Differential Pressure Controller User's Manual

Version 4.5.2

Integrated Production Services
41165 Park 290 Drive
Waller, Texas 77484
(936) 931-2100
www.ipsadvantage.com

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1 Overview of the Differential Pressure Controller

The SMI Differential Pressure Controller is designed to automate the production cycle of an oil or gas well equipped with a plunger lift system. It can also be used for other well hook-ups that do not have a plunger lift system. Configuration data and well data are stored by the controller and can be reviewed through the set and read commands. The data needed most often can be read quickly using the scroll keys. The controller is normally used with a plunger detector switch. The plunger detector is used to detect when the plunger arrives at the surface and signals the controller when Sales Time (Afterflow) should start. Note that Sales Time and Afterflow are used interchangeably in this manual. They both mean the time the motor valve is open after the plunger arrives. There are certain well hook-ups that do not require a plunger detector, for example, when the controller is being used as a Hi-Lo controller or an intermitter. The controller is normally connected to the tubing and sales line via pressure transducers. It also can be connected to the casing pressure using a third pressure transducer. The casing pressure is for monitoring only. The controller optimizes the well by automatically adjusting the Sales Time based on Well Recovery Time and adjusting the differential pressure, (tubing pressure minus the line pressure), based on the Plunger Travel Speed. It can also be used in a manual non-adjusting mode. The controller comes standard with a Modbus interface. This allows all Well and Configuration data to be polled by a host computer. This is useful if the controller is being used as part of an automation system.

1.1 Differential Pressure Control Cycle

The Differential Pressure Controller operates using five timers. The following is a list of the timers: On, Sales, Plunger Fall, Off and Battery Off. All the timers, except the Off Timer and Battery Off Timer, are settable by the user.

When the controller is powered on, it starts up in Plunger Fall Time. This is to ensure the safest possible starting position. The Fall Time is used to get the plunger on the bottom of the well. It also serves as the minimum Off Time for the well. Once the Fall Time expires, the controller will go into Off Time. During Off Time, the controller is waiting on the pressure differential to be met. Unlike the other timers, the Off Timer counts up and not down. This indicates how long the well has been off past the Fall Time or since the plunger arrived on bottom. Once the differential pressure (tubing pressure minus line pressure) has been met, the controller will leave Off Time and go to On Time. During On Time, the controller is waiting on the plunger to arrive. If it does, the controller will go to Sales Time (Afterflow). If the controller does not get the plunger during the On Time, it will go to Plunger Fall Time. If the controller received the plunger arrival signal and went to Sales Time, it will stay there until Sales Time expires and then go to Plunger Fall Time. Once back in Plunger Fall Time, the cycle starts over again. The Battery Off Timer is used to shut the controller off if the battery falls below 5.4 volts. It will stay in this timer until the battery has recovered to 5.8 volts. The controller then goes to Plunger Fall Time and continues the normal cycle. Like the Off Timer, the Battery Off Timer will count up and not down. This is to show how long the controller has been in Battery Off Time.

1.2 Hi and Lo Pressure Kill

The controller has a built in Hi-Lo feature for controlling high and low sales line pressures on the well. This allows the controller to monitor the line pressure and go to Fall Time if the pressure is too high or too low. If the High-Pressure Limit is set and the line pressure goes above the set limit, the controller will start the Hi Kill Timer. This timer will wait for a given amount of time before it will activate the Hi Kill. This allows the limit to be set closer to the wells operating pressure and avoid the pressure spike from packing the line when the well is first turned on and allows the selling of the head gas. The Low Kill does not have a timer associated with it. It will act immediately when the line pressure drops below the low limit. This can be used to shut the well in if the sales line breaks or starts to leak. The High Kill can be disabled by

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entering 9999 as the limit. The low kill can be disabled by entering 0000 as the limit. Set commands 16, 34 and 35 are used to configure this option.

1.3 On and Off (Kill) Switches

The controller has On and Off (Kill) switch inputs. This allows connection to external devices to turn the well on and off. If the well has a tank level switch, it could be connected to the Kill Switch and would close the motor valve if the tank became full. The On Switch will override the pressure differential, which normally turns the well on. This can be used during well testing.

1.4 Battery Save Display Feature

In order to conserve the battery in the controller, the display will be powered off after two minutes if there has been no keypad activity. Pressing any keypad button will reactivate the display. The controller will ignore the key pressed to turn the display on and display the current well information.

1.5 Pressure Spike Operation

The controller can be configured to monitor the line for pressure spikes from sister wells. These spikes are present when a sister well opens its motor valve and tries to surface its plunger. When the controller sees a spike from a sister well, it will delay opening its motor valve. This delay is normally the travel speed of the sister well. This will give the sister well time to surface its plunger. Set commands, 45, 46 and 47 are used to configure this option.

1.6 Purge Operation

The controller can be configured to purge the fluid from the latching valve plumbing while the motor valve is closed. This is can be used during cold weather to keep the latching valve plumbing from freezing which can cause the motor valve to operate incorrectly. It can also be used to supply gas to a well head compressor. If the well head compressor is using gas from the sales line, it could stall during the plunger fall or off time when no gas is flowing. The function will allow some gas to flow while the well is shut-in. The set 22 and set 23 commands are used to configure this function. Setting them both to "00" will disable the function. If this function is configured, the valve counts will continue to increase during plunger fall of off time and the valve counts will not match the plunger arrival counts.

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2 Timers (States)

The Differential Pressure Controller uses four operating timers to control the well cycle. The timers are On, Sales, Fall, and Off. It also uses a Battery Off Timer for low battery conditions. The timers are sometimes referred to as states.

2.1 On Time (Set 10)

The On Time is the state that opens the motor valve to produce product and wait on the plunger. The On Timer counts down from the setting in Set 10. If the On Time value expires without receiving a plunger arrival, the controller will go to Fall Time bypassing the Sales Time (Afterflow). If a plunger arrival is detected during the On Time, the controller will go to Sales Time (Afterflow) without waiting for the On Timer to expire.

2.2 Sales Time, Afterflow (Set 11)

The Sales Time starts when the plunger arrival is detected during On Time. Sales Time can also be referred to as the Afterflow. During the Sales Time, the motor valve remains open. The Sales Time starts with the time that was entered with Set 11. When the Sales Time timer expires, the controller will go to Plunger Fall Time.

The Differential Pressure Controller automatically adjusts the Sales Time based on the Well Recovery Time. The Well Recovery Time is the time it takes the well to build back to the differential pressure needed to run the plunger at the desired speed after the motor valve has closed. When the Differential Setpoint is reached, the controller will calculate how long it took and compare it to the Fall Time. If it took half the Fall Time to reach the Differential Setpoint, then half of the maximum sales adjust value will be added to the Sales Time. If it took 1.5 times the Plunger Fall Time, then half the maximum sales adjust will be subtracted from the sales time. The adjustment is proportional based on the Fall Time. The controller is trying to adjust the well so the Well Recovery Time occurs at the same time the Plunger Fall Time expires, while keeping the plunger traveling at the desired speed.

2.3 Plunger Fall Time (Set 12)

The Plunger Fall Time closes the motor valve and waits for the plunger to fall to the bottom of the well. It cannot be interrupted except by the On or Off key. The Plunger Fall Time is entered at the end of Sales Time and at the end of On Time if no plunger arrival was detected.

