manager RPC has the pumping unit shut down during the programmed Peak Energy Management Period. The Lufkin Well Manager RPC will return to the programmed operating and control mode after the energy management period.

DT/Operator Stop
The Lufkin Well Manager RPC 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.

Malf/Peak Load
Refer to *DT/Peak Load* above. The pumping unit will stay down until a reset malfunctions is done by the operator.

Malf/Min Load
Refer to *DT/Min Load* above. The pumping unit will stay down until a reset malfunctions is done by the operator.

Malf/Setpoint
Refer to *DT/Malf Setpoint* above. The pumping unit will stay down until a reset malfunctions is done by the operator.

Malf/Low RPM
Refer to *DT/Low RPM* above. The pumping unit will stay down until a reset malfunctions is done by the operator.

Malf/Logic Expression (Number)
Refer to *DT/Logic* above. The pumping unit will stay down until a reset malfunctions is done by the operator. The number indicates which of the eight possible logic expressions has proven true.

Malf/No RPM
Refer to *DT/No RPM Signal* above. The pumping unit will stay down until a reset malfunctions is done by the operator.

Malf/No Crank
Refer to *DT/No Crank Sig* above. The pumping unit will stay down until a reset malfunctions is done by the operator.

Malf/Peak Torque
Refer to *DT/Peak Torque* above. The pumping unit will stay down until a reset malfunctions is done by the operator.

Malf/Low Fluid Load
Refer to *DT/Low Fluid Load* above. The pumping unit will stay down until a reset malfunctions is done by the operator.

DT/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 Lufkin Well Manager RPC has successfully stopped the pumping unit and will restart after the programmed downtime elapses.

DT/Prod Cutoff
The Lufkin Well Test (LWT) Cutoff Control feature has been enable and the calculated fluid production since the last Gauge Off time has reached the programmed allowed daily production. The Lufkin Well manager has successfully stopped the pumping unit. The unit will remain down until the next Gauge Off time at which time it will automatically re-start.

Line loading State
The Liner Loading feature of the Lufkin Well manager has been enabled and the feature is active. Normal pump off control is overridden.

Malf/Lockout
The Lufkin Well manager 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.

Appendix D

AGA-3 and NX-19 Definitions

This appendix briefly describes the Lufkin Well Manager RPC implementation of AGA-3 and provides the formulas used in the Lufkin Well Manager RPC for implementation.

The topics covered in this appendix include:

D.1 Overview of AGA Implementation

The Lufkin Well Manager RPC performs an AGA-3 calculation once a second, and an NX-19 supercompressibility calculation once a minute and every time the setup parameters are modified. For flange tap measurement the Lufkin Well Manager RPC implements the AGA-3 1992 Factors method of gas flow calculation; for pipe tap measurement, the AGA-2 1985 Pipe Flow Calculation method is implemented; and for the supercompressibility factor, the Lufkin Well Manager RPC utilizes the NX-19 calculation methods.

D.1.1 AGA Configuration

All required configuration programming can be done using the local keypad/LCD interface, or by using the Modbus register map from SCADA software at a central location. A 24-hour history of calculated flow rate and a 60-day history of daily production are maintained in onboard memory.

To configure the Lufkin Well Manager RPC to perform AGA calculations, the analog channels that will be used need to be configured as well as the AGA-3 parameters and NX-19 parameters. For best results, configure the parameters in the order presented below. Information about these parameters and how to configure them is provided in section 9, "Lufkin Parameter Programming." The topic containing the specific information is provided in the parenthesis.

1. Analog channel configuration (**MENU: 2/6/1/1** — see "Configuring Auxiliary Analog Inputs")

2. AGA-3 configuration (**MENU: 2/6/3/1** — see "Configuring AGA-3 Parameters")

3. NX-19 configuration (**MENU: 2/6/3/2** — see "Configuring NX-19 Design Parameters")

4. Temperature and pressure configuration (**MENU: 2/6/3/3** — see "Configuring Temperature and Pressure")

After all parameters are configured, you must enable the AGA calculations (**MENU: 2/6/3/4**) before the Lufkin Well Manager RPC can perform the calculations. For information about enabling them, see "Enabling and Disabling AGA Calculations" in section 9, "Lufkin Parameter Programming."

D.1.2 AGA Status

You can display the AGA calculation results on the AGA Status screen (**MENU: 7/1/3**). Some of the status data displayed includes:

- Differential pressure
- Flowing pressure and temperature
- Supercompressibility
- Flow rate
- Production totals for the previous day, current day, and total accumulation since last reset

For more information about the status screen, see "AGA Status" in section 10, "Status Screens."

D.1.3 Historical Data

Historical data for AGA-3 gas flow rate in MCF/Day is collected and stored in the Lufkin Well Manager RPC for display as table data and as a graphical plot. Information about this historical data is provided in section 11, "Historical Data." The topic containing the specific information is provided in the parenthesis.

- 24-hour flow rate (**MENU: 3/2/1** — see "24-Hour AGA-3 Gas Flow")
- 60-day production (**MENU: 3/2/2** — see "60-Day AGA-3 Gas Flow")

D.2 AGA Formulas Used in the Lufkin Well Manager RPC Implementation

D.2.1 AGA-3 1992 Tap Type Factors Method

In 1992 AGA released a new version of Report 3. The new version addressed improvements made in gas flow measurement utilizing flange taps. The new formulas introduced in the report offer two methods for calculating flow with flange taps. For the Lufkin Well Manager RPC AGA implementation we use the Factors method.

The general equation using the Factors method is:

$$Q_v = C' F_a F_{am} F_{wl} F_{wt} F_{pwl} F_{hgm} F_{hgt} [h_w P_f]^{0.5}$$

Where:

Q_v = quantity rate of base volume flow in cubic feet per hour at base conditions

C' = orifice flow constant

F_a = orifice thermal expansion factor

F_{am} = correction for air over water in the water manometer during the differential instrument calibration

F_{wl} = local gravitational correction for water column calibration standard

F_{wt} = water weight correction (temperature) for water column calibration standard

F_{pwl} = local gravitational correction for dead weight tester static pressure standard

F_{hgm} = manometer factor, correction for gas column in mercury manometers

F_{hgt} = mercury manometer temperature factor (span correction for instrument temperature change after calibration)

h_w = differential pressure in inches of water at 60° F

P_f = absolute static pressure in pounds per square inch absolute, use subscript 1 when the absolute static pressure is measured at the upstream orifice tap or subscript 2 when the absolute static pressure is measured at the downstream orifice tap

The Lufkin Well Manager RPC uses a modified version of the general equation, which is:

$$Q_v = C' F_{cal}[h_w P_{f1}]^{0.5}$$

Where:

Q_v = quantity rate of base volume flow in cubic feet per hour at base conditions

C' = orifice flow constant

F_{cal} = user - entered calibration factor to correct for following factors: F_a, F_{am} F_{wl}, F_{wt}, F_{pwl}, F_{hgm}, and F_{hgt} see Appendix B for how to calculate these factors

h_w = differential pressure in inches of water at 60^{O} F

P_{f1} = absolute static pressure in pounds per square inch absolute, measured at the upstream orifice tap

D.2.2 Pressure Measured at Upstream Tap P_{f1}

Since the pressure can be measured at either the upstream or downstream, the tap downstream measurement needs to be converted to an upstream pressure for all calculations. The conversion is as follows:

$$P_{f1} = \frac{h_w}{27.707} + P_{f2}$$

Where:

P_{f1} = absolute static pressure in pounds per square inch absolute, measured at the upstream orifice tap

h_w = differential pressure in inches of water at 60^{O} F

P_{f2} = absolute static pressure in pounds per square inch absolute, measured at the downstream orifice tap

D.2.3 Orifice Flow Constant C'

In the 1992, formula C' becomes:

$$C' = F_n (F_c + F_{sl}) Y_1 F_{pb} F_{tb} F_{tf} F_{gr} F_{pv}$$

Where:

F_n = numeric conversion factor

F_c = orifice calculation factor

F_{sl} = orifice slope factor

Y_1 = expansion factor referenced to upstream

F_{pb} = pressure base factor

F_{tb} = temperature base factor

F_{tf} = flowing temperature factor

F_{gr} = real gas relative density factor

F_{pv} = supercompressibility factor

The terms (F_c+F_{sl}) combined are called the discharge coefficient $C_d(FT)$.

