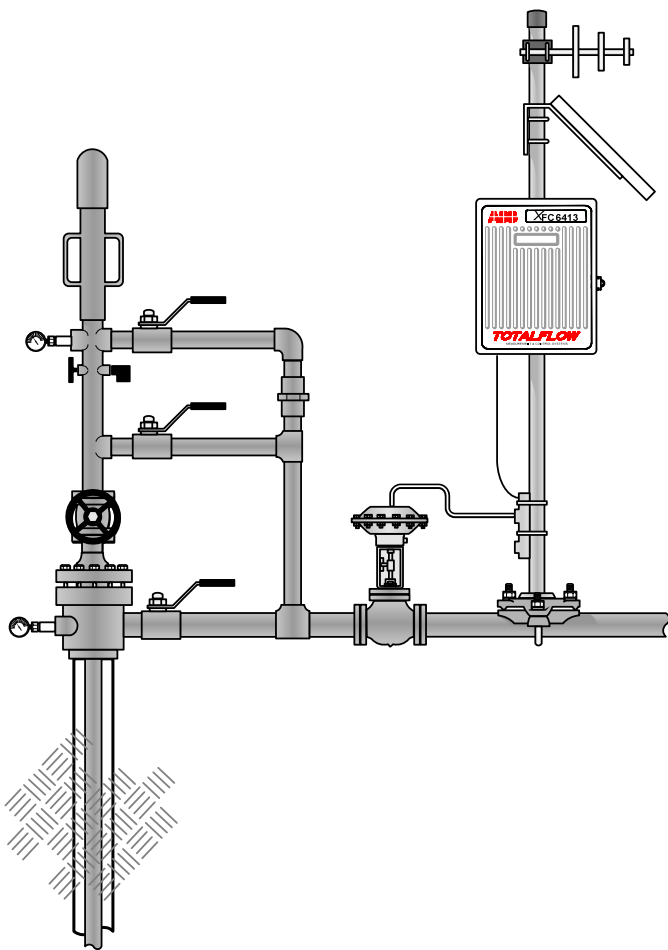




Plunger Lift Startup Guide



TOTALFLOW

MEASUREMENT & CONTROL SYSTEMS

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Inquiries regarding this manual should be addressed to ABB Inc., Totalflow Products, Technical Communications, 7051 Industrial Blvd., Bartlesville, Oklahoma 74006, U.S.A.

Introduction

This is a quick start guide designed for typical installations only. It is recommended that inexperienced technicians consult the *Application Information* document provided for more detailed information while doing the installation and startup. An additional explanation of Plunger Lift Theory may be found in "Background of Plunger Lift" found later in this document. Scan through the guide to see what information is available before you begin the installation. If for some reason, you have questions that are not answered in this guide or your other documentation, call your local Totalflow representative or call the number listed on the back page of this guide. Be advised that a special application file (or FLASH) is required: XFC-2102888 or XRC-2102889.

Recommended Startup Sequence

The following installation steps are for a typical Plunger Lift installation. These steps will refer you to the appropriate section within the Startup Guide. There are more variations and permutations to Plunger Lift than we could possibly cover in a single document. However, the steps listed below should present a very useful guide to other Plunger Lift installations.

Our particular example makes the following installation assumptions:

- A single upstream production valve (pneumatic/spring) is used.
NOTE: The Plunger Lift Example figure is an overview of our configuration both mechanically and electrically.
- Production valve will "close" on a system failure

- A single 12VDC 2-solenoid spooling valve (Versa-Valve®) is used to control the production valve. **NOTE: We discuss controlling the Versa-Valve® using a DI/DO module and a Valve Control module (see Electrical Installation).**
- No Blow Valve is used
- No Capture Valve is used
- No Valve Control application will be running
- System will monitor casing, tubing and line pressures for control
- System will incorporate an arrival sensor and a bar stock plunger
- An XFC controller will interface to the Versa-Valve® through an 8/Combo Digital TFIO Module
- The main production valve will open on a sufficient differential between the line and casing pressures
- The main production valve will close on reduced flow rate
- Well depth is assumed to be 10,000 feet using 2¾ inch tubing (1.998 I.D.)

STEP 1 Mechanical Installation.

Using the information contained in the “Mechanical Installation” section, later in this booklet, complete the equipment and mechanical installation

STEP 2 Electrical Installation.

Following the guidelines in the “Electrical Installation” section, later in this booklet, make all field wiring connections required.

STEP 3 PCCCU32 Software Setup.

Using the steps contained in the “Software Setup” section, later in this booklet, make necessary designations in PCCCU32. See additional steps for trending if desired.

Mechanical Installation

While a great deal of the mechanical installation is beyond the scope of this startup guide, a brief discussion is appropriate. The discussion will deal with a typical plunger lift installation (see Figure 1). The system will have one main production valve and no blow valve. The main production valve will be a pneumatic/spring actuated valve. Applying pneumatic pressure will open the valve. Removing pneumatic pressure will allow an internal spring to return the valve to a normally closed position.

Having a pneumatic/spring production valve will require that there is access to a pressurized air line to operate it. An electrically controlled slide, or spooling valve, is used to switch air pressure on and off to the production valve. Totalflow recommends a 12VDC two-solenoid spooling valve (Totalflow stocks the Versa-Valve®) to control the production valve. For discussion let us assume a production valve that opens when air pressure is applied and closes when pressure is removed. The

spooling valve will be controlled electrically from the flow computer (XFC/XRC). The electronics will control the spooling valve and the spooling valve will pneumatically control the production valve. Some production valves require one pressure line to open and another pressure line to close. These would require two spooling valves. Again, our discussion will involve one spooling valve to control the production valve.