The Differential Pressure Controller also uses the Plunger Fall Time as its minimum Off Time. A good starting point is to calculate the Fall Times based on the plunger you have. For an Ultra Seal Plunger 200, ft/minute is a good number to use. If the well is a poor well and requires extra shut-in time to increase the sales time, you can increase the Plunger Fall Time to allow the well to build pressure during the Plunger Fall Time and not in the Off Time. If your Differential Pressure Setpoint is not met in the Plunger Fall Time, you will not add Sales Time. In fact, you will be subtracting Sales Time.

2.4 Off Time (Not a Settable Timer)

During the Off Time the motor valve remains closed. When the controller goes to Off Time, the timer value begins to count up. This is indicating how long the well has been off since the Fall Time expired. The controller will stay in Off Time until the Differential Setpoint is reached.

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2.5 Battery Off Time (Not a Settable Timer)

This timer is entered when the battery voltage falls below 5.4 volts. The controller will stay in this timer until the battery is charged back to 5.8 volts. This counter will count up, and not down, indicating the amount of time that the controller has been in the Battery Off state. During this state, the controller will keep the motor valve closed and not operate the pressure transducers. It does this to preserve battery power. Once the battery reaches 5.8 volts the controller will switch to Plunger Fall Time and resume normal operation.

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3 Display Layout

The Differential Pressure Well Controller display is laid out in four separate sections. The top left section has the current Controller State and the time remaining of that state. The top right section displays status flags, configuration information and battery voltage. The bottom left section displays four sets of travel time information. The bottom right section displays the valve and plunger arrival counts, Sales Time and casing pressure.

3.1 On Time Display

You will see this display when the controller is waiting on the plunger. The motor valve is open during this time.

On HH:MM:SS	**MHLOKS X.X**
T *HHH:MM:SS*	**V *XXX* P *XXX***

3.2 Sales Time (Afterflow) Display

You will see this display after the plunger has arrived. The motor valve is open during this time.

Sale HH:MM:SS	**MHLOKS X.X**
T *HHH:MM:SS*	**V *XXX* P *XXX***

3.3 Plunger Fall Time Display

You will see this display if the On Time or Sales Time has timed out. The motor valve will be closed during this time. This is also the display that will be displayed if a pressure limit has been exceeded or the Off (kill) Switch is tripped.

Fall HH:MM:SS	**MHLOKS X.X**
T *HHH:MM:SS*	**V *XXX* P *XXX***

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3.4 Off Time Display

You will see this display after the Plunger Fall Time has timed out. During this On Time, the motor valve is closed and the controller is waiting on the Differential Setpoint to be met. The timer will be counting up indicating how long the controller has been waiting on the Differential Setpoint to be met.

Off HH:MM:SS	**MHLOKS X.X**
T *HHH:MM:SS*	**V *XXX* P *XXX***

3.5 Battery Off Time Display

You will see this display if the battery voltage drops below 5.4 volts. The time will be counting up indicating how long the controller has been in this state. Once the battery voltage is above 5.7 volts the controller will go to Plunger Fall Time. The motor valve will be closed during this time.

Batt HH:MM:SS	**MHLOKS X.X**
T *HHH:MM:SS*	**V *XXX* P *XXX***

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4 Controller Status Flags

As shown in the examples above, the controller status flags are displayed in the top right section of the display next to the battery voltage. They are only visible when their corresponding condition is active.

4.1 "M" Manual Mode Flag

The letter "M" on the screen indicates the controller is in manual mode. Manual mode is enabled and disabled though the set 77 command. Manual mode will stop the On and Off cycles from running. The motor valve can be held open during a swabbing operation using the On key or the motor valve can be held closed using the Off key overnight to allow the well to build pressure.

4.2 "H" Hi Kill Flag

The letter "H" indicates the line pressure has exceeded the High Limit Setpoint. See set command 34. When this occurs, the controller will start the high kill delay timer, Set 16. If the high condition is present when the timer expires, the controller will go to Fall Time and remain there until the high condition goes away.

4.3 "L" Lo Kill Flag

The letter "L" indicates the line pressure has dropped below the Low Limit Setpoint. See set command 35. When this occurs, the controller will go to Plunger Fall Time and remain there until the high condition goes away.

4.4 "O" On Switch Flag

The letter "O" indicates the On Switch is made and the controller will go to On Time if the controller is in Off Time.

4.5 "K" Kill (Off) Switch Flag

The letter "K" indicates the Kill (Off) Switch is made. When this occurs, the controller will go to Plunger Fall Time and remain there until the kill switch is reset.

4.6 "S" Pressure Spike Detected

The "S" on the screen indicates the controller has detected a pressure spike on the sales line. Settings 45,46 and 47 are used to configure the spike detection. When the "S" is present, the controller is counting down the Spike Delay Time while holding the motor valve closed.

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5 Scroll Data

The differential has two sets of scroll keys. They are the '7' ,'8' and '9'. They are used to scroll data on the display. The following sections describe the information in detail.

5.1 '7' Key Scroll Data

5.1.1 Total Sales Time

The Total Sales Time has the following format: Total Sale HHH:MM:SS. The Total Sales Time is the total time the motor valve has been open since last being cleared.

5.1.2 Longest Travel Time

The Longest Travel Time has the following format: Long Travel MM:SS. The Longest Travel Time is the slowest run the plunger has made.

5.1.3 Shortest Travel Time

The Shortest Travel Time has the following format: Short Travel MM:SS. The Shortest Travel Time is the quickest run the plunger has made.

5.1.4 Average Travel Time

The Average Travel Time has the following format: Ave Travel MM:SS. The Average Travel Time is calculated using an 25-value weighted-average. This weighted-average calculation uses the last Travel Time average in 24 of the 25 travel times to calculate a new average. The 25th travel time is the newest or last travel time that is detected. The total of the 25 travel times is determined. The total is then divided by 25, with the result reduced to the nearest whole number.

5.1.5 Total Off Time

The "Total Off Time" has the following format: Off Time HH:MM:SS. It is the total time the motor valve has been closed since the controller was last cleared.

5.1.6 Longest Off Time

The "Longest Off Time" has the following format: Long Off Time HH:MM:SS. It is the longest time the motor valve has been closed during a well cycle since the controller was last cleared. If looking at the timers, it would be the longest time viewed in the Off Time state. When looking at the display, it would be the longest time during the "OFF HH:MM:SS" time.

5.1.7 Shortest Off Time

The "Shortest Off Time" has the following format: Short Off Time HH:MM:SS. It is the shortest time the motor valve has been closed during a well cycle since the controller was last cleared. If looking at the timers, it would be the shortest time viewed in the Off Time state. When looking at the display, it would be the shortest time during the "OFF HH:MM:SS" time.

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5.1.8 Average Off Time

The "Average Off Time" has the following format: Ave Off Time HH:MM:SS. The Average Off Time is calculated using an 8-value weighted-average. This weighted-average calculation uses the last Off Time average in seven of the eight travel times to calculate a new average. The eighth Off Time is the newest or last Off Time that is calculated. The total of the eight off times is determined. The total is then divided by eight, with the result always reduced to the nearest whole number.

5.2 '8' Key Scroll Data

5.2.1 Casing Pressure

The Casing Pressure is displayed in the following format: Case Pres: XXXX. If casing pressure is needed, the controller must be equipped with a third transducer that is connected to the casing of the well. The controller does not use this in the calculation. It is for display purposes and available though the Modbus interface.