D.2.4 Numeric Conversion Factor — F_n

The numeric conversion factor is calculated as:

$$F_n = 338.265 E_v d^2 \sqrt{Z_{b_{air}}}^{\,2}$$

Where:

E_v = the velocity approach facor

$d = d_r[1+\alpha_1(T_f \quad T_r)]$

d_r = reference orifice plate bore diameter at T_r

α_1 = linear coefficient of thermal expansion of the orifice plate material

α_2 = linear coefficient of thermal expansion of the meter tube material

$Z_{b_{air}}$ = supercompressibility of air at base conditions

$$E_v = \frac{1}{\sqrt{1 \quad \beta^4}}$$

Where:

$\beta = d/D$

$d = d_r[1+\alpha_1(T_f \quad T_r)]$

$D = D_r[1+\alpha_2(T_f \quad T_r)]$

d_r = reference orifice plate bore diameter at T_r

D_r = reference meter tube internal diameter at T_r

α_1 = linear coefficient of thermal expansion of the orifice plate material

α_2 = linear coefficient of thermal expansion of the meter tube material

D.2.5 Velocity Approach Factor — Ev

The velocity approach factor is calculated as:

α_1 and α_2 are as follows:

Material	Linear Coefficient (in/in-^{O}F)
Type 304 and 316 stainless steel	0.00000925
Monel	0.00000795
Carbon Steel	0.00000620

D.2.6 Orifice Calculation Factor — F_c

The orifice calculation factor is calculated as:

$$F_c = 0.5961 + 0.0291\beta^2 - 0.2290\beta^8$$
$$+ (0.0433 + 0.0712e^{-8.5/D} - 0.1145e^{-6.0/D})\left(1 - 0.23\left(\frac{19{,}000\beta}{\mathrm{Re}_D}\right)^{0.8}\right)\left(\frac{\beta^4}{1-\beta^4}\right)$$
$$- 0.116\left(\frac{2}{D(1-\beta)} - 0.52\left(\frac{2}{D(1-\beta)}\right)^{1.3}\right)\beta^{1.1}\left(1 - 0.14\left(\frac{19{,}000\beta}{\mathrm{Re}_D}\right)^{0.8}\right)$$

Where

$\beta = \mathrm{d/D}$

$d = \mathrm{d_r}[1 + \alpha_1(\mathrm{T_f} - \mathrm{T_r})]$

$D = \mathrm{D_r}[1 + \alpha_2(\mathrm{T_f} - \mathrm{T_r})]$

d_r = reference orifice plate bore diameter at $\mathrm{T_r}$

D_r = reference meter tube internal diameter at $\mathrm{T_r}$

α_1 = linear coefficient of thermal expansion of the orifice plate material

α_2 = linear coefficient of thermal expansion of the meter tube material

Re_d = Reynolds number

For meter tubes whose internal diameter is less than 2.8 inches, F_c is modified by an additional term such that:

$$F_c' = F_c + 0.003(1-\beta)(2.8-D)$$

D.2.7 Reynolds Number — Re_D

The Reynolds number can be calculated by assuming an initial value and iterating the following equation:

$$\mathrm{Re}_D = 0.0114541 \frac{Q_v P_b G_r}{\mu D T_b Z_{b_{air}}}$$

Where :

Q_v = volume flow rate

P_b = base pressure

G_r = specific gravity

T_b = base temperature

$D = D_r[1+\alpha_2(T_f \quad T_r)]$

D_r = reference meter tube internal diameter at T_r

α_2 = linear coefficient of thermal expansion of the meter tube material

μ = viscoscity

$Z_{b_{air}}$ = supercompressibility of air at T_b

The initial value can be assumed from the table below.

Nominal Tube Diameter (inches)	Assumed Reynolds Number Re_D
2	500,000
3	750,000
4	1,000,000
6	1,500,000
8	2,000,000
10	2,500,000
12	3,000,000
16	4,000,000
20	5,000,000
24	6,000,000
30	8,000,000

After calculating Re_D, the calculated Re_D can be reused in the equations and a new Q_v calculated. From this new Q_v, Re_D can be calculated. After three to five iterations, the calculated values should be acceptable.

D.2.8 Orifice Slope Factor – F_{sl}

The orifice slope factor is calculated as:

$$F_{sl} = 0.000511\left(\frac{1{,}000{,}000\beta}{\mathrm{Re}_D}\right)^{0.7} + \left(0.210 + 0.049\left(\frac{19{,}000\beta}{\mathrm{Re}_D}\right)^{0.8}\right)\beta^4\left(\frac{1{,}000{,}000\beta}{\mathrm{Re}_D}\right)^{0.35}$$

Where

$\beta = d/D$

$d = d_r[1 + \alpha_1(T_f - T_r)]$

$D = D_r[1 + \alpha_2(T_f - T_r)]$

d_r = reference orifice plate bore diameter at T_r

D_r = reference meter tube internal diameter at T_r

α_1 = linear coefficient of thermal expansion of the orifice plate material

α_2 = linear coefficient of thermal expansion of the meter tube material

Re_d = Reynolds number

D.2.9 Expansion Factor – Y

The expansion factor is calculated as:

$$\mathrm{Y}_1 = 1 - (0.41 + 0.35\beta^4)\frac{x_1}{k}$$

and: $$x_1 = \frac{h_w}{27.707 P_{f1}}$$

Where:

Y_1 = the expansion factor based on the absolute static pressure measured at the upstream tap.

x_1 = the ratio of differential pressure to absolute static pressure at the upstream tap.

h_w = differential pressure, in inches of water at $60^{\circ} F$.

P_{f1} = absolute static pressure at the upstream pressure tap, in pounds per square inch absolute

k = isentorpic exponent. A value of 1.3 was used in the generation of AGA lookup tables.

D.2.10 Pressure Base Factor — F_{pb}

The pressure base factor is applied to change the base pressure from 14.73 psi absolute and is calculated as:

$$F_{pb} = \frac{14{,}73}{P_b}$$

Where:

P_b = the required (contract) base pressure, pounds per square inch absolute

D.2.11 Temperature Base Factor — Ft_b

The temperature base factor is applied to change the base temperature from 60° F and is calculated as:

$$F_{tb} = \frac{T_b}{519.67}$$

Where:

T_b = the required (contract) temperature in degreees Rankine

D.2.12 Flowing Temperature Factor — F_{tf}

The flowing temperature factor is applied to change from the assumed flowing temperature of 60° F to the actual flowing temperature T_f and is calculated as:

$$F_{tf} = \frac{519.67}{T_f}^{0.5}$$

Where:

T_f = acutal flowing temperatur of the gas in degrees Rankine

D.2.13 Real Gas Relative Density (Specific Gravity) Factor — F_{gr}

The real gas relative density (specific gravity) factor is used to change from a real gas relative density of 1.0 to the actual real gas density of the gas flowing, and is calculated as:

$$F_{gr} = \left(\frac{1}{G_r} \right)^{0.5}$$

Where:

G_r = acutal real gas density of the flowing gas

D.2.14 Supercompressibility Factor — F_{pv}

The basic supercompressibility equation is:

$$F_{pv} = \sqrt{\frac{Z_b}{Z_f}}$$

Where:

Z_b = gas compressibility at base conditions

Z_f = gas compressibility at flowing conditions

For the MPC implementation of AGA-3, the supercompressibility factor will be calculated using NX-19.

D.2.15 AGA-3 1985 Formula — Pipe Taps

The AGA-3 1985 formula is given as:

$$Q_v = C' F_a F_{am} F_{wl} F_{wt} F_{pwl} F_{hgm} F_{hgt} [h_w P_f]^{0.5}$$

Where:

Q_v = quantity rate of base volume flow in cubic feet per hour at base conditions

C' = orifice flow constant

F_a = orifice thermal expansion factor

F_{am} = correction for air over water in the water manometer during the differential instrument calibration

F_{wl} = local gravitational correction for water column calibration standard

F_{wt} = water weight correction (temperature) for water column calibration standard

F_{pwl} = local gravitational correction for dead weight tester static pressure standard

F_{hgm} = manometer factor, correction for gas column in mercury manometers

F_{hgt} = mercury manometer temperature factor (span correction for instrument temperature change after calibration)

h_w = differential pressure in inches of water at 60^{O} F

P_f = absolute static pressure in pounds per square inch absolute, use subscript 1 when the absolute static pressure is measured at the upstream orifice tap or subscript 2 when the absolute static pressure is measured at the downstream orifice tap

The Lufkin Well Manager RPC uses a modified version of the 1985 formula, which is:

$$Q_v = C' F_a F_{cal} [h_w P_f]^{0.5}$$

Where:

Q_v = quantity rate of base volume flow in cubic feet per hour at base conditions

C' = orifice flow constant

F_{cal} = user - entered calibration factor to correct for following factors: Fa, F_{am} F_{wl}, F_{wt}, F_{pwl}, F_{hgm}, and F_{hgt} see Appendix B for how to calculate these factors

h_w = differential pressure in inches of water at 60^{O} F

P_f = absolute static pressure in pounds per square inch absolute, use subscript 1 when the absolute static pressure is measured at the upstream orifice tap or subscript 2 when the absolute static pressure is measured at the downstream orifice tap

D.3 Orifice Flow Constant — C'

The orifice flow constant is given as:

$$C' = F_b F_r Y F_{pb} F_{tb} F_{tf} F_{gr} F_{pv}$$

Where:

F_b = basic orifice factor

F_r = Reynolds Number factor

Y = expansion factor

F_{pb} = pressure base factor

F_{tb} = temperature base factor

F_{tf} = flowing temperature factor

F_{gr} = real gas relative density factor

F_{pv} = supercompressibility factor

D.3.1 Basic Orifice Factor — F_b

The basic orifice factor is given as:

Calculating K_o

K_o is calculated using the following formulas:

$$K_o = \frac{K_e}{1 + \dfrac{15E}{d(10^6)}}$$

Where:

d = orifice diameter

D = measured meter tube diameter

$E = d(830 \quad 5000\beta + 9000\beta^2 \quad 4200\beta^3 + B)$

β = ratio of orifice diameter to measured meter tube diameter (d / D)