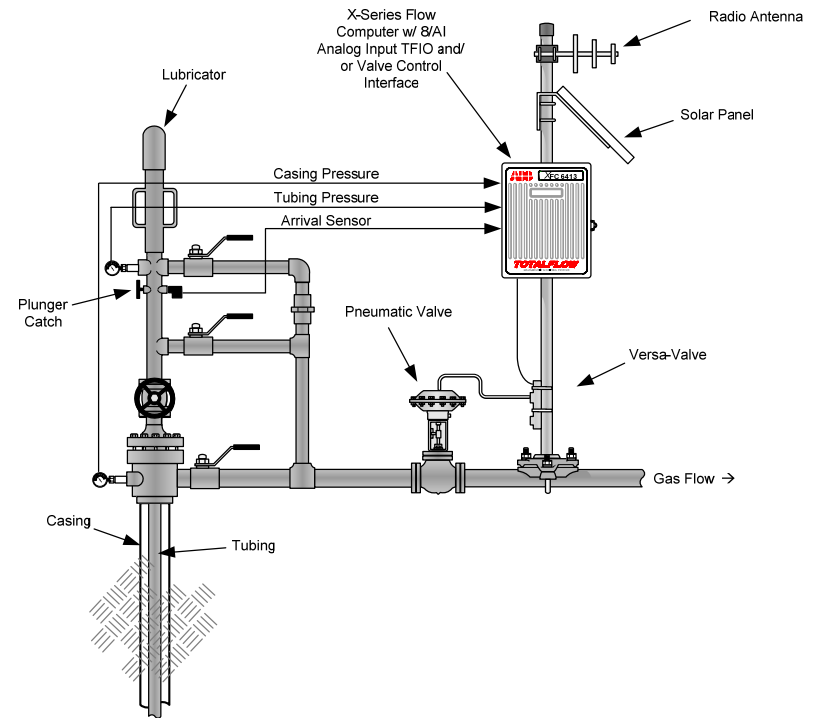


Figure 1. Typical Plunger Lift Installation

Example: Plunger Lift

An arrival sensor is required to recognize plunger arrival. The arrival sensor is generally a Hall Effect device that responds to the plunger passing through its magnetic field. The arrival sensor generates a pulse as the plunger passes. This pulse is recognized by the plunger lift application as marking plunger arrival.

Two external pressure transducers will be required. One transducer is used to monitor casing pressure, the other to monitor tubing pressure. Our discussion will place the production valve upstream from the flow computer (XFC). The flow computer will calculate line pressure from its AP (absolute pressure) reading and barometric pressure. Line pressure will be the absolute pressure minus the barometric reading. If the production valve is downstream from the flow computer, you would use an external transducer to monitor line pressure and the flow computer

would use its AP reading minus the barometric pressure to determine the tubing pressure.

Electrical Installation

The typical example involves driving a single production valve. In the Mechanical Installation section it was discussed how a 12VDC two-solenoid spooling valve (Versa-Valve®) is used to control the pneumatic production valve. The spooling valve is controlled electrically from the XFC/XRC TFIO module (see Figure 2 and Figure 3) and pneumatically controls the production valve. Totalflow manufactures two TFIO modules that will support control of the two-solenoid spooling valve; the Valve Control Interface Module (PN 2100412) or the Combo Digital Module (PN 2100543).

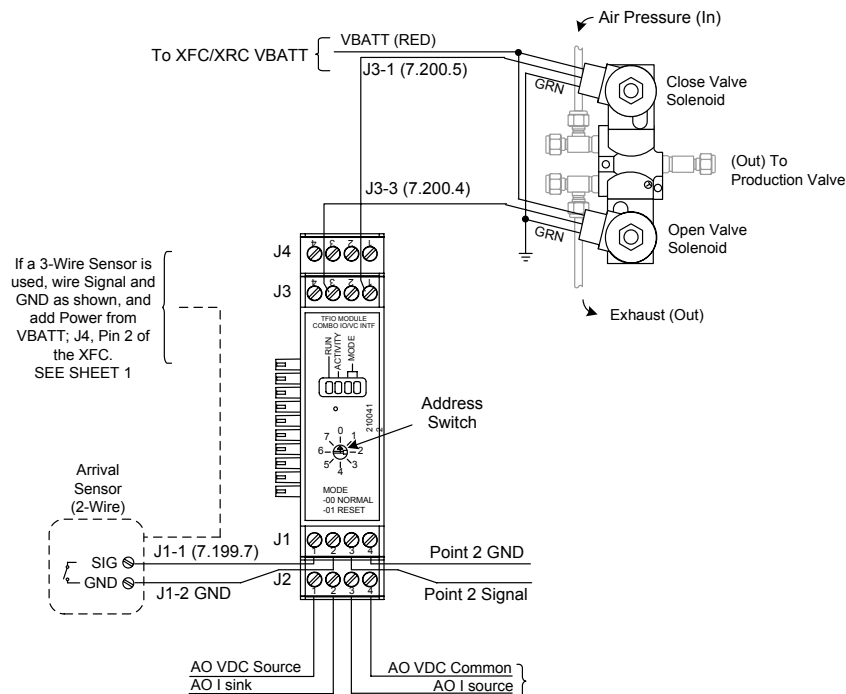


Figure 2. Valve Control Module Controlling Spooling Valve

The register addresses in both examples assume that you only have one Valve Control Interface Module and/or one Combo Digital Module (i.e. the address switch is set to zero).

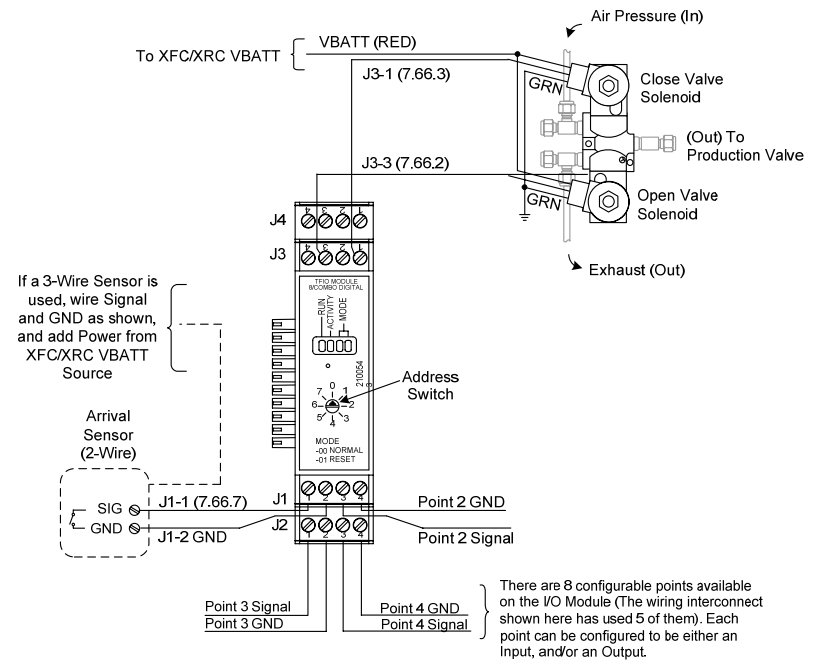


Figure 3. Combo Digital TFIO Module Controlling Spooling Valve

PCCU32 Software Setup

Instantiating Plunger Lift (PCCU32)

If you don't see the Plunger application in the tree view (see Figure 4), it isn't turned on (instantiated). To turn on the Plunger application, you need to go to the "Applications" table. The "Applications" table has 24 rows of applications (0-23). Each instantiated application requires processing time and memory to run. Don't turn on all of the applications at once, only the ones you need. Each application has an application slot that it should occupy when turned on. If you aren't sure what app slot any application should occupy, call our customer support and they will be glad to help you.