5.2.2 Tubing and Line Pressure

The Tubing and Line Pressure has the following format: Tube Pres: XXXX and Line Pres: XXXX.

5.2.3 Differential Pressure Calculated and Current Setpoint

The Calculated Differential Pressure and the Current Differential Setpoint have the following format: **Cal:**XXXX **Diff:**XXXX. The "**Cal:**XXXX" represents the Calculated Differential Pressure (tubing minus the line). The "**Diff:**XXXX" represents the pressure that is set in command "SET 43".

5.3 '9' Key Scroll Data

5.3.1 Valve and Plunger Counts

The Valve and Plunger Counts have the following format: Valve Cnt**:** XXX and Valve Arvl:XXX. The "Valve Cnt:XXX" is the number of times the valve has been operated or cycled. The "Valve Arvl:XXX" being the number of times the plunger has arrived. The maximum number for both is 999; after 999 it will roll back to zero.

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6 Keypad Operation

The SMI Differential Pressure Controller is equipped with a 4 x 4 keypad. In an effort to keep the keypad as simple as possible it was necessary to have some keys provide more than one function. While the 'ON' and 'OFF' keys will always turn the well on and off, the 'C', 'S' and 'R' keys perform multiple functions. Also, the '7' & '4' and the '9' & '6' are used for the quick data scroll. While this may seem a little confusing at first, it does not take long to get used to.

CURRENT 7 STATUS	PRESSURE 8 STATUS	VALVE 9 COUNTS	ON
4	CURRENT 5 TIME	6	OFF
TRAVEL 1 TIME	YES 2	SETUP 3	⇧ SET
CANCEL C CLEAR	NO 0	ENTER E EXIT	⇩ READ

6.1 'ON' Key

This key will turn the well on and change the timer to the On Timer and open the motor valve. This is the only function this key will perform and it cannot be overridden. When the controller is turned on with the 'ON' key, the tubing and line pressure will not be recorded in the history.

6.2 'OFF' Key

This key will turn the well OFF and change the timer to the Plunger Fall Time and close the motor valve. This is the only function this key will perform and it cannot be overridden.

6.3 'C' Key

The 'C' key is the clear or cancel key. It will backspace on "Set" and "Read" commands, clear the values in certain "Read" commands, and cancel out of a "Set" command once it is backspaced to the beginning. To cancel out of a command, you use the 'C' key to backspace to the beginning and then press the 'C' key again to cancel out of the command. This works for both the command entry and the data entry. It is also used to clear any message the controller may display. For example, the keypad locked and unlocked messages.

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6.4 'E' Key

The 'E' key is the enter key. It is used to save the data that is entered in the "Set" commands and exit out of the "Set" and "Read" commands. If you do not want to save the data that is in the "Set" command, you can use the 'C' key to backspace to the beginning and then press the 'C' key again to cancel out of the command.

6.5 ⇧ 'S' Key

The 'S' key is the Set key. It has two functions. One is to start a set command operation and the second is to scroll commands and scroll history data. If the controller is in the normal mode displaying one of the timers and the 'S' key is pressed, the controller will change the display to read "Set". You now would enter the number for the set command you wanted to view and press the 'E' key. This would bring up that command.

The key has a secondary use, which is scrolling the set and read commands and the Travel Time history data. The scrolling is used with the read 13 command. When you have a set or read command on the display, you can use the 'S' key to go to the next command. For example, if you are viewing the set 10 command and you press the 'S' key, the set 11 command will be displayed. When viewing the Travel Time history entries, the set key is used as an upward directional key when scrolling through the history entries. (Example: If the #5 entry is shown on the display, pressing the 'S' key will move the history entries to the #4 entry.) Note on the read 13 command: when you first enter the command it will show the current Travel Time. If you scroll from the current Travel Time, entry '0', you will go to the next "Read" command. If you want to scroll the history data you will need to hit enter again, then scroll.

6.6 ⇩ 'R' Key

The 'R' key is the set key. It has two functions. One is to start a read command operation and the second is to scroll commands and scroll history data. If the controller is in the normal mode displaying one of the timers and the 'R' key is pressed, the controller will change the display to read "Read". You now would enter the number for the read command you wanted to view and press the 'E' key. This would bring up that command.

The key has a secondary use, which is scrolling the set and read commands and the Travel Time history data. The scrolling is used with the read 13 command. When you have a set or read command on the display, you can use the 'R' key to go to the previous command. For example, if you are viewing the set 11 command and you press the 'R' key, the set 10 command will be displayed. When viewing the Travel Time history entries, the 'R' key used as a downward directional key when scrolling through the history entries. (Example: If the #5 entry is shown on the display, pressing the 'R' key will move the history entries to the #6 entry.) Note on the read 13 command: when you first enter the command it will show the current Travel Time. If you scroll from the current Travel Time, entry '0', you will go to the next read command. If you want to scroll the history data you will need to hit enter again, and then scroll.

6.7 Secondary key functions

Most of the numeric keys have a secondary function. This secondary function is accessed when the key is pressed and a numeric value is not needed for a set or read command. The name of the secondary function is printed on the key along with the numeric value of the key. When the secondary function is accessed, the name of the function of the first item on the list is displayed. The list of items can now be scrolled through using the arrow keys. To exit the secondary function the 'E' key is pressed.

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6.7.1 '1' Key, Travel Time

This key brings up the travel times which are the same as the Read 13 command.

6.7.2 '3' Key, Set up

This key brings up the setup command, which is the same as the Set 50 command.

6.7.3 '7' Key, Current Status

This key brings up the current status information. The following is a list of the items: Total Sale HHH:MM:SS, Long Travel MM:SS, Short Travel MM:SS, Ave Travel MM:SS, Off Time HH:MM:SS, Long Off Time HH:MM:SS, Short Off Time HH:MM:SS, Ave Off Time HH:MM:SS, and Battery voltage.

6.7.4 '8' Key, Pressure Status

This key brings up the pressure status information. The following is a list of the items: Tubing Pres:XXXX, Line Pres:XXXX, Casing Pres:XXXX, Hi Limit Cnt:XXXX, Lo Limit Cnt:XXXX, Hi Switch Cnt:XXXX, Lo Switch Cnt:XXXX, Ave Line Pressure, and Cal:XXXX Diff:XXXX.

6.7.5 '9' Key, Pressure Status

This key brings up the valve count information. The following is a list of the items: Valve Cnt:XXX and Valve Arvls:XXX.

6.8 '0-9' Numeric Keys

These keys are used to enter numbers into the controller during a set function. As described in the section below, a few have a dual use for scrolling quick data.

7 Set Commands

The set commands are used for configuring the controller. To enter a set command, press the 'S' key. Next press the first digit of the set command you want to execute. Now press the last digit of the two-digit number of the set command you want to execute. If the display reads "Set XX" with XX being your entered command, press the 'E' key to enter the function. If you make a mistake you can use the 'C' to backspace. If the 'C' key is pressed when only "Set" is in on the screen, the controller will cancel the current set operation.

Once the values are displayed for you, the 'C' key will continue to be used as a backspace and cancel. As you enter numbers, the display will wrap the cursor for you. Also, the cursor will skip over the ':' in the timer set commands or any other formatting character you may see. You enter the data as if formatting characters were not there. Once you have the correct data entered, pressing the 'E' key will save it to memory and exit the set command. If you do not want to save the entered data or you were just viewing the value, the 'C' key will cancel the command without saving the data. You will have to backspace to the beginning of the line for the cancel to work.