$B = \dfrac{530}{D^{0.5}}$, for flange taps $\qquad B = \dfrac{875}{D} + 75$, for pipe taps

K_e = flow coefficient when R_d is $d(10^6)/15$

K_e is calculating as:

For pipe taps:

$$\mathrm{K}_e = 0.5925 + \frac{0.0182}{D} + \quad 0.440 + \frac{0.06}{D} \quad \beta^2 + \quad 0.935 \quad \frac{0.225}{D} \quad \beta^5 + 1.35\beta^{14}$$

$$+ \underbrace{\frac{1.43}{D^{0.5}}\left(0.25 \quad \beta\right)^{5/2}}_{Term\ \mathrm{A}}$$

If $\beta > 0.25$ then drop Term A

D.3.2 Reynolds Number Factor — F_r

The Reynolds number factor is given as:

$$F_r = 1 + \frac{b}{\sqrt{h_w P_f}}$$

Where:

h_W = differential pressure

P_f = absolute static pressure (flowing)

$$b = \frac{\mathrm{E}}{12835\mathrm{dK}}$$

d = orifice diameter

$$E = d(830 \quad 5000\beta + 9000\beta^2 \quad 4200\beta^3 + B)$$

β = ratio of orifice diameter to measured meter tube diameter (d / D)

$B = \dfrac{530}{D^{0.5}}$, for flange taps $\qquad B = \dfrac{875}{D} + 75$, for pipe taps

$K = \dfrac{0.604}{(1 \quad \beta^4)^{0.5}}$, for flange taps

for pipe taps K must be determined from table:

β	K	β	K	β	K	β	K	β	K
0.100	0.607	0.225	0.623	0.350	0.658	0.475	0.724	0.600	0.837
0.125	0.608	0.250	0.628	0.375	0.668	0.500	0.742	0.625	0.869
0.150	0.611	0.275	0.634	0.400	0.680	0.525	0.763	0.650	0.904
0.175	0.614	0.300	0.641	0.425	0.692	0.550	0.785	0.675	0.943
0.200	0.618	0.325	0.650	0.450	0.707	0.575	0.810	0.700	0.988

Expansion Factor — Y

The Expansion factor is calculated based on whether measurement is referenced to upstream or downstream pressure, and the type of tap being used. Calculations are as follows:

Referenced to Upstream Pressure

For pipe taps:
$$\mathrm{Y}_1 = 1 \quad [0.333 + 1.145(\beta^2 + 0.7\beta^5 + 12\beta^{13})]\frac{x_1}{k}$$

and:
$$x_1 = \frac{P_{f1} \quad P_{f2}}{P_{f1}} = \frac{h_w}{27.707 P_{f1}}$$

Where:

Y_1 = the expansion factor based on the absolute static pressure measured at the upstream tap. The values of Y_1 computed by these equations are subject to a tolerance varying from 0, when x = 0, to plus or minus 0.5 percent, when x = 0.20. For larger values of x, a somewhat larger uncertainty may be expected. The equation for flange taps may be used for a range of beta ratios from 0.10 to 0.80, while that for pipe taps may be used over a range from 0.10 to 0.70.

x_1 = the ratio of differential pressure to absolute static pressure at the upstream tap.

h_w = differential pressure, in inches of water at $60^{\mathrm{O}} F$.

P_{f1} = absolute static pressure at the upstream pressure tap, in pounds per square inch absolute

P_{f2} = absolute static pressure at the downstream pressure tap, in pounds per square inch absolute

x_1 / k = the acoustic ratio

Where:

$k = c_p / c_v$, the ratio of the specific heat of the gas at constant pressure to the specific heat of the gas at constant volume at flowing conditions (accepted practice is to use the ratio at standard conditions for most gas phase measurements.) A value of 1.3 was used in the generation of AGA lookup tables.

Referenced to Downstream Pressure

For pipe taps : $Y_2 = [1+x_2]^{0.5} \; 1 \;\; [0.333+1.145(\beta^2+0.7\beta^5+12\beta^{13})] \dfrac{x_2}{k(1+x_2)^{0.5}}$

and : $$x_2 = \frac{P_{f1} \;\; P_{f2}}{P_{f2}} = \frac{h_w}{27.707 P_{f2}}$$

Where :

Y_2 = the expansion factor based on the absolute static pressure measured at the downtream tap.

x_2 = the ratio of differential pressure to absolute static pressure at the downstream tap.

Pressure Base Factor — F_{pb}

The pressure base factor is applied to change the base pressure from 14.73 psi absolute and is calculated as:

$$F_{pb} = \frac{14{,}73}{P_b}$$

Where :

P_b = the required (contract) base pressure, pounds per square inch absolute

D.3.3 Temperature Base Factor — Ft_b

The temperature base factor is applied to change the base temperature from 60° F and is calculated as:

$$F_{tb} = \frac{T_b}{519.67}$$

Where :

T_b = the required (contract) temperature in degreees Rankine

D.3.4 Flowing Temperature Factor — F_{tf}

The flowing temperature factor is applied to change from the assumed flowing temperature of 60° F to the actual flowing temperature T_f and is calculated as:

$$F_{tf} = \left(\frac{519.67}{T_f}\right)^{0.5}$$

Where:

T_f = acutal flowing temperatur of the gas in degrees Rankine

D.3.5 Real Gas Relative Density (Specific Gravity) Factor – F_{gr}

The real gas relative density (specific gravity) factor is used to change from a real gas relative density of 1.0 to the actual real gas density of the gas flowing, and is calculated as:

$$F_{gr} = \left(\frac{1}{G_r}\right)^{0.5}$$

Where:

G_r = acutal real gas density of the flowing gas

D.3.6 Supercompressibility Factor — F_{pv}

Supercompressibility can be calculated using the NX-19 Manual equations or the AGA-8 method. This section will describe the NX-19 Manual derivation. Over most normal measurement ranges, 500 to 1500 psia (3.5 to 10.4 MPa) and –10 to 100º F (-23 to 38º C), the NX-19 will compute the gas compressibility factor to within 0.2% of the values computed by the AGA-8 method. The basic supercompressibility equation is:

$$F_{pv} = \sqrt{\frac{Z_b}{Z_f}}$$

D.4 NX-19 Formulas

The ranges over which the NX-19 method of calculation are valid are:

- Pressure p_g To 5000 psig (10.34 MPa, gauge)
- Temperature T_f -40º to 240º F (-40º to 116º C)
- Specific Gravity 0.554 to 1.0
- CO_2 and N_2 0 to 15%

D.4.1 Adjusted Pressure And Temperature Calculations

Four methods are use to obtain the adjusted temperature and pressure:

Method 1 — Specific Gravity Method

Calculates adjusted pressure and temperature from the mole fractions of carbon dioxide and nitrogen as:

$$P_{adj} = \frac{156.47 p_g}{160.8 \quad 7.22G + 100x_{CO_2} \quad 39.2x_{N_2}}$$

$$T_{adj} = \frac{226.29(T_F + 460)}{99.15 + 211.9G \quad 100x_{CO_2} \quad 168.1x_{N_2}}$$

Where:

p_g = gauge pressure

G = specific gravity

x_{CO_2} = mole fraction of carbon dioxide

x_{N_2} = mole fraction of nitrogen

$\mathrm{T_F}$ = temperature flowing in degrees Fahreneheit

Method 2 — Analysis Method

Recommended for high specific gravity gas (G > 0.75). Calculate adjusted pressure and temperature as:

$$P_{adj} = \frac{671.4 p_g}{\sum x_i p_{ci}}$$

$$T_{adj} = \frac{359.46(T_F + 460)}{\sum x_i T_{ci}}$$

Where:

p_g = gauge pressure

T_F = temperature flowing in degrees Fahreneheit

x_i = mole fraction of each component

T_{ci} = critical temperature of each component

p_{ci} = critical pressure of each component

Method 3 — Methane Method

Recommended for high specific gravity gas (G > 0.75). Requires methane mole fraction and the two inert mole fractions of carbon dioxide and nitrogen. Calculates adjusted pressure and temperature as:

$$P_{adj} = \frac{671.4 p_g}{891.11 \quad 172.56G + 443.04 x_{CO_2} \quad 232.23 x_{N_2} \quad 122.52 x_{CH_4}}$$

$$T_{adj} = \frac{359.46(T_F + 460)}{327.77 + 214.82G \quad 144.12 x_{CO_2} \quad 319.52 x_{N_2} \quad 102.78 x_{CH_4}}$$

Where:

p_g = gauge pressure

T_F = temperature flowing in degrees Fahreneheit

x_{CO_2} = mole fraction of carbon dioxide

x_{N_2} = mole fraction of nitrogen

x_{CH_4} = mole fraction of methane

Method 4 — Heating Value Method

Uses the measured heating value [wet basis, Btu/(std ft^3) at 14.73 psia and 60º F] and the mole fractions of nitrogen and carbon dioxide. Calculates adjusted pressure and temperature as:

$$P_{adj} = \frac{671.4 p_g}{693 \quad 0.0209 H_{Btu,wet} + 379 x_{CO_2} \quad 201 x_{N_2}}$$

$$T_{adj} = \frac{359.46(T_F + 460)}{124.7 + 0.2203 H_{Btu,wet} + 384.99 x_{CO_2} + 91.11 x_{N_2}}$$