The Plunger Lift application is assigned to application slot 18 (see Figure 5). This is important for a couple of reasons. First, applications can sometimes pull data from other applications. In this case it is necessary that the Plunger Lift application be in slot 18 so that other applications that might require Plunger data will know where to find it. Secondly, if it's in a slot other than slot 18 it can be very confusing to our customer support personnel if you call.

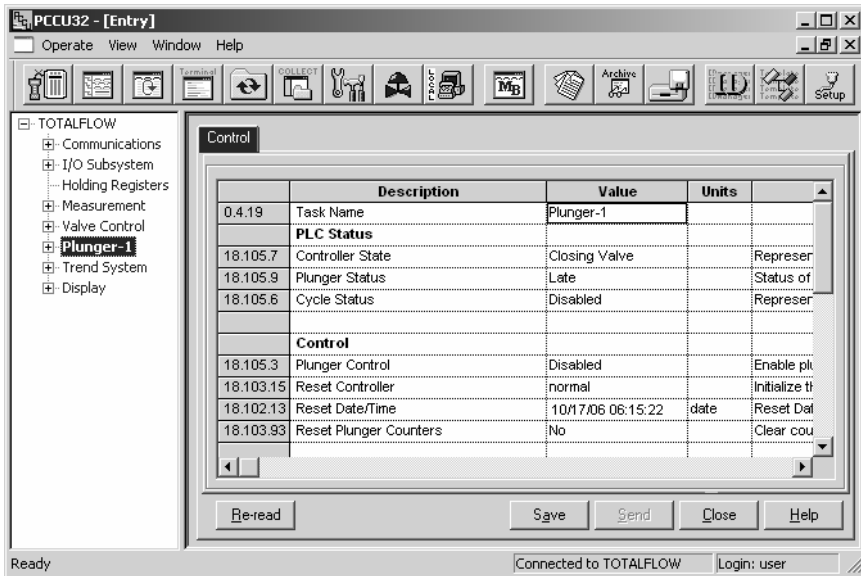


Figure 4. Plunger Lift is Instantiated

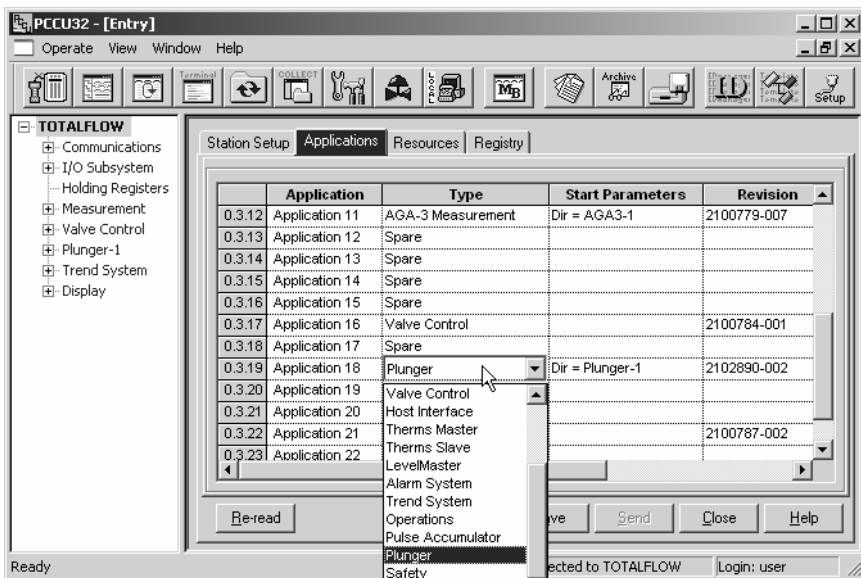


Figure 5. Instantiating Plunger in Slot 18

Plunger Lift Setup

The Plunger Lift application has been instantiated. Let's walk through the PCCU32 setup of a typical Plunger Lift application. At this point it would be good if you could connect to a Totalflow flow computer and walk through the Plunger screens.

The following is a step by step explanation of PCCU32 setup for the Plunger Lift application. Not all of the parameters are going to be mentioned. Many parameters will be good with the default values that were set when you Reset VCBs. Some explanations will be offered in **highlighted text**.

1. Open the Plunger Lift tree view
2. Go to Setup
 - General Setup
 - Reset VCBs = Yes and Send (all defaults assume Upstream)
 - Re-read
 - Plunger Control = Disabled (disable during setup procedure)
 - Startup Mode = 1 Closing valve
 - Optimization = ENABLED (application will tune some timing values to optimize production)
 - Plunger Fail Factor Tune = 1.5
 - Tubing Length = 10,000 (enter tubing length for you well)
 - Tubing ID = 1.998 (enter your tubing's internal diameter)
 - And Send
 - Valve Setup
 - Valve Position = Upstream
 - Valve Time Limit = 5 seconds
 - Main Valve Type = Pulse-Two output
 - Main Open DO = 7.66.3
 - Main Close DO = 7.66.2
 - Main Valve Fail State = Close (**close valve on failure**)
 - Valve Controller Option = Disabled
 - And Send
 - Input Setup
 - Most parameters are good with the default values
 - Casing Pressure AI = 7.3.4
 - Ext Pressure AI = 7.3.3 (dependent upon whether upstream or downstream.. default values assume upstream)
 - Detector Type = I/O (I/O implies a plunger. Intermitt implies no plunger.)
 - Plunger Arrival PI = 7.64.7