7.1 Set 10, On Time

The SET 10 command is used to set the On Time. The display will show "On Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. This is the time the controller is waiting on the plunger. To enter a time of one hour, you would enter 010000, then press 'E'.

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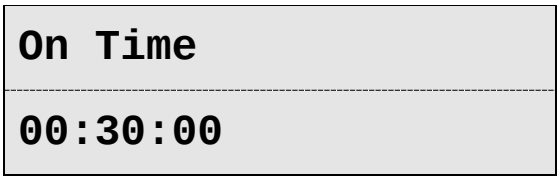
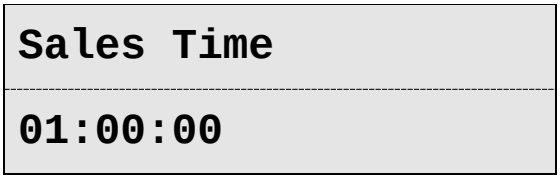


Above shows the "On Time" set to 30 minutes.

7.2 Set 11, Sales Time, Afterflow

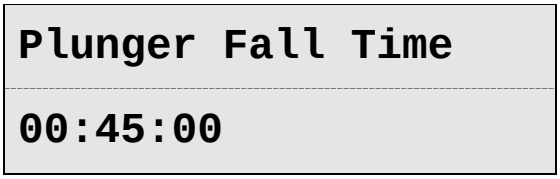
The SET 11 command is used to set the Sales Time. The display shows "Sales Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. The controller, depending on the pressure recovery, adjusts Sales Time. The time you put in is a starting point. You can lock the Sales Time by putting a zero in set 40. The Sales Time is the time the well sells gas after the plunger arrives. To enter a time of 30 minutes, you would enter 003000, then press 'E'.



Above shows the "Sales Time" set to 1 hour.

7.3 Set 12, Plunger Fall Time

The SET 12 command is used to set the Plunger Fall Time. The display shows "Plunger Fall Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. This time is also your minimum Off Time. The controller uses this time for the Well Recovery Time. The sooner the pressure recovers in the time the more Sales Time will be added. This is one of the critical setpoints for the Differential Controller. Some care must be taken when selecting a value. You want to make sure your plunger is on bottom and you are giving the well enough time to build pressure. By increasing this time you can cause the controller to add more Sales Time. The opposite is also true. If you decrease this time you can reduce your Sales Time. You should never reduce this time to less time than it takes for your plunger to get on bottom. To enter a time of 45 minutes, you would enter 004500, then press 'E'.



Above shows the "Plunger Fall Time" set to 45 minutes.

7.4 Set 13, Maximum Off Time

The SET 13 command is used to set the maximum Off Time. The display shows "Max Off Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. This is the maximum time the controller can be off. If the differential pressure is not reached before the controller reaches "Max Off Time", the controller will go ahead and turn the well on. It also grabs the current differential pressure

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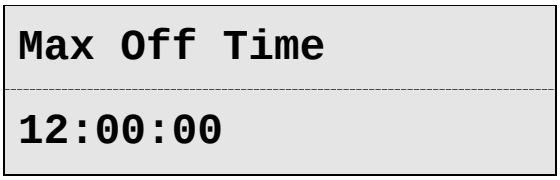
and uses it as the new setpoint. This allows the controller to configure and continue on without human intervention. It also allows for a compressor going down and the controller building the differential to a point the well cannot build to. Without a max Off Time, the controller would have to be kicked off manually. This way it is kicked off automatically. To enter a time of 12 hours, you would enter 120000, then press 'E'.



Above shows the "Max Off Time" set to 12 hours.

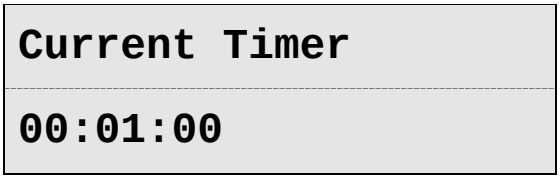
7.5 Set 16, Hi Kill Delay Time

The SET 16 command is used to set the Hi Kill Delay Time. The display shows "Hi Kill Delay Time" on the top line of the display and the time in seconds "SSSS" on the bottom line of the display. The time is entered in seconds. To enter a time value of 5 minutes, press "0300" then 'E'. This is the delay time before the high kill is activated. It is used to let the head gas blow down before looking for a high line condition.

Above shows the "Hi Kill Delay Time" set to 300 seconds or 5 minutes.

7.6 Set 19, Current Timer

The SET 19 command is used to change the current timer. The display shows "Current Timer" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. This is the values of the current timer. The current timer is used to countdown the time of the active state. For example, if the "On Time" is active the current timer is counting down from the time that is entered in "On Time". Set 19 allows the current timer to be modified from its normal count. This is used when more or less time is needed for a given well cycle. To enter a time of 1 minute, enter 000100, then press 'E'.



Above shows the "Current Timer" set to 1 minute.

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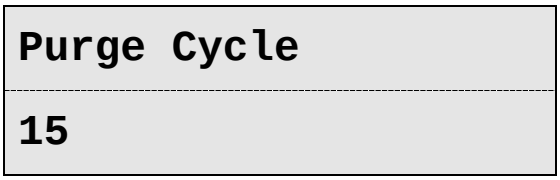
7.7 Set 20, Clear Command

The SET 20 command is used to clear the Sales Time, Travel Time, Valve Counts, Plunger Counts and the Travel Time history. The display will show "Clear All" on the top line and a '0' on the bottom line of the display. To clear the data you will have to enter a '1' then press the 'E' key. If you do no enter a '1' and press 'E', the data will not be cleared.

Above shows the "Clear All" set to 1 to clear data.

7.8 Set 22, Purge Cycle Command

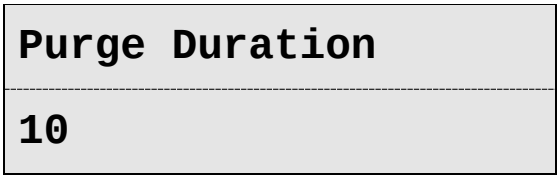
The SET 22 command is used to set the purge cycle time. The display will show "Purge Cycle" on the top line display and "XX" on the bottom line of the display. The "XX" represents the purge cycle in minutes. The purge command allows the motor valve to open briefly on a periodic basis during Off Time and Plunger Fall Time. This function can be used during cold weather to keep the motor valve from freezing closed due to moister in the plumbing of the latching valve. It can also be used to supply gas to a wellhead compressor Setting the value to 00 will disable this feature. Please note, this command will cause the plunger counts and valve counts not to match. Use set 22 and 23 together.



Above shows the "Purge Cycle" set to 15 minutes.

7.9 Set 23, Purge Duration Command

The SET 22 command is used to set the purge duration time. The display will show "Purge Cycle" on the top line display and "XX" on the bottom line of the display. The "XX" represents the purge cycle in seconds. Setting the value to 00 will disable this feature. Use set 22 and 23 together.



Above shows the "Purge Duration" set to 10 seconds.