Where:

p_g = gauge pressure

T_F = temperature flowing in degrees Fahreneheit

x_{CO_2} = mole fraction of carbon dioxide

x_{N_2} = mole fraction of nitrogen

$H_{Btu,wt}$ = heating value

D.4.2 Pressure and Temperature Correlation Parameters

Once the adjusted temperature and pressure are calculated, the mixtures pressure and temperature correlation parameters are calculated as:

$$p = \frac{p_{adj} + 14.7}{1000} \qquad T = \frac{T_{adj}}{500}$$

D.4.3 NX-19 Natural Gas Regions and E Equations

With the calculated pressure and temperature correlation parameters, the user can find the appropriate E equation by matching the corresponding region as follows:

Ranges		
p	**T**	**E Equation**
0 to 2	1.09 to 1.40	E_1
0 to 1.3	0.84 to 1.09	E_2
1.3 to 2.0	0.88 to 1.09	E_3
1.3 to 2.0	0.84 to 0.88	E_4
2.0 to 5.0	0.84 to 0.88	E_5
2.0 to 5.0	0.88 to 1.09	E_6
2.0 to 5.0	1.09 to 1.32	E_7
2.0 to 5.0	1.32 to 1.40	E_8

The E equations are calculated as follows:

$$T_a = T \quad 1.09 \qquad\qquad T_b = 1.09 \quad T$$

$$E_1 = 1 \quad 0.00075\,p^{2.3}\,\exp(\;\, 20T_a) \quad 0.0011T_a{}^{0.5}\,p^2[2.17 + 1.4T_a{}^{0.5} \quad p]^2$$

$$E_2 = 1 \quad 0.00075\,p^{2.3}[2 \quad \exp(\;\, 20T_b)] \quad 1.317T_b{}^4\,p(1.69 \quad p^2)$$

$$E_3 = 1 \quad 0.00075\,p^{2.3}[2 \quad \exp(\;\, 20T_b)] + 0.455(200T_b{}^6 \quad 0.03249T_b + 2.0167T_b{}^2$$
$$\quad 18.028T_b{}^3 + 42.844T_b{}^4)(p \quad 1.3)[1.69(2)^{1.25} \quad p^2]$$

$$E_4 = 1 \quad 0.00075\,p^{2.3}[2 \quad \exp(\;\, 20T_b)] + 0.455(200T_b{}^6 \quad 0.03249T_b + 2.0167T_b{}^2$$
$$\quad 18.028T_b{}^3 + 42.844T_b{}^4)(p \quad 1.3)[1.69(2)^{1.25+80(0.88 \;\, T)^2} \quad p^2]$$

$$E_5 = E_4 \quad X$$

$$E_6 = E_3 \quad X$$

$$E_7 = E_1 \quad X$$

$$E_8 = E_7 \quad X_1$$

$$X = A(p \quad 2) + A_1(p \quad 2)^2 + A_2(p \quad 2)^3 + A_3(p \quad 2)^4$$

$$X_1 = (p \quad 1.32)^2(p \quad 2)[3 \quad 1.483(p \quad 2) \quad 0.1(p \quad 2)^2 + 0.0833(p \quad 2)^3]$$

$$A = 1.7172 \quad 2.33123T \quad 1.56796T^2 \quad 0.78221T^3 \quad 1.28603T^4$$

$$A_1 = 0.016299 \quad 0.028094T + 0.48782T^2 \quad 0.78221T^3 + 0.27839T^4$$

$$A_2 = \quad 0.35978 + 0.51419T + 0.16453T^2 \quad 0.52216T^3 + 0.19687T^4$$

$$A_3 = 0.075255 \quad 0.10573T \quad 0.058598T^2 + 0.14416T^3 \quad 0.054533T^4$$

D.4.4 Flowing Compressibility — Z_f

The flowing compressibility is calculated as follows:

$$Z_f = \frac{1}{\frac{B}{D} \quad D + \frac{n}{3p}}$$

Where:

$$m = 0.0330378T^{\ 2} \quad 0.0221323T^{\ 3} + 0.0161353T^{\ 5}$$

$$n = (0.265827T^{\ 2} + 0.0457697T^{\ 4} \quad 0.133185T^{\ 1})m^{\ 1}$$

$$B = \frac{3 \quad mn^2}{9mp^2}$$

$$b = \frac{9n \quad 2mn^3}{54mp^3} \quad \frac{E}{2mp^2}$$

$$D = [b + (b^2 + B^3)^{0.5}]^{\frac{1}{3}}$$

$E =$ comes from E equations calculated above

p = pressure correlation parameter

T = temperature correlation parameter

D.4.5 Base Compressibility — Zb

The base compressibility is calculated as follows:

$$Z_b = \quad 1 + \frac{0.00132}{T^{3.25}} \quad ^{2}$$

Where:

T = temperature correlation parameter

D.5 Calibration Factors

The following factors can be calculated to calibrate readings closer to actual conditions on site. The factors should be combined and entered in the **AGA-3 Calibration Factors** field.

D.5.1 Orifice Thermal Expansion Factor — F_a

The orifice thermal expansion factor is used to correct for the error associated with the expansion or contraction of the orifice plate due to the operating temperature differing from the temperature at which the orifice was measured. The orifice thermal expansion factor is given as:

For 304 and 316 stainless steel:

$$F_a = 1 + [0.0000185(t_f \quad t_{meas})]$$

For Monel:

$$F_a = 1 + [0.0000159(t_f \quad t_{meas})]$$

Where:

t_f = temperature of the fluid flowing at the orifice in degrees Fahrenheit

$\mathrm{t}_{\mathrm{meas}}$ = temperature in degrees Fahrenheit of the orifice plate when the orifice plate is measured

D.5.2 Water Manometer Correction Factor — Fam

This factor is used to correct for the gas leg over water when a water manometer calibration standard is used to calibrate a differential pressure gage. The factor is calculated as:

$$F_{am} = \sqrt{\frac{\rho_w \quad \rho_a}{\rho_w}}$$

Where:

ρ_w = density of water at $60^{\mathrm{O}} F$ ρ_w is 62.3663 $\mathrm{lb_m} / ft^3$

ρ_a = density of air

The real gas density of air (ρ_w) is calculated for any h_w pressure above atmospheric pressure as:

$$\rho_{\mathrm{a}} = \frac{P_{atm} + \dfrac{h_w}{27.707}}{192.4}$$

Where:

P_{atm} = local atmospheric pressure in pounds per square inch absolute

h_w = differential pressure

The local atmospheric pressure can be calculated using the following equation from the *Smithsonian Meteorological Tables*:

$$P_{atm} = \frac{55096 \quad (Elevation, ft \quad 361)}{55096 + (Elevation, ft \quad 361)} * 14.54$$

D.5.3 Local Gravitational Correction Factor For U-Tube Manonmeters — F_{wl}

This factor is used to correct for local gravity effect on manometer fluids and is calculated as:

$$F_{wl} = \sqrt{\frac{g}{32.17405}}$$

Where:

g = local acceleration due to gravity in feet per second squared.

The ambient value of gravity at any location is most accurately obtained from a U.S. Coast and Geodetic Survey reference to aeronautical data or from the *Smithsonian Meteorological Tables*. In the absence of better data, practical values of g can be obtained from the following equations:

For mid - latitudes, between 30^{O} and 60^{O} :

$$g = 0.032808(980.665 + [0.087(L \quad 45)] \quad 0.000094H)$$

For latitudes fron 0^{O} to 90^{O} a curve fit equation :

$$\mathrm{g} = 0.032808(978.01855 - 0.0028247\mathrm{L} + 0.0020299\mathrm{L}^{2}$$
$$0.000015058L^{3} \quad 0.000094H)$$

Where:

L = latitude in degrees

H = elevation in feet above sea level

D.5.4 Water Manometer Temperature Correction Factor — F_{wt}

This factor is used to correct for variations in the density of water used for calibration due to temperature or other reasons. The factor can be calculated as follows:

$$F_{wt} = \sqrt{\frac{\rho_w}{62.3663}}$$

Where:

ρ_w = density of the water in the calibration U-tube manometer in U.S. avoirdupois pounds per cubic foot. The effect of atmospheric air is excluded (usually defined as weight in vacuo of the fluid sample at the pressure and temperature existing in the U-tube manoometer during the instrument calibration.

D.5.5 Local Gravitational Correction Factor For Weight Standards — F_{pwl}

This factor is used to correct for the local gravity effect on the weights of the dead weight calibrator and can be calculated as follows:

$$F_{pwl} = \sqrt{\frac{g}{g_0}}$$

Where:

g = acceleration due to local gravitational force

g_0 = acceleration of gravity used to calibrate the weights or dead weight tester

D.5.6 Correction for Gas Column in Mercury Manometer Instruments – F_{hgm}

This factor is used to correct for the gas vapor leg of fluid at P_{f1} static pressure and the temperature of the manometer or instrument. This factor is used to correct for the effect of the gas column above the mercury during the flow measurements and can be calculated as follows:

$$F_{hgm} = \sqrt{\frac{\rho_{hg} \quad \rho_{g}}{\rho_{hg}}}$$

Where:

ρ_g = real gas density of the gas or vapoir in the differential pressure instrument in U.S avoirdupois pounds per cubic foot. The effect of atmospheric air is excluded (usually defined as weight in vacuo of the mercury sample at the base pressure and temperature defined for the flow measurement).