- And Send
- 3. Go to States
 - 1 – Closing Valve
 - Plunger Fall Delay Limit = 00:00:30 (time required for plunger to fall to bottom of tubing.. and through any accumulated fluids)
 - **NOTE: Logic does not look for any open condition until this limit has expired.**
 - **Example:**
Assume well depth = 10,000ft
Assume fall velocity 375ft/sec (bar stock plunger)
PFDelayLimit = 10,000/375 = 26.7 (00:27:00)
 - And Send
 - 2 – Valve Closed
 - Go to 2 – Valve Closed tab
 - Option Case – Line Open = ENABLED (main valve will open when casing pressure is sufficiently higher than line pressure)
 - And Send
 - Go to Case - Line Tab
 - Case Line Open Limit = 25.00 (we will start a plunger cycle with a 25psig differential)
 - Case – Line Open Tune = 1 psig (**initial tuning factor**)
 - Case – Line Open Min Tune = 15psig (**don't tune below this floor**)
 - Plunger Fail Factor Tune = 1.5 (if plunger fails, bump tuning factor)
 - And Send
 - 3 – Plunger Arriving
 - Go to Timers tab

If arrival time is longer than Max (plunger slow to arrive), close main valve or open blow valve.

 - Max ≈ 00:16:40 (10,000ft @ 600ft/min)

If arrival time is between Max and Slow, tuning will occur.

 - Slow ≈ 00:13:20 (10,000ft @ 750ft/min)

If arrival time is between Slow and Fast no tuning is necessary.

 - Fast ≈ 00:10:00 (10,000ft @1000ft/min)

If arrival time is between Fast and Min tuning will occur.

- Min ≈ 00:08:00 (10,000ft @ 1200ft/min)
- If arrival time is shorter than Min (plunger arrival too soon), logic assumes plunger did not reach bottom. Don't set Min shorter than the Plunger Fall Delay Limit.**
- Max Arrivals Allowed = 10
 - If the number of Max (SLOW) Arrivals exceeds this number, shut-in the well until it can be checked manually and reset.
 - And Send
- 4 – Blow Valve (not applicable in our example)
- 5 – Plunger Arrived
 - Cycles before Maintenance = 1000 (many plungers will require replacement after some number of cycles)
 - And Send
- 6 – Afterflow
 - Option Flow Rate Close = ENABLED
 - And Send
 - Go to FR tab
 - Flow Rate Limit = 100 (when flow rate remains below this limit for..)
 - Flow Rate Low Time Limit = 00:01:00 ..this amount of time, close the valve)
 - “FR Limit” Tune = 5
 - “FR Limit” Minimum = 50 (do not tune below this floor)
 - And Send
- 4. Go to Setup
 - General Setup
 - Plunger Control = Enabled (with setup completed you can now start the Plunger Lift application)
 - And Send

Trending with Advanced PCCU32

Note: Basic PCCU32 does not support Trending. You must have the advanced version of PCCU32 to support Local Remote Protocol and Trending. WinCCU32 can also be used to create a Trend file. Using WinCCU32 lets the operator setup a Trend file remotely.

Trending is nothing more than the ongoing sampling of a particular piece of data. For example; the operator has noticed that one of his flow meters is going into Sleep mode. Going into Sleep mode would generally indicate that battery voltage has dropped significantly. The Solar Panel appears to be in good working condition. The flow meter's onboard battery charging regulator seems to be okay. What is causing the battery voltage to drop and the meter to go into Sleep mode?

A very handy diagnostic tool is the "Trending System". In the above example it might be helpful to collect, or sample, battery voltage. If battery voltage is sampled over a period of time (several hours) you may find a clue as to what is causing the battery voltage to drop. The Trending System will do this sampling.

Creating a Trend File

To create a Trend file you must have the Trending System application turned on (instantiated) in the flow meter (see Figure 6). If the Trend System is NOT in the tree view you will need to go into the Applications table and instantiate the Trend System in application slot 21.

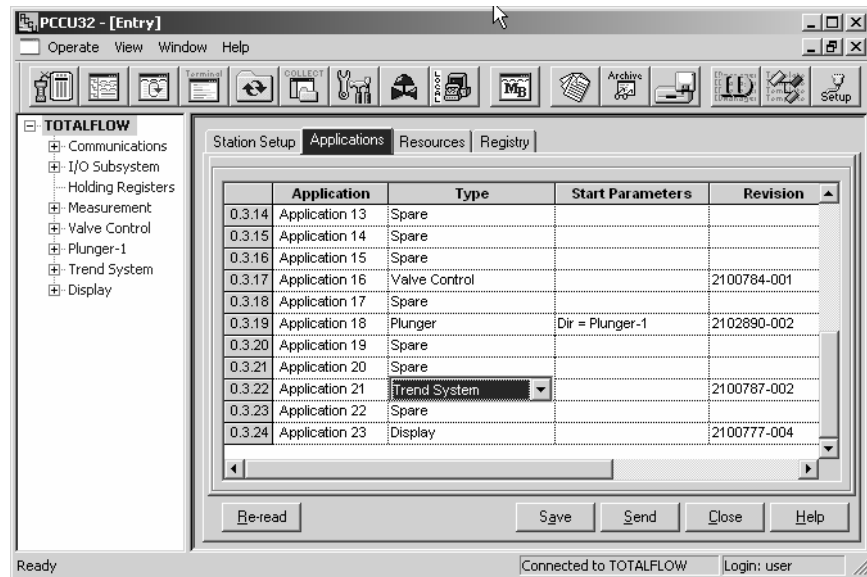


Figure 6. Instantiating the Trend System

Every variable, parameter and/or value in the flow computer, is represented by a three part register number (i.e. app.array.register). In the above screenshot the Trend System is instantiated in Application slot 21. This fact is recorded by the System application in register 0.3.22. If you look at the top of the Application table you will see that Application 0 is the System application. And again, within Application 0 (System), register 22 records the fact that the Trend System is assigned to Application 21. The Array number generally has no meaning to the operator.

Casing pressure, tubing pressure, line pressure and flow rate are extremely important when setting up or diagnosing a plunger system. When customers call for help diagnosing a plunger lift issue we often ask that they have these data to aid in our analysis.

Let's walk through the steps involved in trending casing pressure. All the other values (tubing, line and flow rate) would be trended similarly.