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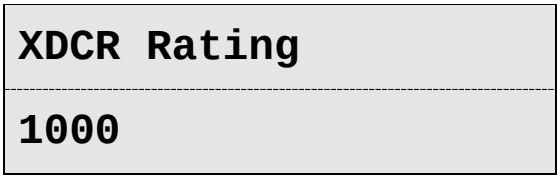
7.10 Set 30, Transducer Max Value

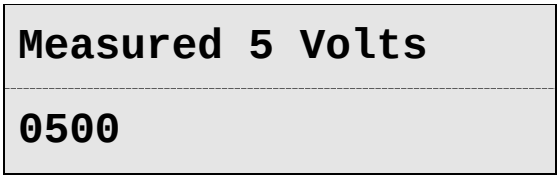
The SET 30 command is used to enter the Transducer Rating. This allows the controller to scale the analogs channels correctly. For a 1000 PSI transducer, 1000 is entered. For a 2000 PSI transducer, 2000 is entered. The display will show "XDCR Rating" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the transducer rating in PSI. You can also use the command to scale the transducer to match a gauge on the well. If you need the controller to read a little higher you can enter 1100 for the scale instead of 1000. This will not affect the operation on the controller.



Above shows the "XDCR Rating" set to a 1000 PSI transducer.

7.11 Set 31, Measured 5 Volts

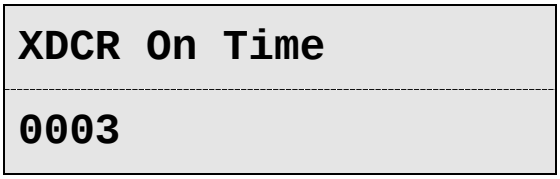
The SET 31 command is used to enter the actual 5-volt reading. The controller uses the 5 volts as a reference when measuring pressures and voltages. This value will normally be entered at the factory. The value should range from 0470 to 0520. If value is outside that range, set to 0500. The display will show "Measured 5 Volts" on the top line and "XXXX" on the bottom line. The "XXXX" represents the voltage in the following format: XX.XX. To set it to 4.9 volts you would enter 0490. You must have a leading zero.



Above shows the "Measured 5 Volts" set to 5 volts.

7.12 Set 32, Pressure Transducer On Time

The SET 32 command is used to enter the time the pressure transducer is on before the pressure is read. The display will show "XDCR On Time" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the 50mS steps. This allows the transducer to settle before a reading is taken. A normal value is 0003, which represent 150mS. This should not have to be changed unless a special transducer is used.



Above shows the "XDCR On Time" set to 3 X 50mS or 150mS.

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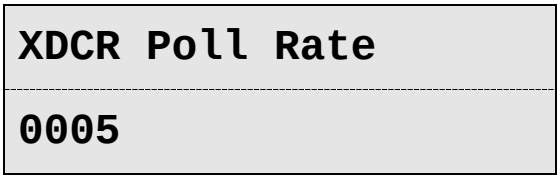
7.13 Set 33, Pressure Transducer Poll Rate

The SET 33 command is used to enter the poll rate of the pressure transducers. The display will show "XDCR Poll Rate" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the poll rate in seconds. A normal value of 0005 indicates the pressure transducer will be read every five seconds. Polling the transducer too often will cause the battery to drain faster. A poll rate of five is recommended for most applications.



Above shows the "XDCR Poll Rate" set to 5 seconds.

7.14 Set 34, Line Pressure High Pressure Limit

The SET 34 command is used to enter the high line pressure limit. The display will show "High Pres Kill Limit" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the high-pressure limit in PSI. When the line pressure exceeds the high-pressure limit, the controller will count down the High Kill Delay Time then go to Fall Time. The Fall Time will count down to zero and if the high pressure is still present, hold at zero. If the high pressure has passed, it will go to Off Time. Setting the high-pressure limit to 9999 will disable it.

Above shows the "High Pres Kill Limit" set to 500 PSI.

7.15 Set 35, Line Pressure Low Pressure Limit

The SET 35 command is used to enter the low line pressure limit. The display will show "Low Pres Kill Limit" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the low-pressure limit in PSI. When the line pressure drops below low-pressure limit, the controller will go to Fall Time. The Fall Time will count down to zero and if the low pressure is still present, hold at zero. If the low pressure has passed, it will go to Off Time. Setting the low-pressure limit to 0000 will disable it.

Above shows the "Low Pres Kill Limit" set to 40 PSI.

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7.16 Set 40, Maximum Sales Time Adjust

The SET 40 command is used to set the maximum time in minutes that can be added or subtracted from the Sales Time. The display will show "Max Sales Time Adj" on the top line of the display and "XX" on the bottom line of the display. The "XX" represents the maximum adjustment to the Sales Time in minutes. The controller will add or subtract Sales Time proportionally based on the Well Recovery Time. The maximum sales adjust is the 100% value that can be added or subtracted from the Sales Time. For example, if the well met the Differential Setpoint half way through the Fall Time, the controller would add 50% of the maximum sales adjust to the Sales Time. With the maximum adjust set to 10 minutes, the controller would have added five minutes to the Sales Time. The opposite is also true. If the Plunger Fall Time was set at one hour and the Differential Setpoint was met one hour and a half after the motor valve closed, or 30 minutes into the Off Time, the controller would have subtracted five minutes from the Sales Time. Also, the Sales Time can only be increased on a given well cycle if the plunger runs successfully. When the "Maximum Sales Time Adjust" is set to zero, the automatic adjustment for Sales Time will be disabled. This will lock the Sales Time, "SET 11", at its current value.

Above shows the "Max Sales Time Adj" set to 10 minutes.

7.17 Set 41, Maximum Differential Pressure Adjust

The SET 41 command is used to set the maximum differential pressure adjustment in PSI. The display will show "Max Diff Pres Adj" on the top line of the display and "XX" on the bottom line of the display. The "XX" represent the maximum adjustment to the Differential Setpoint in PSI. The controller will increase or decrease the Differential Setpoint proportionally based on the Plunger Travel Time. The maximum differential setpoint pressure adjust is the 100% value that can be added or subtracted from the Differential Setpoint. For example, if the Plunger Travel Time is set to 10 minutes and it arrived in 5 minutes, the controller would subtract 50% of the differential adjustment from the Differential Setpoint. If you had the differential adjustment set to 10 PSI, then 5 PSI would be subtracted from the Differential Setpoint. The opposite is also true. If the Plunger Travel Time were 15 minutes with the same scenario as above, the controller would add 5 PSI to the Differential Setpoint. If the plunger does not arrive the maximum adjustment is added to the Differential Setpoint. When the maximum Differential Setpoint is set to zero, the automatic adjustment for plunger travel speed will be disabled. This will lock the Differential Setpoint, "SET 43", at its current value.

Above shows the "Max Diff Pres Adj" set to 10 PSI.

7.18

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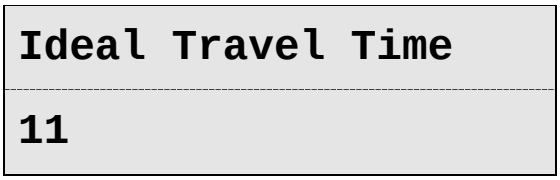
7.19 Set 42, Plunger Travel Time Setpoint

The SET 42 command is used to set the optimum plunger travel speed. When picking this number you should take into account the type of plunger you have and well depth. The display will show "Ideal Travel Time" on the top line of the display and "XX" on the bottom line of the display. The "XX" represents the Plunger Travel Time in minutes. The Plunger Travel Time is one of the main set points for the differential control process. Calculating it correctly is very important for proper well operation. If you pick one that is too fast, the controller will adjust the Differential Setpoint high enough to run the plunger at that speed. This will take more gas energy that could have been used for increased sales. The opposite is also true. If you run the plunger too slow the controller could add too much Sales Time as cause the well to load.