ρ_{hg} = density of the mercury in the differential pressure instrument in U.S avoirdupois pounds per cubic foot. The effect of atmospheric air is excluded (usually defined as weight in vacuo of the mercury sample at the base pressure and temperature defined for the flow measurement). ρ_{hg} can be calculated as:

$$\rho_{hg} = 846.324[1 \quad 0.000101(T_a \quad 519.67)]$$

Where:

T_a = ambient temperature in degrees Rankine

D.5.7 Mercury Manometer Temperature Factor — F_{hgt}

This factor is used to correct for the change in mercury density in the mercury manometer due to the temperature change from the temperature at the time of instrument calibration and can be calculated as follows:

$$F_{hgt} = \sqrt{\frac{\rho_{hgo}}{\rho_{hgc}}}$$

Where:

ρ_{hgo} = density of the mercury in the differential pressure instrument in U.S avoirdupois pounds per cubic foot at he mercury gage operating conditions. The effect of atmospheric air is excluded (usually defined as weight in vacuo of the mercury sample at the base pressure and temperature defined for the flow measurement and the temperature of the mercury gage).

ρ_{hgc} = density of the mercury in the differential pressure instrument in U.S avoirdupois pounds per cubic foot at the time of its calibration. The effect of atmospheric air is excluded (usually defined as weight in vacuo of the mercury sample at the base pressure and temperature defined for the flow measurement).

Appendix E

Pump Intake Pressure and Lufkin Well Test Theory

This appendix describes the theory behind the new feature, Lufkin Well Test (LWT), available for calculating pump intake pressure and fluid production through the pump.

The topics covered in this appendix include:

E.1 Overview of PIP and LWT

Lufkin Well Manager RPCs operating with application firmware version 4.66 or higher offer a new Pump Intake Pressure (PIP) feature. This version has a patent-pending 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 wellsites 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.

An improved algorithm for the traditional Lufkin Well Manager RPC inferred production feature is also included in firmware version 4.66 or higher. The IPA (inferred production algorithm) in older firmware versions is replaced with the improved Lufkin Well Test (LWT) feature.

The new LWT algorithm replaces the older IPA K factor with automated fluid volume adjustments for pump slippage, fluid shrinkage, and tubing movement. Pump slippage can be either a user-entered value, or the Lufkin Well Manager RPC will use the leakage value from a completed analysis of a Valve Check file (For details about how to record and analyze valve check data, see appendix B, “Valve Checks, Counter Balance Effect and Residual Friction.”). Fluid volume shrinkage calculations use the PVT properties programmed for the PIP feature.

E.2 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 E-1. Input data from the pump card includes fluid load, gross stroke, net stroke, and tubing movement if applicable.

Pump intake pressure, designated as P_p in Figure E-1, can be calculated from the formula:

$$P_p = P_d - F_o/A_p$$

The Lufkin Well Manager RPC uses an iterative process to solve for pump intake pressure. In involves the following steps:

1. D_p, A_p, and P_t are entered by the user as known values.

2. The Lufkin Well Manager RPC measures F_o, *GS*, and *NS* from analysis of the downhole pump card. The remaining unknown is P_d.

3. Knowing *GS* and *NS*, barrels of free gas through the pump are calculated.

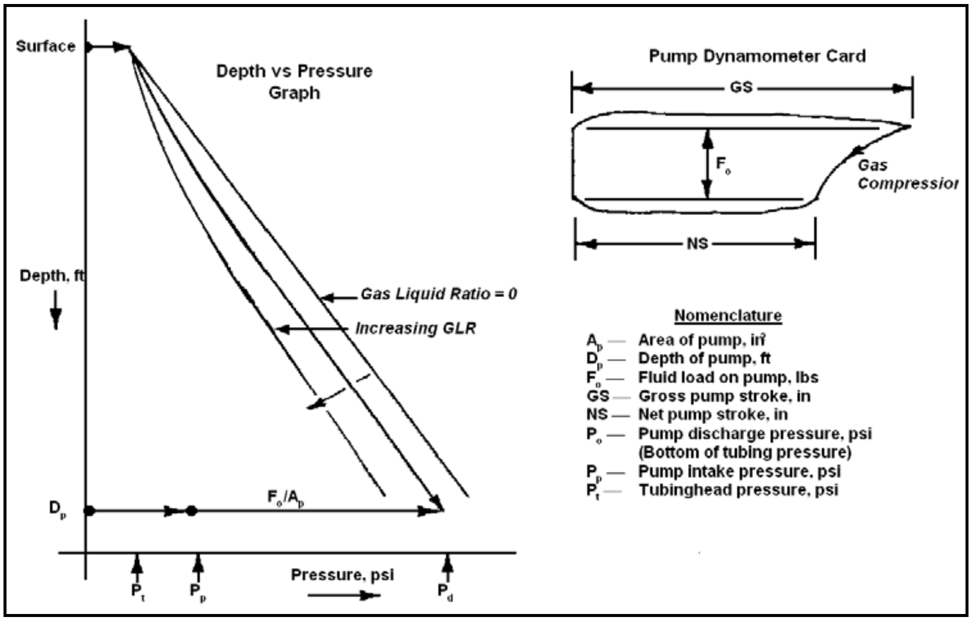


Figure E-1. Pump Intake Pressure from Dynamometer Data

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 Lufkin Well Manager 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 E-2). This load should not include friction and fluid inertia effects.

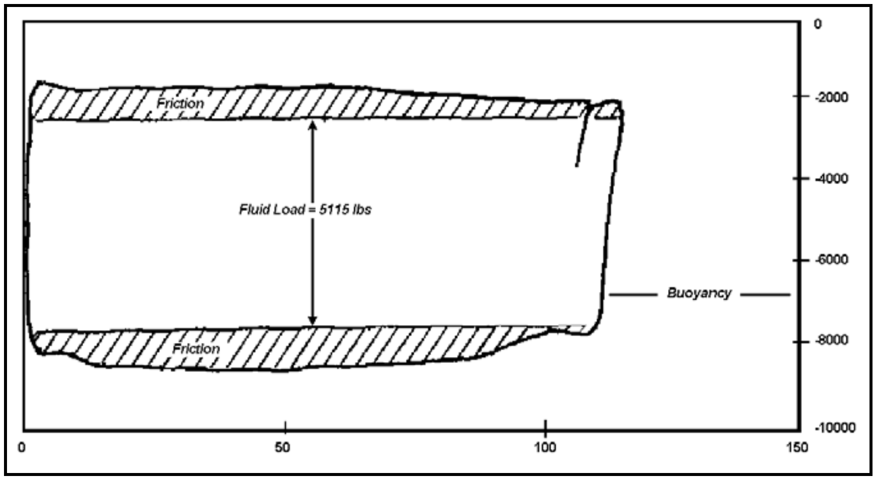


Figure E-2. Fluid Load Measured from Pump Card

The Lufkin Well Manager 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 E-3 shows the algorithms Lufkin Well Manager RPC uses to pick the fluid load line.

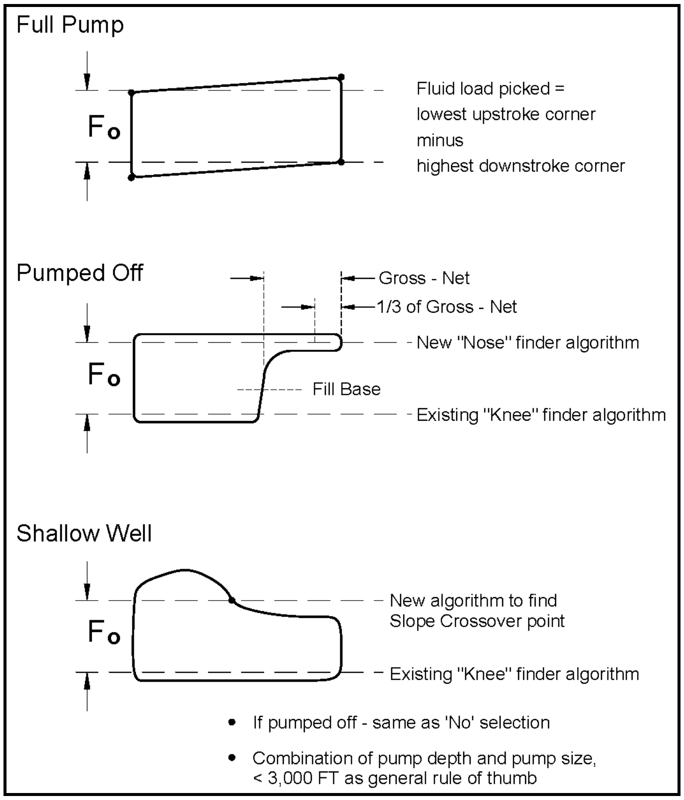


Figure E-3. Lufkin PIP Fluid Load Detection

E.3 Theory of LWT Calculated from a Downhole Card

The Lufkin Well Manager RPC Well Test can be configured to work in the Advanced mode or the older Basic mode.

E.3.1 Advanced LWT Algorithm

The Advanced Lufkin Well Test algorithm is based on analysis of the downhole dynagraph card. Figure E-4 illustrates the relevant concepts from the pump card.