One of the first pieces of information necessary to setup a trend file is the register number of the value to be trended. Most register numbers are posted in PCCU32 just to the left of the value. Connect the casing pressure transducer to the onboard analog input, AI1. The register number for AI1 is 7.4.3 (see Figure 7). Tubing pressure is often connected to analog input, AI2. However, for the example only AI1, or casing pressure will be trended. **NOTE: Analog inputs must be calibrated. Refer to PCCU32 Help Screens for calibration help.**

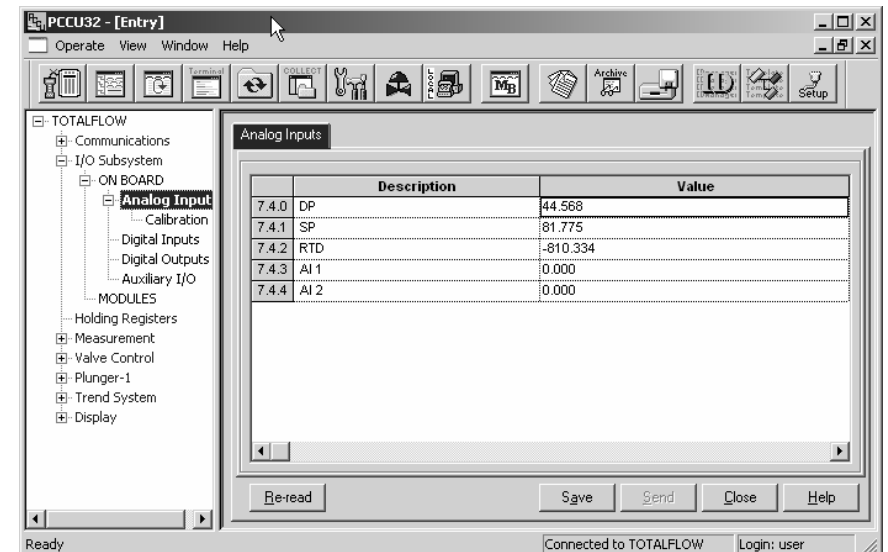


Figure 7. Analog Input AI1

To setup a trend file using PCCU32 you must connect through the Local Port (military connector) using Remote Protocol (see Figure 8).

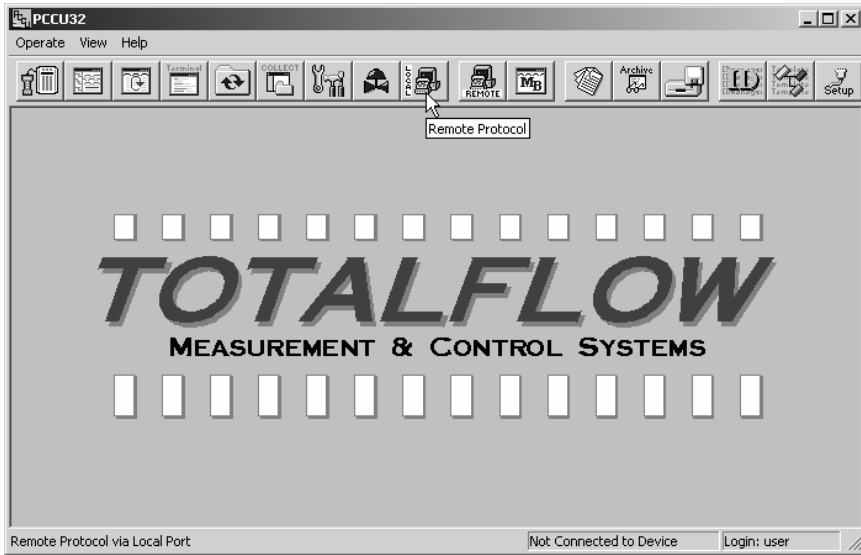


Figure 8. Remote Protocol Connection

The Trend System screen will appear (see Figure 9). Hit the “Configure Device” button.

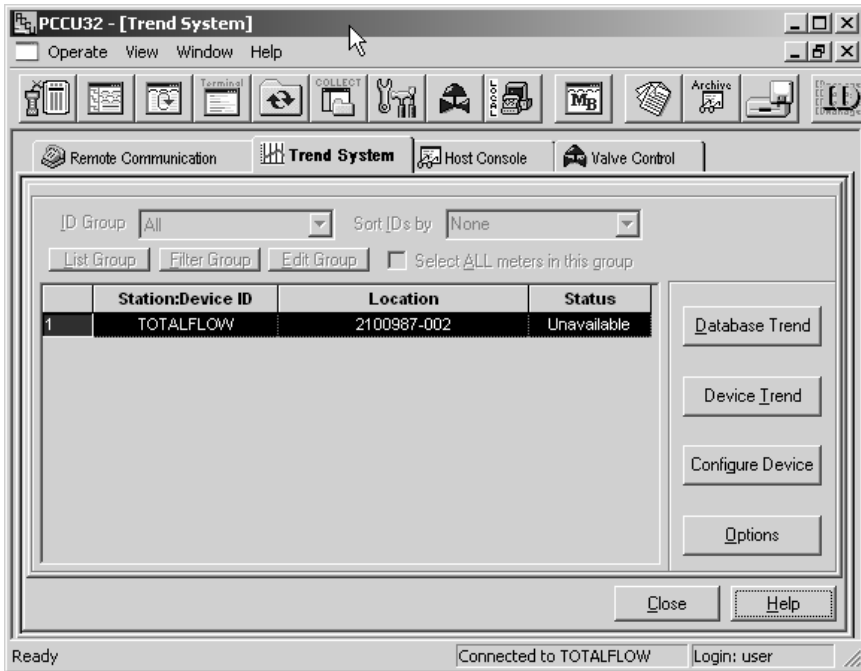


Figure 9. The Trend System Screen

The Configure Device screen will appear (see Figure 10).