Above shows the "Ideal Travel Time" set to 11 minutes.

7.20 Set 43, Differential Pressure Setpoint

The SET 43 command is the starting differential pressure in PSI that is required to bring the plunger to the surface at the desired plunger travel speed. The controller will adjust this set point to keep the plunger at the plunger travel speed set point. The controller will also never let it go below the minimum differential set point. The display will show "Diff Pres Setpoint" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the Differential Setpoint in PSI. When setting this value keep in mind the controller will adjust it based on the plunger travel speed. Also, if you set it too high and the well cannot build to that pressure, you will never get your well to turn on. If you set the Differential Setpoint to zero, the controller will run at the end of the next Plunger Fall Time and use the differential that was recorded at the end of the Plunger Fall Time as the starting point. This feature is useful when you have a well that you are not sure of the pressure that it will need to run, but are pretty sure it can surface the plunger.

Above shows the "Diff Pres Setpoint" set to 285 PSI.

7.21 Set 44, Minimum Differential Pressure Setpoint

The SET 44 command is used to set the minimum differential pressure the controller can use and it prevents the controller from adding Sales Time if the current Differential Setpoint is higher. The display will show "Min Diff Pres" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the minimum differential setpoint in PSI. This is used when you do not want any Sales Time added until the well has cleaned up some. While a well is unloading a large amount of fluid the differential pressure will be higher than normal. If the controller was to start adding Sales Time it would reduce the number of runs per day and that would cause the well to take longer to clean up. Once the well has cleaned up and the Differential Setpoint has come down to the minimum the controller will start adding Sales Time.

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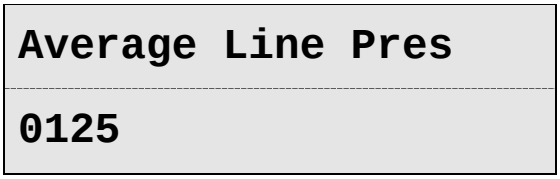
Above shows the "Min Diff Pres" set to 250 PSI.

7.22 Set 45, Average Line Pressure

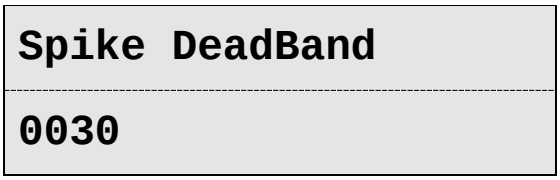
The SET 45 command is used to set the average line pressure that the controller uses when performing spike detection. The display will show "Average Line Pres" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the average line pressure in PSI. Once set, the controller will start averaging the line pressure from the number entered. What you will see is this number changing as your sales line conditions change.



Above shows the "Average Line Pres" set to 125 PSI.

7.23 Set 46, Pressure Spike DeadBand

The SET 46 command is used to set the pressure amount the line must rise above the current average before the spike delay will be activated. If the line average is set to 100 PSI and you have 20 PSI in set 46, then when the sales line reaches 121 PSI the spike delay will be activated. The display will show "Spike DeadBand" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the pressure spike in PSI. When selecting this number, you should watch your sales line and see how high the sister will spike it. The smaller the value you pick for the pressure spike the more sensitive it is to both noise and other wells.



Above shows the "Spike DeadBand" set to 30 PSI.

7.24

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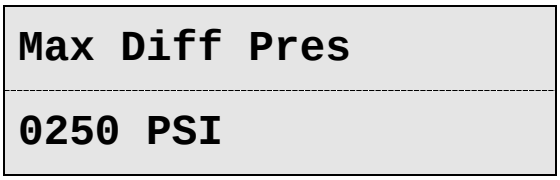
7.25 Set 47, Pressure Spike Delay

The SET 47 command is used to set the amount of time in seconds the controller will remain off after a spike is detected. This is normally set to the longest travel time of a sister well. The display shows "Pres Spike Delay" on the top line of the display and the time in seconds "XXXX" on the bottom line of the display. The time is entered in seconds. To enter a time value of 10 minutes, press "0600" then 'E'.

Above shows the "Pres Spike Delay" set to 600 seconds or 10 minutes.

7.26 Set 48, Maximum Differential Pressure Setpoint

The SET 48 command is used to set the maximum differential pressure the controller can use. It is also used when the plunger misses a trip. When the controller detects the plunger did not arrive, it will switch from the normal Differential Setpoint to the maximum differential. This is done to give the plunger the best possible chance of arriving. Once the plunger arrives it will switch back to the normal Differential Setpoint. The display will show "Max Diff Pres" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the maximum differential setpoint in PSI. Also, the controller will not increase the differential passed the maximum setpoint.



Above shows the "Max Diff Pres" set to 250 PSI.

7.27 Set 50, Well Depth

The SET 50 command is used to configure the controller quickly. Once the well depth in feet is entered, the controller will figure out the reset of the parameters. All the parameters can still be changed manually if desired. The well depth is entered in feet with leading zeros. The display shows "Well Depth" on the top line of the display and "XXXXX" on the bottom line of the display. The "XXXXX" represents the well depth in feet. This command will configure the all the timers for you. It sets up the transducers to be polled every five seconds and disable the high and low pressure kills. It will set the differential pressure setpoint to zero, which will causer the controller to run at the end of the fall Time and use the current differential as the starting setpoint.

Above shows the "Well Depth" set to 7500 feet.

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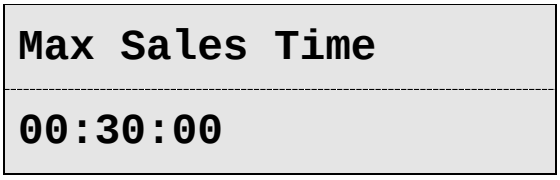
7.28 Set 51, Maximum Sales Time, Afterflow

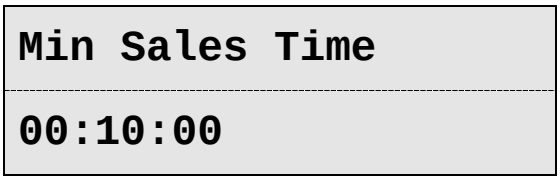
The SET 51 command is used to set the maximum sales time. The display shows "Max Sales Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. Set 51 is used to set the upper limit of the sales time. The controller will adjust the sales time depending of the pressure recovery time. Set 51 will limit the maximum time the controller will adjust to. To enter a time of 30 minutes, you would enter 003000, then press 'E'.



Above shows the "Max Sales Time" set to 1 hour.

7.29 Set 52, Minimum Sales Time, Afterflow

The SET 52 command is used to set the minimum sales time. The display shows "Min Sales Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. Set 52 is used to set the lower limit of the sales time. The controller will adjust the sales time depending of the pressure recovery time. Set 52 will limit the minimum time the controller will adjust to. To enter a time of 10 minutes, you would enter 001000, then press 'E'.



Above shows the "Min Sales Time" set to 1 minute.

7.30 Set 61, Modbus Address Command

The SET 61 command is used to set the Modbus address. The display will show "Modbus Addr" on the top line display and "XXXX" on the bottom line of the display. The "XXXX" represents the Modbus address. The Modbus address must be between 0 and 255. General 0 will not be used since it is the broadcast address and will cause the control to take action on all Modbus commands, with no response back to the master.