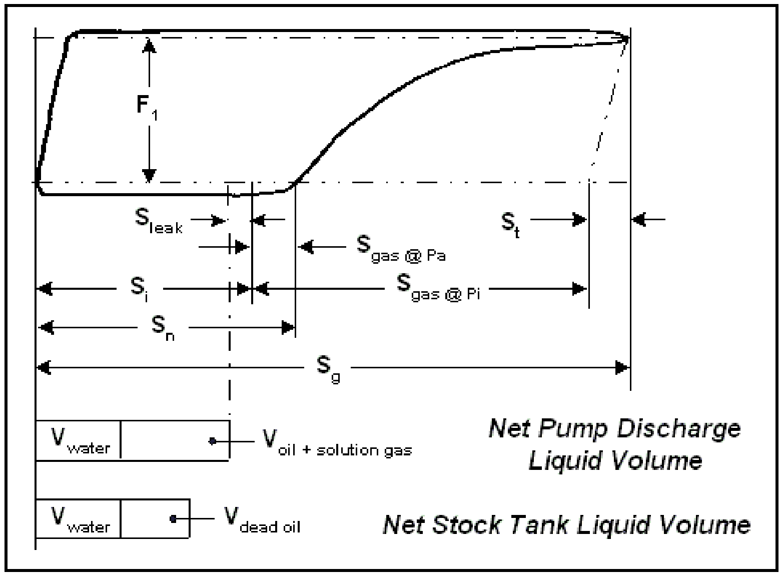


Figure E-4. Elements of LWT Analysis of Downhole Pump Stroke

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.

E.3.2 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 (in^2) of pump plunger from pump diameter, and to convert cubic inches to barrels

D = 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 Lufkin Well Manager 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 Lufkin Well Manager 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 E-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 Lufkin Well Manager 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.

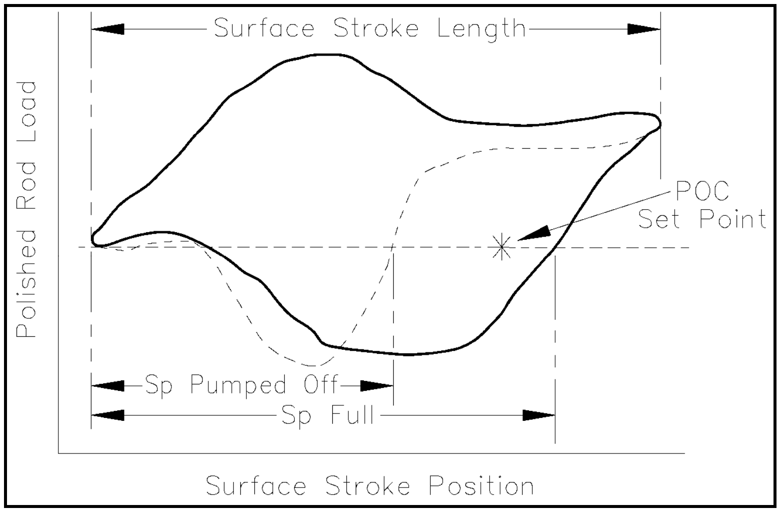


Figure E-5. S_P Inferred From Surface Dynagraph

Basic LWT from Downhole Pump Card

If the Downhole control method is selected, the Lufkin Well Manager RPC infers the effective plunger stroke length S_P by analyzing the downhole pump card (see Figure E-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 Lufkin Well Manager 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 E-6 is not an obvious parameter.

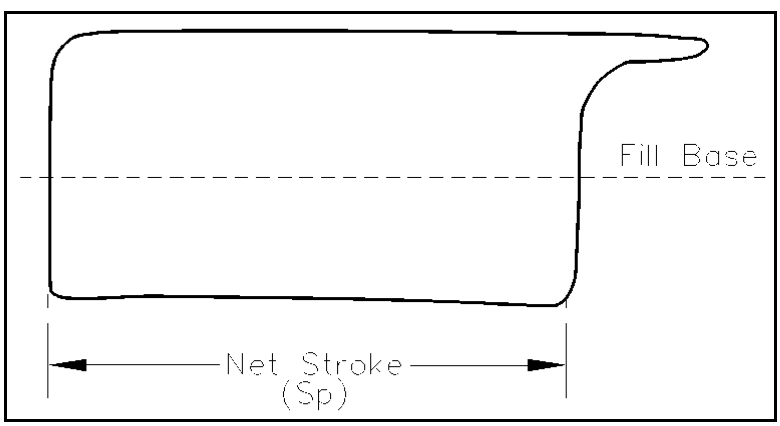


Figure E-6. S_P Inferred From Downhole Pump Card

The fill base value is a percentage level at which the Lufkin Well Manager 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 Lufkin Well Manager 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 Lufkin Well Manager RPC has selected the wrong net stroke, adjust the fill base up or down to bring the Lufkin Well Manager RPC net stroke selection into agreement with your visual analysis.

E.3.3 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 Lufkin Well Manager 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 Lufkin Well Manager 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.

E.4 Consider Formation Pressure? Query Feature

In the LWT/PIP Parameters Screen 3/3 (**MENU: 2/1/3**), you are presented with a Yes/No option in the **Consider Formation Pressure** field to specify whether you want 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).

Below are two cases to help you decided when to use the query. Consult Figure E-7 while reading the cases.

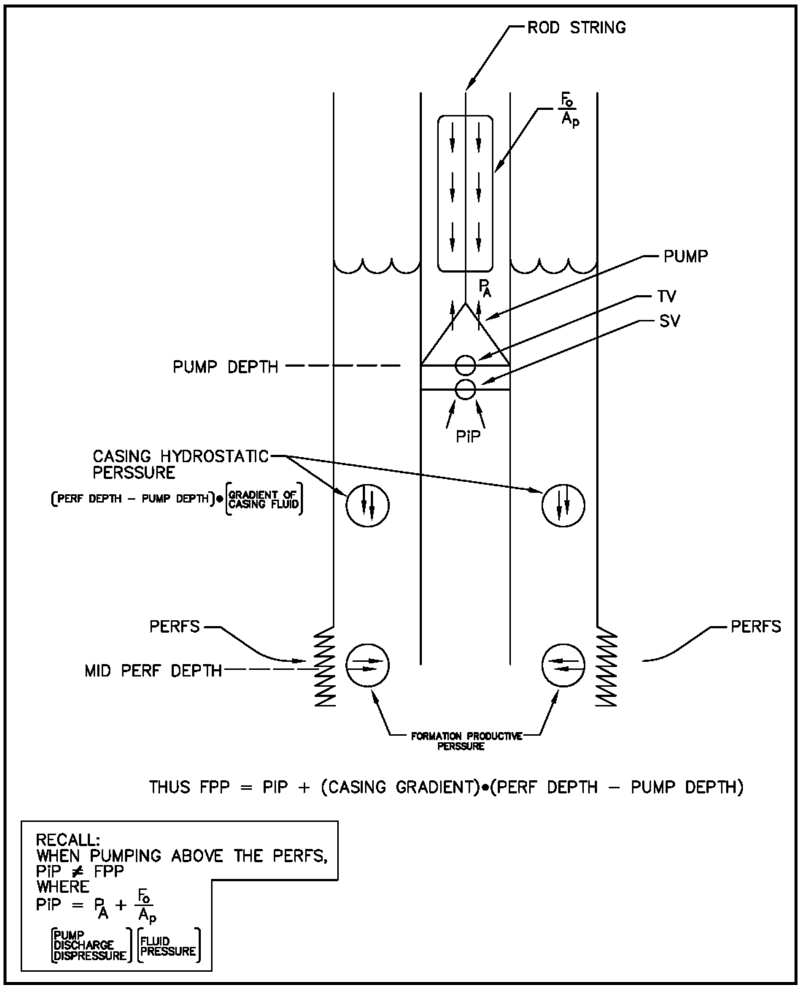


Figure E-7. Illustration Showing Pump Placement Above Perforations

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 occuring, 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 F

Linear Pumping Unit Application

The Lufkin Well Manager RPC can control the operation of a linear pumping unit.

The topics covered in this appendix include:

F.1 Overview of the Linear Pumping Unit Application

Linear pumping units generally have longer stroke lengths and slower pumping speeds than beam type units. Several types of linear units are available. The Lufkin Well Manager RPC will work with any of these units that have the same upstroke and downstroke speed. That condition rules out hydraulic powered units that can be set to different upstroke and downstroke speeds.

The linear unit option becomes available when you select one of the two linear position transducer options available on the End Devices Parameters screen (**MENU: 2/1/2**), which are **ONE DIGITAL-LINEAR** and **RPM/CRANK-LINEAR**. For information about selecting these options, see “Configuring End Device Parameters” in section 8, “RPC Parameter Programming.”

F.2 Installing Position Input Devices

Information about installing one digital and RPM/crank linear input devices are described separately below.

F.2.1 Installing One Digital Linear Input Devices

A proximity switch or Hall-Effect sensor must be mounted to sense the bottom of the stroke.

Proximity Switch

A proximity switch is recommended on units that use a chain drive that is immersed in an oil bath to sense the passage of the “master link” of the chain as it passes over the top of the upper idler sprocket at the bottom of the stroke. This “master link” includes the drive pin that moves the belt carriage assembly up and down. It is typically noticeably larger than the other chain links. Lufkin Automation offers a proximity switch that is oil tight (Part No. 184.0073).