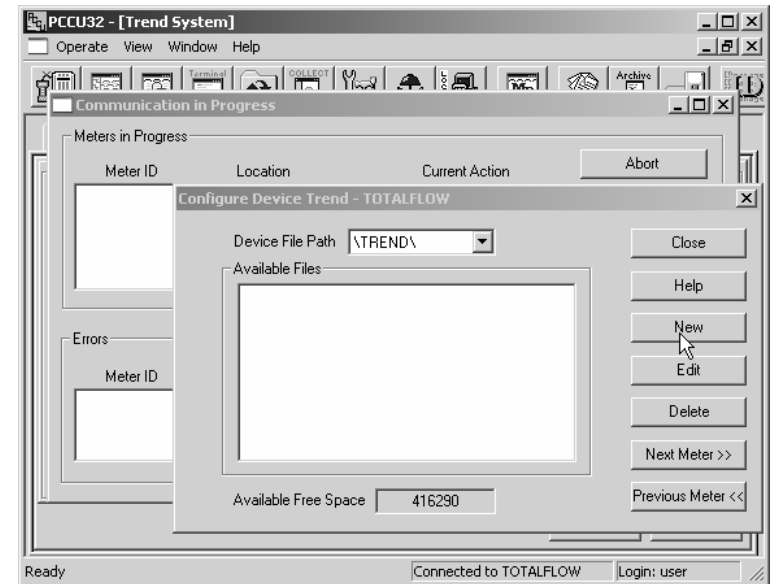


Figure 10. Configure Device

Now you can hit the “New” button and the “Trend File Configuration” dialog box will come up (see Figure 11). Enter a filename and description of “Casing Pressure” and hit the “Add” button.

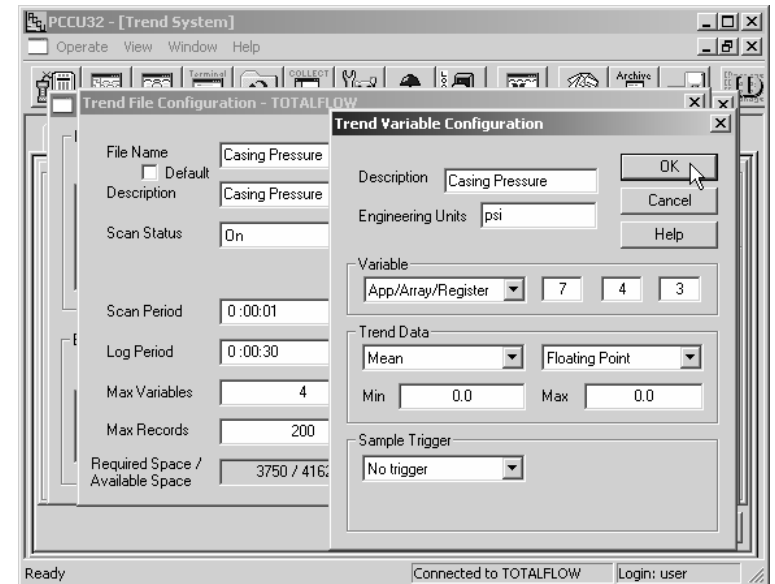


Figure 11. Add ‘Casing Pressure’ Variable

In Figure 11. Add 'Casing Pressure' Variable the variable "Casing Pressure" was added to the Trend file and pointed to the appropriate register, analog input AI1 (7.4.3). Notice how "Casing Pressure" has been added to the variable list (see Figure 12).

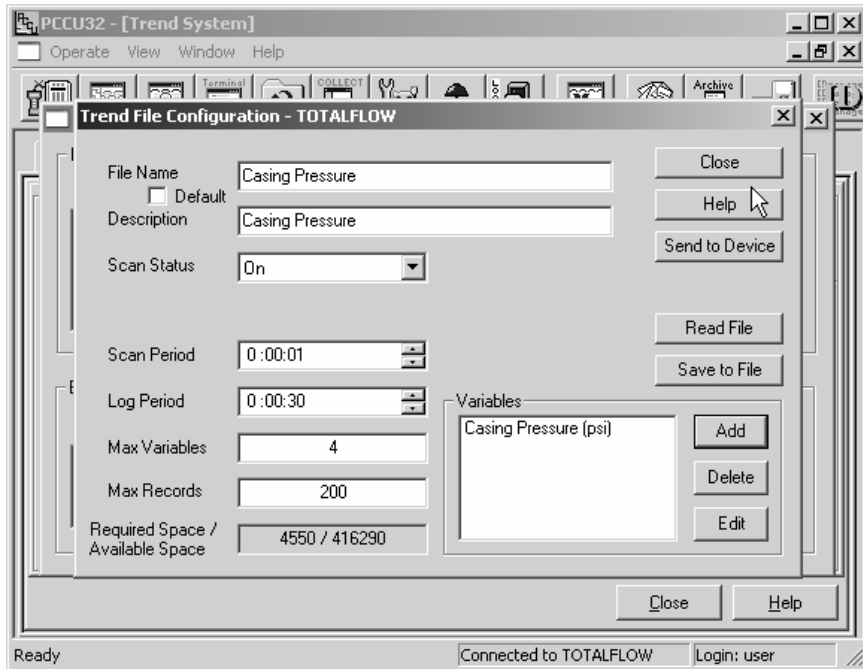


Figure 12. Casing Pressure Added to Variables

If more than four variables are required, bump the "Max Variables" field. However, with four variables, tubing pressure, line pressure and flow rate could be added. Go into Entry mode in PCCU32 and find the appropriate register numbers for the variables to be added.

At this point several options are available. The Trend file can be saved with "Save to File", the variable list can be edited with "Edit" and/or the file can be downloaded to the meter with the "Send to Device" command.

Some thought needs to be given to creating a Trend file. How many records are needed? How often should the register be scanned? How often should the scanned data be logged? How much memory is required to store the trend file? **NOTE: There is a finite amount of memory available for applications in the flow meter. If things are getting tight (memory-wise) make sure you don't have any applications turned on that are not being used.**

Plunger Lift Background

The Plunger Lift concept is very simple. The plunger works the same as a pneumatic piston. It only becomes complicated by the many parameters. Plunger Lift is generally used to remove liquids from gas wells having a gas to liquid ratio (GLR) greater than 400SCF per barrel per 1000 feet of lift. For every barrel of fluid you have to lift 1000 feet, you'll need at least 400SCF of gas.

Example: *A 10,000 foot well that makes 5BBLS per day would need to make at least 20MCF/per day (The higher the GLR, the better chance of success).*

The basic idea is to insert a steel plunger into the production tubing. This plunger will act as a seal between the liquids and the gas. As the plunger settles to the bottom of the production tubing, liquids will accumulate above it. When the production valve closes the down-hole pressure will build in the casing. Casing pressure will eventually be sufficient to lift the plunger and accumulated fluids to the surface. When the production valve is opened this increased casing pressure is expelled into the tubing, driving the plunger and its liquid load to the surface. At the surface separators remove the liquids from the gas.