Above shows the "Modbus Addr" set to 1.

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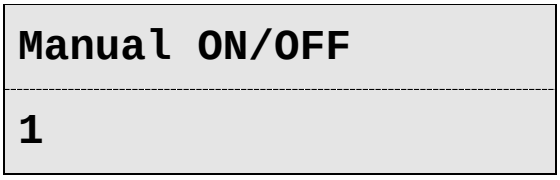
7.31 Set 77, Manual On/Off

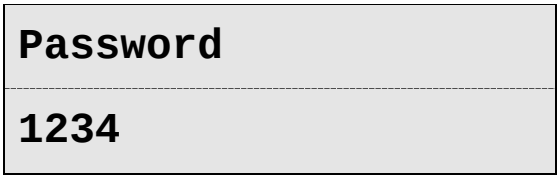
The SET 77 command is used to disable the timers on the controller. The display shows "Manual ON/OFF" on the top line of the display and "0" on the bottom line of the display. This is used when the well is going to be tested. Entering a '1' disables the timers and the well can only be turned on and off through the buttons on the front panel. Leaving a '0' will exit and do nothing. The controller will display a 'M' in the status flag section of the display when in manual mode.



Above shows the "Manual ON/OFF " set to 1 to enable.

7.32 Set 78, Password

The SET 78 command is used to enter a password into the controller. Passwords are in the range from 0000 to 9999, where 0000 is the disabled password value. The display shows "Password" on the top line of the display and "XXXX" on the bottom line of the display. When the controller is shipped from the factory is it will have the password set to 0000. This disables the password feature. If you try to change a value and you get the message Keypad Locked. You will need to enter the password that was selected. The controller has a one-hour timeout for the password. If no keys are pressed in one hour, the controller will lock the keyboard.



Above shows the "Password" entered as 1234.

7.33 Set 79, New Password

The SET 79 command is used to enter a new password into the controller. The display shows "New Password" on the top line of the display and "XXXX" on the bottom line of the display. After the correct password is entered with SET 78, a new one can be entered in SET 79. The password can be any four-digit integer. If you get a "Keypad Locked" message, you must clear it with the 'C' key and enter the correct password.

Above shows the "New Password" set to 5678.

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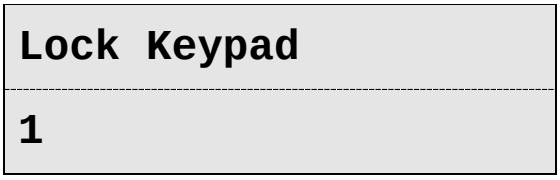
7.34 Set 80, Lock Keypad

The SET 80 command is used to lock the keypad on the controller. The display shows "Lock Keypad" on the top line of the display and "0" on the bottom line of the display. Entering a '1' will lock the keypad when the 'E' key is pressed. Leaving a '0' and pressing 'E' will exit and do nothing. There is a one-hour auto lock function. If you have a password set and a key is not pressed in an hour the keypad will lock its self.



Above shows the "Lock Keypad" set to 1 for locking.

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8 Read Commands

The Read commands are used for viewing well data. It should also be noted that some read commands have the option to clear the data that is being viewed. To enter a Read command, first press the 'R' key. Next press the first digit of the read command you want to execute. Now press the last digit of the two-digit number. If the display reads "Read XX" with XX being your entered command, press the 'E' key to enter the function. If you made a mistake, you can use the 'C' key to backspace. If the 'C' key is pressed while only "Read" is displayed, the controller will cancel the current read command. Pressing the 'E' key will exit the read functions.

8.1 Read 13, Travel Time History

The READ 13 command allows reading of the travel time history and the current travel time. The times are the current Plunger Travel Time and the last 25 plunger travel times with the tubing and line opening pressures. The display will show "No Trv T Tube Line" on the top line and "XX MM:SS TTTT LLLL" on the bottom line. The "XX" is a number from 0 to 25. Zero represents the current travel time and 1 to 25 are the newest to the oldest. The time is displayed in the MM:SS format minutes and seconds. The "TTTT" represents the tubing pressure in PSI and "LLLL" represents the line pressure in PSI. The travel time will read "NoArv" instead of "MM:SS" if no plunger arrival detected for that cycle. If the controller was opened with the keypad, the pressure will display "Man Open" instead of "TTTT LLLL". When the command is first entered the current travel time will be displayed. You can tell you are on the current travel time by the "No" being '0'. If you hit enter again, you cannot use the 'S' and 'R' keys to scroll through the travel times. The 'R' key moves the history entries upward in numerical order and the 'S' key moves the history entries downward. Once you start scrolling though the histories you will have to exit using the 'E' key to see the current travel time again.

```
No Trv T Tube Line
01 11:10 0408 0078
```

Above shows the travel time history display. You are looking at the newest entry "No 1". It took 11 minutes and 10 seconds for the plunger to surface and the tubing was reading 408 PSI and the line was reading 78 PSI when the motor valve was opened to surface the plunger.

8.2 Read 23, On and Off (Kill) Switch Counts

The READ 23 command allows you to read the external switch counts. This is the number of times the external switch have cycled the controller on or off (Kill). The display shows "ON KILL" on the top line of the display and "OOOO KKKK" on the bottom line of the display. The "OOOO" represents the number of times the on switch has turn the well on. The "KKKK" represents the number of times the off (Kill) switch has shut-in the well. You can clear it with the 'C' key without clearing any other value.

```
ON    KILL
0002  0020
```

Above shows the on and off switch count showing the well turn on 2 times and shut-in 20.

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8.3 Read 24, Average Line Pressure, Delay, and Count

The READ 24 command is used with the spike delay feature. It allows you to see the average line pressure, current line pressure, the delay time, and the numbers of times the spike detection has been activated. The display shows "AVE LINE DLAY CNT " on the top line of the display and "AAAA LLLL DDDD CCCC" on the bottom line of the display. The "AAAA" is the average line pressure in PSI. The "LLLL" is the current line pressure in PSI". The "DDDD" is the delay time in seconds. This will be counting down. Once it reaches zero the well can turn on if conditions allow. The "CCCC" is the number of times the spike detection has been activated. This is useful if the spike is still present after the delay has finished. You will see this increment by one. This is an indication you may need to adjust the delay time. The count can clear it with the 'C' key without clearing any other value.

AVE	LINE	DLAY	CNT
125	101	0000	0010

Above shows the average line pressure display showing 125 PSI for the average line pressure, 101 PSI for the current line pressure, zero for the delay time, and 10 in the number of times the spike detection has run.

8.4 Read 25, Battery Voltage, High Volts, and Low Volts

The READ 25 commands allows you to read the current battery voltage as well as the highest voltage it has been and the lowest voltage it has been since last being cleared. The display shows "BAT HI LO" on the top line of the display and "VV.V HH.H L.L" on the bottom line of the display. The "VV.V" is the current battery voltage. The "HH.H" is the highest voltage the battery has been charged to. The "L.L is the lowest voltage that the battery has been drawn down to. The highest voltage normally occurs in the late afternoon and the lowest voltage early in the morning. You can clear the high and low voltage with the 'C' key without clearing any other value.