A general purpose aluminum mounting bracket, (Part No. 291.6124) is also offered. Some field ingenuity is typically required to cut and bend the bracket and drill mounting holes to make the bracket work for a particular type of linear unit.

The proximity switch offered by Lufkin Automation has indicator lights to help with the alignment and spacing of the switch. The green light illuminates when power is applied to the switch and the yellow/amber light illuminates when ferrous metal is detected.

Hall-Effect Sensor

A magnet and Hall Effect sensor can be used for units that have an open drive mechanism and counterweights. Mount the Hall-Effect probe so that it senses the magnet at the exact bottom of the stroke. In many cases, the magnet can be mounted on the side of the counterweights. For information regarding magnet polarity and clearance requirements, see “Installing the Crank Arm Hall-Effect Transducer,” in section 6, “Installing the System.”

F.2.2 Installing RPM/Crank Linear Input Devices

This option requires both the bottom-of-stroke sensor (proximity switch or Hall-Effect) described above and a motor shaft RPM sensor. Lufkin Automation offers a kit (Part No. 530.4550) that includes the magnet, Hall-Effect sensor cable, and mounting brackets. Refer to section 6.11 for description of how to mount the motor shaft sensor, see “Installing the Motor RPM Hall-Effect Transducer” in section 6, “Installing the System.”

F.2.3 Wiring Position Input Devices

The proximity switch for bottom of stroke is wired to the CSW input on terminal block TB4 on the Lufkin Well Manager RPC motherboard. The wire termination is provided in the table below:

Proximity Switch Terminal	Lufkin Terminal
1	+12V on back panel
3	TB4-4 Common
4	TB4-3 CSW

Wire the motor shaft RPM sensor and, if used, the Hall-Effect type bottom of stroke switch (CSW) to terminal **TB4** on the Lufkin Well Manager RPC motherboard. For a wiring diagram and more information, see “Wiring Hall-Effect Transducers” in section 7, “Wiring the System.”

F.3 Installing the Load Cell and the Lufkin Coiled Load Cell Cable on a Rotaflex Pumping Unit

A load input is also required for the linear pumping unit application. The load cell and the spherical washer set must be installed on top of the carrier bar. For more installation information and an installation diagram, see "Installing the Polished Rod Load Cell" in section 6, "Installing the System."

The installation and routing of the load cell cable requires special techniques due to the long stroke length and the unit design. Figure F-1 shows a recommended method developed by Lufkin Automation.

Figure F-1. Recommended Load Cell Cable Routing

Materials and Tools Required

- Coiled load cable assembly (100 feet) with molded Molex connector and strain relief (Part No.510.8100)
- 1-inch rigid conduit, 10-foot length
- Load cable support kit, which includes thimbles, clevises, and eyebolt (Part No. 069.0004)
- 1-inch offset rigid par clamps
- Hilti™ gun, studs, and clamps
- Plastic tie wraps

Installation Procedure

Follow the steps below to properly install the coiled load cell cable on a Rotaflex® pumping unit.

1. Drill a 5/16-inch diameter hole near one end of a 10-foot joint of 1-inch rigid conduit and mount the eyebolt (included in the load cable support kit) through that hole.

2. Fasten the conduit to the side of the unistructure using two 1-inch offset rigid par clamps. The height of the conduit should be at the mid-point of the unit stroke.

3. Fasten the coiled cable to the load cell using the molded connector and the CGB fitting included.

4. Hook the strain relief to the S-hook on the load cell.

5. Attach the coiled cable to the end of the rigid conduit using one thimble, eye bolt, and clevis from the load cable support kit by doing the following (see Figure F-2):

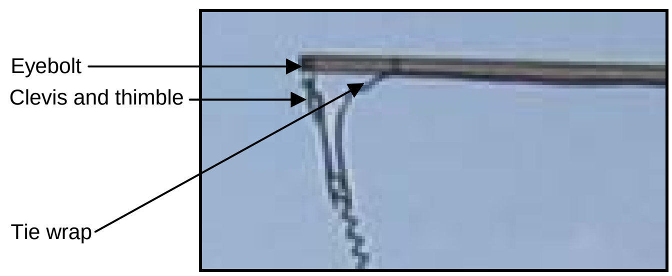


Figure F-2. Coiled Cable Attached to 1-inch Conduit

   a. Fasten the cable to the eyebolt installed in step 1 with the thimble and clevis.

   b. Fasten the loose cable to the 1-inch conduit using plastic tie wraps.

Note: Install the cable with enough slack so that the cable is not over-stretched, but the coiled section of cable can function as designed.

6. Fasten the remainder of the cable to the structure using Hilti studs and cable clamps.

7. Terminate the cable to the Lufkin Well Manager RPC. For details about making that connection, see the topic about wiring the cable to the transducer under “Wiring the Polished Rod Load Cell” in section 7, “Wiring the System.”

8. Run the pumping unit and check to make sure that the cable is stretching evenly and functioning safely and correctly.

The coiled load cell cable is now installed to the Rotaflex pumping unit

F.4 Configuring Linear Pumping Unit Data

Linear pumping unit dimensional data can be entered manually or the necessary data can be retrieved from the Lufkin Well Manager RPC database.

MENU 2/1/4

Note: This screen only displays when the **RPM/CRANK-LINEAR** option is specified in the **Position Transducer Type** field of the End Devices Parameters screen (**MENU: 2/1/2**).

To program linear pumping unit data, from the Main Menu screen, use **MENU: 2/1/4** to display a Pumping Unit Parameters screen. If the position input option selected was RPM/Crank-Linear, a Pumping Unit Parameters programming screen similar to Figure F-3 displays.

Note: This screen is also included in the Quick-Start feature described in section 18, "Quick-Start Feature."

```
RPC Ver. 5.42        CS:05D8A7B1    02-10-2011  12:58
                PUMPING UNIT PARAMETERS
                        Pumping Unit Type:   LINEAR PUMP
                       Stroke Length(in):    144.05
  Distance Between Sprocket Center(ft):    0000.00
                      Sprocket Radius(ft):    0000.00
            Chain Sprocket Output Ratio:    0001.00




   1.DATABASE SEARCH           3.CALC STROKE LENGTH
   2.ROTOFLEX DEFINITION       4.CALC OUTPUT RATIO
LUFKIN AUTOMATION             Tel. No. (281)-495-1100
```

Figure F-3. Pumping Unit Parameters for RPM/Crank-Linear Units

From the Pumping Unit Parameters screen, the required data can be entered manually or it can be retrieved from the pumping unit database in the Lufkin Well Manager RPC.

Data Field Descriptions

Information about each data field is provided below.

Pumping Unit Type

This field is a reminder that a linear pumping unit is in use. This field cannot be edited.

Stroke Length

States the length of the pump stroke in the selected units. Note that the Lufkin Well Manager RPC will calculate this value after you enter the sprocket radius and the distance between sprocket centers.

Distance Sprocket Center

States the distance between the centers of the lower chain drive sprocket and the upper chain idler sprocket. Check with the manufacturer of the pumping unit for this data.

Sprocket Radius

States the radius of the drive and idler sprockets in selected units. Check with the manufacturer of the pumping unit for this data.

Chain Sprocket Output Ratio

Described as the total length of the drive chain divided by the sprocket radius. This value indicates the number of drive sprocket revolutions required to complete one pump stroke cycle. Note that the Lufkin Well Manager RPC will calculate this value for you after you enter the sprocket radius and the distance between sprocket centers.

Entering Linear Pumping Unit Data Manually

If the required dimensions are known, entering the data manually is the fastest data entry method.

Follow the steps below to enter the data manually.

1. Display the Pumping Unit Parameters screen (**MENU: 2/1/4**).

2. Enter the appropriate data in each field.

3. When all data fields read as desired, select **3. CALC STROKE LENGTH** to have the Lufkin Well Manager RPC calculate the theoretical stroke length from the dimensions just entered.

4. After the stroke length calculation is completed, select **4. CALC OUTPUT RATIO**.

   The output ratio is used in the Lufkin Well Manager RPC torque calculations to factor in the additional speed reduction of the chain/sprocket.

Entering Linear Pumping Unit Data Using the Lufkin Well Manager RPC Database

If the required dimensions are not known, you may be able to retrieve the necessary linear pumping unit data from the Lufkin Well Manager RPC database.

Follow the steps below to retrieve the data from the database.

1. Display the Pumping Unit Parameters screen (**MENU: 2/1/4**) and then select **1. DATABASE SEARCH** to display the Database Search Options Menu screen (Figure F-4).