Production flow continues until down-hole fluids begin to again accumulate in the tubing. Accumulating fluids restrict the free flow of gas. As the volume of flowing gas drops it will become necessary to close the production valve, allowing the plunger to drop to the bottom of the production tubing. With the well again shut-in, down-hole pressures will build and the cycle will be repeated.

Plunger Lift is very simple. Shut-in the well (close the production valve) and allow down-hole pressures to build in the casing. Open the production valve and down-hole casing pressures are expended as the plunger is driven up the production tubing to the surface. Complexities arise when you start to optimize production by opening and closing the production valve at the "right" times. There are several methods used for determining when to open and close the production valve. No one method is the "right" method for all conditions.

How long should the well be shut-in to produce the optimal lifting pressure? What pressures and flow rates should be monitored to best determine when to open the production valve and let the well flow? What situations might cause the system to fail and how should the system respond to those situations? As down-hole characteristics change how should the system be "tuned" to respond to these changes? All of these issues result in a myriad of user selectable modes and programmable settings. Below is a listing of user defined modes and settings for determining when to open or close the production and blow valves.

Upstream or Downstream?

Note that the production valve position relative to the meter determines which inputs are used for line pressure and tubing pressure. Production valve position is specified as part of the setup for plunger logic.

If the valve position is “Downstream” of the orifice plate then:

- line pressure is read from the input specified using the “Ext Pressure AI”, and
- tubing pressure is read from the input specified using the “AP Register” and the value in the “Baro Press Register” is subtracted from it to calculate the tubing pressure in PSIG.

If the valve position is “Upstream” of the orifice plate then:

- line pressure is read from the input specified using the “AP Register” and the value in the “Baro Press Register” is subtracted from it to calculate the line pressure in PSIG, and
- tubing pressure is read from the input specified using the “Ext Pressure AI”.

Conditions to Open the Production Valve

If any one of the following optional conditions is TRUE and valve is closed, the valve will open.

- Timer > Limit
- (Tubing pressure – Line Pressure) > Limit
- (Casing Pressure – Tubing Pressure) > Limit
- (Casing Pressure – Line Pressure) > Limit
- ((Casing Pressure – Line Pressure) > Limit) AND ((Tubing pressure – Line Pressure) > Limit)
- Load Ratio < Limit for a user specified time AND Casing Pressure greater than Line Pressure by user specified amount OR Load Ratio < Load Ratio Trip
- (Tubing pressure > Limit) OR (Tubing pressure < Limit) for user defined amount of time
- (Casing pressure > Limit) OR (Casing pressure < Limit) for user defined amount of time
- (Static pressure > Limit) OR (Static pressure < Limit) for user defined amount of time
- Slug Size > Limit
- (Input 1 > Limit) OR (Input 1 < Limit) for user defined consecutive minutes
- (Input 2 > Limit) OR (Input 2 < Limit) for user defined consecutive minutes

- Mandatory close timer > Mandatory close time. This is only used after a plunger non-arrival.
- Total Cycle time from valve open to valve open.
- Hold in closed state if status indicates
- Hold in closed state if pressure \geq limit
- Hold in closed state during certain hours of the day.
- Using the Open Push Button. **NOTE: This will open the valve even if the valve has just been closed and the plunger has not fallen to the bottom of the tubing.**

Conditions to Close the Production Valve

If any of the following optional conditions are TRUE and the controller is in the After Flow state, the valve will be closed.

- Timer > Limit
- DP < Limit for user defined amount of time
- Flow Rate < Limit for user defined amount of time
- (Tubing Pressure – Line Pressure) < Limit
- (Casing Pressure – Tubing Pressure) < Limit
- Casing Pressure < Limit
- (Flow Rate < (Turner flow * Turner Multiplier) AND (ABS(Line pressure – casing pressure) < user specified value) for user defined amount of time
- Load Ratio < Limit for a user specified time
- (Tubing pressure > Limit) OR (Tubing pressure < Limit) for user defined amount of time
- (Casing pressure > Limit) OR (Casing pressure < Limit) for user defined amount of time
- (Static pressure > Limit) OR (Static pressure < Limit) for user defined amount of time
- Slug Size > Limit
- (Input 1 > Limit) OR (Input 1 < Limit) for user defined amount of time
- (Input 2 > Limit) OR (Input 2 < Limit) for user defined amount of time
- Using the Close Push Button. **NOTE: This will close the valve even if the valve has just been opened and the plunger is heading upward.**

Conditions to Open the Blow Valve

If any of the following conditions are TRUE and the controller is waiting for Plunger Arrival, the Blow Valve will be commanded Open. This is a separate action from the existing blow valve state, which is activated by

the number of arrivals that exceed the Maximum Arrival Time. These conditions will open the Blow Valve in an effort to assist Plunger Arrival by reducing head pressure to something close to atmospheric pressure. The controller will remain in the Plunger Arrival state.

- Casing Pressure < Setpoint
- Flow Rate < Setpoint for user defined amount of time
- DP < Setpoint
- Timer > Setpoint

State Transition Logic or Theory of Operation

A good way to describe the operation of the Plunger Lift application is through the use of a State Diagram (see Figure 13). State Diagrams are simple pictorial representations of how a software application (such as Plunger Lift) might behave. As they say, a picture is worth a thousand words.

In the State Diagram each State is represented by an oval and the name of that State. A State name is somewhat arbitrary, but should represent a fairly recognizable “condition” or State within the overall behavior of the application. Seven States (0-6) have been identified in the Plunger Lift application. These seven States were also given names to identify the application’s “condition” or State at that point (e.g. Plunger Arrived, After Flow, etc.).

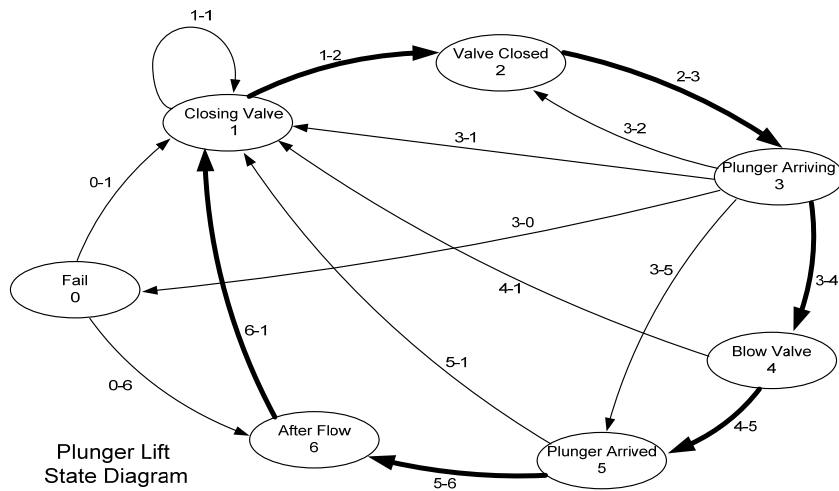


Figure 13. Plunger Lift State Diagram

Normal operation involves moving from one State to another. These moves, or State transitions, are well behaved and clearly defined. In the diagram the arrows represent valid State transitions and are labeled “X-Y”, where X is the prior state and Y is the current state. Basic operation

involves little beyond opening or closing the production valve at the “right” time. Plunger arrival time is key in determining that “right” time.

Typical operation can be traced through the heavier arrows. The lighter arrows generally represent exceptions to normal operation. You’ll notice that while there are States referring to Closing (Closing Valve and Valve Closed) the production valve, there are no corresponding States referring to Opening the production valve. The production valve is Opened during the transition (2-3) between Valve Closed and Plunger Arriving (see below).

Example: Typical Plunger Lift Cycle

Let’s follow the heavier arrows through a typical Plunger Lift cycle. Start at the beginning (Closing Valve or State 1). What typical transition causes us to leave “Closing Valve”? Answer: State Transition 1-2. Looking at State Transition “1-2”...

1-2 Closing Valve to Valve Closed

- *Plunger Fall Delay Timer expires*
 - *Close Push Button pressed (optional)*
 - *Mandatory Recovery Time > Mandatory Recovery Timer (optional)*
 - *Flow Rate < Valve Close Setpoint for user Defined Time (optional)*
 - *If this option is enabled the others cannot be used*
- Upon transition, Valve is considered Full Closed.*
The Closed Timer is started.

Go to State 2

Any of the “bulleted” items becoming “true” will cause the application to assume a fully closed production valve and start the **Closed** timer. The Plunger Lift (PL) application now moves to State 2 (Valve Closed).

Now the PL application is sitting in “Valve Closed” or State 2. Only one arrow “leaves” State 2, transition 2-3. Look at State transition 2-3. There are several “bulleted” items that might cause a State transition from State 2 (Valve Closed) to State 3 (Plunger Arriving). Here the Plunger Lift application determines “when” to Open the production valve. Here is where much of the complexity is encountered. Do you want to Open the production valve after having left the well shut-in for a period of time?

- *Close Valve Timer >= Close Cycle parameter*

Or would you rather Open the production valve based on the pressure difference between Tubing Pressure and Line Pressure?

- *(Tubing Pressure – Line Pressure) > TL Delta*

There are several selections the operator can make here. You can even select multiple options. Of the selections you make, the first to become “true” will cause the application to Open the production valve, compute

the shut-in time, start the Plunger Arrival timer and transition to State 3 (Plunger Arriving).

Now the Plunger Lift application is in State 3 (Plunger Arriving) waiting for the plunger to arrive. There are several ways out of State 3. For our example we're going to assume that there is no Blow Valve (i.e. Blow Valve is disabled). With no Blow Valve transition, 3-5 would be the more typical path. We're going to assume a normal plunger arrival time:

- *IF: Fast Arrival Time < Plunger Arrival < Slow Arrival Time OR Plunger Arrival < Minimum Arrival Time*

Do not tune any Open or Close Valve times..

Go to State 5

Now the plunger has arrived and the application is in State 5 (Plunger Arrived). With the arrival of the plunger the system has lifted any liquids off of the well and is in gas flow. If swabbing is disabled the following events will be true:

5-6Plunger Arrived to After Flow

- *IF: Plunger has arrived*

Compute Plunger arrival time (minutes)..

Log number of Normal, Fast, Late and consecutive Normal arrivals..

Compute Plunger arrivals for current contract day..

Reset Max. Arrival Count = 0..

Start the After Flow Timer..

Give control of Main Valve to standard Valve Controller if enabled by user. Standard Valve Controller will start controlling valve based on previous user selectable settings (i.e. Auto DP, AP or Flow Rate).

Go to State 6

Transition to State 6 (After Flow). In State 6, After Flow, the system is waiting for the "right" moment to Close the production valve. There are many options for Closing the production valve. Again, the first selection to become "true" will drive the application to the next State. In the example, the production valve is Closed when the After Flow timer expires.

- *After Flow Timer >= Flow Time*
- *IF: any one of the above conditions occur..*

Compute Flow Cycle Time..

Starts the Plunger Fall Delay Timer..

Go to State 1

Returning to State 1 (Closing Valve) where the cycle will be continued.

Some Last Thoughts on Startup

Casing pressure is responsible for driving the plunger to the surface. Casing pressure must overcome the weight of the plunger and slug, well depth and line pressure. Do we have enough casing pressure?

$$[(CP - TP) / (CP - LP)] * 100 \leq 40\%$$

Where CP, TP and LP are casing, tubing and line pressures respectively.

- Most plunger manufacturers suggest running their plungers at speeds between 750 and 1000 feet per minute. If your well depth is 20,000 feet, you'd want your plunger to arrive between 20 (1000ft/min) and 26.5 minutes (750ft/min). If your plunger is arriving faster than 20 minutes you would want to lessen casing pressure buildup (shorten the shut-in time) on your subsequent runs. However, if the plunger is arriving later than 26.5 minutes you would want to increase casing pressure buildup (lengthen shut-in time).
- It's possible that your plunger continues to arrive earlier than you would like. You cannot continue to shorten the well's shut-in time. You must allow a minimum shut-in time to allow the plunger to fall to the bottom of the production tubing. In this situation you might increase the after flow time to bleed off excessive casing pressures.
- As you make adjustments to shut-in and after flow times, do so gradually. Don't make huge adjustments, as that might shock the well and require time to stabilize. Allow the well to cycle a couple of times between adjustments.