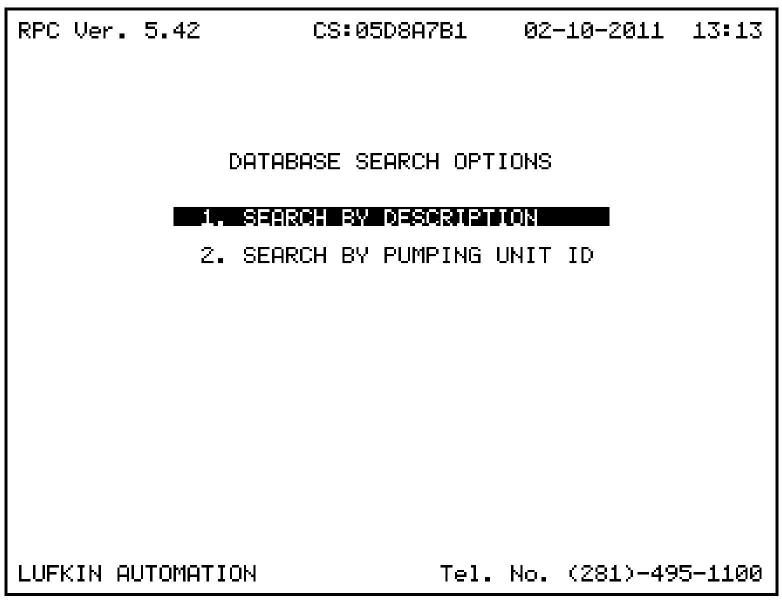


Figure F-4. Database Search Options Menu Screen

2. Select **2. SEARCH BY PUMPING UNIT ID** to display the Linear Pumping Unit Selection screen (Figure F-5).

3. If the pumping unit needed is not shown, continue pressing <↓> to scroll to the next page.

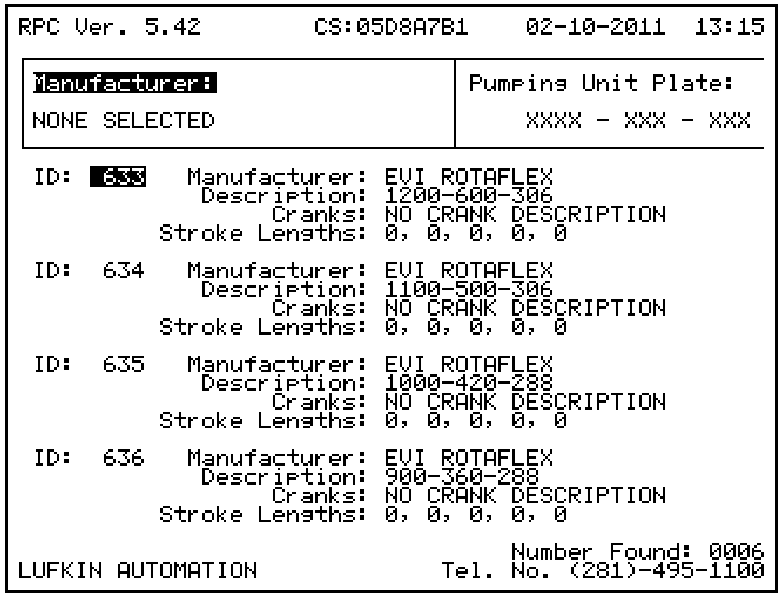


Figure F-5. Linear Pumping Unit Selection

4. Press <↑> and <↓> to highlight the correct unit.

   If the pumping unit needed is not shown, continue pressing <↓> to scroll to the next page.

5. When the desired unit description is highlighted, press **<ENTER>** to select that unit and return to the Pumping Unit Parameters programming screen (Figure F-3).

   A popup window appears briefly to notify you that the database selection is completed.

6. From the Pumping Unit Parameters programming screen, select **3. CALC STROKE LENGTH** to have the Lufkin Well Manager RPC calculate the stroke length.

7. Select **4. CALC OUTPUT RATIO**.

   The output ratio is used in the Lufkin Well Manager RPC Torque calculations to factor in the additional speed reduction of the chain/sprocket.

8. After the calculations are finished, and you are satisfied with the data, do one of the following:

   - If the Pumping Unit Parameters programming screen was accessed as part of the Quick-Start process, press **<NEXT>** to select the displayed pumping unit data and continue the Quick-Start.

- If the Pumping Unit Parameters programming screen was accessed directly using **MENU: 2/1/4**, press **<EXIT>** to select the displayed pumping unit data and return to the RPC Parameters menu screen (Figure 7-5).

F.5 Displaying Rotaflex Definitions

MENU 2/1/4

When **RPM/Crank-Linear** is selected in the **Position Transducer Type** field in the End Devices Parameters screen (**MENU: 2/1/2**), the Rotoflex Definitions screen (Figure F-6) is available for display when the Pumping Unit Parameters option is selected. Press **<2>** to display this screen. This screen defines the mathematical relationships used by the Lufkin Well Manager RPC to calculate the stroke length and the chain sprocket output ratio. This screen is for information purposes only and cannot be edited.

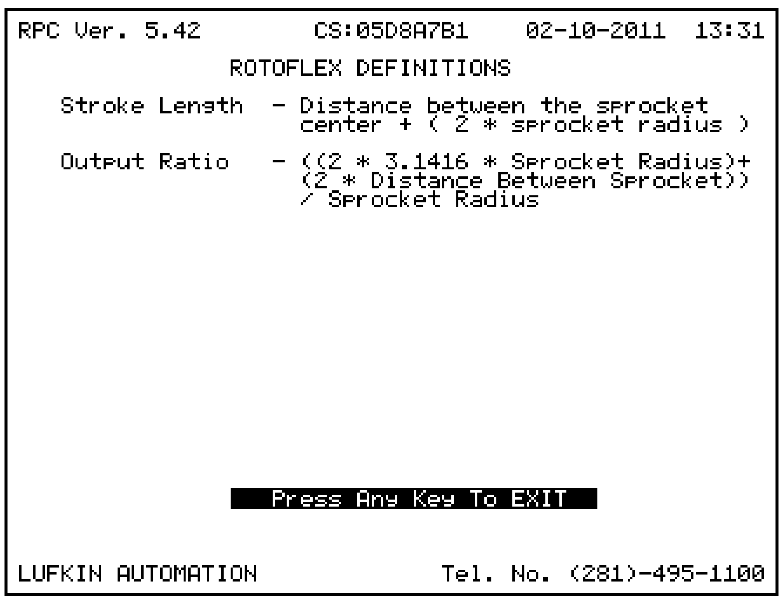


Figure F-6. Rotoflex Definitions Screen

Data Field Descriptions

Information about each data field is provided below.

Stroke Length

States the length of the Rotaflex pump stroke in the selected units.

Output Ratio

States the total length of the drive chain divided by the sprocket radius. This value indicates the number of drive sprocket revolutions required to complete one pump stroke cycle.

The Lufkin Well Manager RPC will calculate this value for you.

F.6 Configuring the Malfunction DO Channel

When the RPM/Crank-Linear option is selected on the End Devices Parameters screen, the **Malfunction DO Channel** field is added to the screen, as shown in Figure F-7.

MENU
2/1/2

```
RPC Ver. 5.42        CS:05D8A7B1    02-10-2011  13:36
                END DEVICES PARAMETERS
         Load Transducer Type  Calibrated 30000
     Using Intrinsic Barriers   NO
     Position Transducer Type  RPM / CRANK-LINEAR
                   Motor type  Nema-D
Full Load Power (Motor Plate)    40  hp
Full Load Speed (Motor Plate)  1140
                  Synch Speed  1200
       Malfunction DO Channel  DO 00




[UP/DWN] to navigate           [EDIT] to modify item
LUFKIN AUTOMATION            Tel. No. (281)-495-1100
```

New field

Figure F-7. End Devices Parameters Screen with Malfunction DO Channel Field

A digital output must be configured for use as an emergency/malfunction stop/start control input, which is required by some models of Rotaflex control panels. This emergency stop/start is in addition to the normal dedicated stop/start DO 2 on the Lufkin Well Manager RPC. The virtual digital output number entered in this field must be defined using the Digital Configuration screen (**MENU: 2/6/1/3**). For information about this screen, see "Configuring Auxiliary Digital Inputs and Outputs" in section 9, "Lufkin Parameter Programming."

An interposing relay must be wired to the defined digital output and the normally open contacts of that relay connected to the Rotaflex control panel malfunction start/stop input.

F.7 Other RPC and Lufkin Parameter Programming

The Pumping Unit Parameters screen (Figure F-3 on page F-6) is the only one that is unique to the linear pumping unit application. All other control parameters are configured as described in programming sections 8 and 9.

Appendix G

IEC Compliance Statements

This appendix describes the IEC compliance statements that Lufkin Automation adheres to for the Lufkin Well Manager RPC.

The topics covered in this appendix include:

G.1 IEC 60529

The Lufkin Well Manger RPC enclosure is rated to IP54 (NEMA 4X). To conserve this rating, all bulkhead fittings and blanking plates MUST be a minimum of IPX4 for all holes provided for electrical wiring by the installer.

G.2 IEC 601010-1 2001/02/01 CB

The Lufkin Well Manager RPC meets or exceeds IEC 601010-1 Standard for electrical equipment for measurement, control, and laboratory use; Part 1: General Requirements.

G.3 IEC 61000-6-2 2005 CB

The Lufkin Well Manager RPC meets or exceeds IEC 61000-6-2:2005 Electromagnetic Compatibility (EMC) – Part 6-2: Generic Standards – Immunity for Industrial Environments

G.4 IEC 61000-6-4 2006 CB

The Lufkin Well Manager RPC meets or exceeds IEC 61000-6-4:2006 Electromagnetic Compatibility (EMC) – Part 6-4: Generic Standards – Emission Standard for Industrial Environments

Index