Bat	HI	LO
06.7	8.1	5.8

Above is the battery voltage display showing a current battery voltage of 6.7 volts. The highest battery voltage recorded was 8.1 volts the lowest was 5.8 volts.

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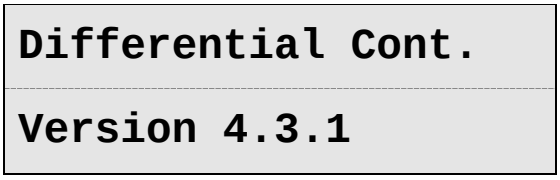
8.5 Read 50, Software Version

The READ 50 command allows reading of the current software version used by the controller. The top line shows "Differential Cont." on the top line and "Version 4.3.1" on the bottom line. If the version is different from 4.3.1 some of the functions may not operate as described in the manual. Pressing the 'E' key will exit this function.



Above shows the differential controller with software version 4.3.1.

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9 Command Summary

Set #	Commands	Entry Description
Set 10	On Timer Value	HH:MM:SS, Time waiting to get plunger
Set 11	Sales Timer Value	HH:MM:SS, Afterflow, time after plunger arrives
Set 12	Plunger Fall Time	HH:MM:SS, Time for the plunger to return to bottom
Set 13	Maximum Off Time	HH:MM:SS, This is the maximum time the controller will be off
Set 16	Hi Kill Delay	XXXX Delay Timer in Seconds for the Hi Kill.
Set 19	Current Time	HH:MM:SS, current timer that is running
Set 20	Clear All	X – '1' clears, '0' does not clear
Set 22	Purge Cycle Time	XX enter the desired purge cycle time in minutes
Set 23	Purge Duration Time	XX enter the desired purge duration time in seconds
Set 30	Transducer Scale	XXXX Enter the maximum pressure rating of the transducer
Set 31	Measured 5 Volts	XXXX Enter the 5 volts from the PCB. Two decimal assumed. 0500 default
Set 32	XDCR On Time	XXXX Transducer on time on 50mS steps. 0003 default
Set 33	XDCR Poll Rate	XXXX The poll rate of the transducers in seconds. 0005 default
Set 34	Hi Kill Limit	XXXX The hi pressure limit 9999 will disable
Set 35	Lo Kill Limit	XXXX The lo pressure limit 0 will disable
Set 40	Max Sales Adjust	XX enter the maximum time to adjust in minute. 10 default
Set 41	Max Diff Pres Adjust	XX enter the maximum pressure to adjust the Diff Set point in PSI. 10 default
Set 42	Plunger Travel Time	XX enter the desired plunger travel time in minutes
Set 43	Diff Press Setpoint	XXXX enter the differential set point in PSI
Set 44	Minimum Diff Setpoint	XXXX enter the Minimum Differential Set point in PSI
Set 45	Average Line Pres	XXXX enter the Average Line Pressure in PSI
Set 46	Pres Spike DeadBand	XXXX enter the pressure spike dead band in PSI
Set 47	Pres Spike Delay	XXXX enter the pressure spike delay in seconds
Set 48	Maximum Diff Setpoint	XXXX enter the Maximum Differential Set point in PSI
Set 50	Well Depth	XXXXX, Enter the well depth in feet. Auto-Configures the Controller
Set 51	Max Afterflow	HH:MM:SS, maximum afterflow
Set 52	Min Afterflow	HH:MM:SS, minimum afterflow
Set 61	Modbus Address	XXXX enter the desired Modbus Address 0 – 255 Caution when using 0.
Set 77	Manual On/Off	X '1' Put the well in manual On/Off Mode Timers disabled
Set 78	Password	XXXX Enter the controller password, 0000 disables password
Set 79	New Password	XXXX Enter a new password 0000 disables password
Set 80	Lock Keypad	X '1' Lock keypad '0' do nothing
Read #	**Commands**	**Description**
Read 13	Travel Time History	XX, HH:MM:SS XXXX XXXX Read travel times and Pressures. When first enter entry #0 will read current travel time. Press 'E' again will allow you to scroll the history.
Read 23	Pressure Switch Count	XXXX XXXX Reads the number of On and Kill pressure switch counts 'E' exit 'C' clear
Read 24	Ave Line Pressure	Ave Line XXXX Line XXXX Counts XXXX 'E' exit 'C' clear
Read 25	Battery Voltage	Volts XX.X, High Volts XX.X, Low Volts X.X
Read 50	Software Version	Differential Controller Ver X.X.X

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10 SMI Differential Pressure Well Controller Hardware Connections

10.1 Bottom Terminal Row

Terminal number	Description
1	Solar Panel Positive connection (+), Red wire on solar panel
2	Solar Panel Negative connection (-), Black wire on solar panel
3	Battery Negative connection (-), Black wire on battery lead
4	Battery Positive connection (+), Red wire on battery lead
5	Plunger Detector Power, Normally the red wire. ***Not used*** on a two-wire detector or three-wire MSO/GO switch. DO NOT SHORT TO GROUND
6	Plunger Detector Signal (+), Normally the white or blue wire.
7	Plunger Detector ground, (-), Normally the black wire on the MSO switch.
8	On Switch (+), Normally, the XXXX wire on the Murphy switch
9	On Switch (-), Normally, the XXXX wire on the Murphy switch
10	Kill Switch (+), Normally, the XXXX wire on the Murphy switch
11	Kill Switch (-), Normally, the XXXX wire on the Murphy switch
12	Valve A Power, This is the black wire on the latching valve
13	Valve A Open, This is the green wire on the latching valve
14	Valve A Close, This is the red wire on the latching valve
15	Transducer 1 Power, This is the red wire on the transducer
16	Transducer 1 Signal, This is the clear or white wire on the transducer
17	Transducer 1 Ground, This is the black wire on the transducer
18	Transducer 2 Power, This is the red wire on the transducer
19	Transducer 2 Signal, This is the clear or white wire on the transducer
20	Transducer 2 Ground, This is the black wire on the transducer
21	RS232 Receive Data, Normally Pin 3 on a D connector
22	RS232 Ground Data, Normally Pin 7 or Pin 5 on a D connector
23	RS232 Transmit Data, Normally Pin 2 on a D connector
24	Chassis Ground

10.2 Top Terminal Row

Terminal number	Description
25	Not Used
26	Not Used
27	Not Used
28	Transducer 1 Power, This is the red wire on the transducer
29	Transducer 1 Signal, This is the clear or white wire on the transducer
30	Transducer 1 Ground, This is the black wire on the transducer
31	Not Used.

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11 Configuration Examples

The following sections describe in the detail different configuration for the Differential Pressure Controller. They are more configurations possible, but the ones below are the most common.

11.1 Intermitter

The intermitter is the most basic type of well control. It simply turns the well on for a set period of time and off for a set period of time. To configure the differential pressure controller as an intermitter, perform the following:

11.1.1 Configuration with pressure transducers connected

This setup assumes you will have more tubing pressure than sales line pressure.

1. Set 50, with your well depth.
2. Set 10, on time, enter time in hours, minutes, and seconds that you want the well on.
3. Set 11, the sales time, enter all zeroes.
4. Set 12, plunger fall time, enter the time you want the well off hours, minutes, and seconds
5. Set 40, sales adjust, enter zeroes.
6. Set 41, differential adjust enter zeros.
7. Set 43, Differential Setpoint, to 0001 PSI.
8. Set 13, maximum off time, enter all zeroes.
9. Set 20, to clear all the history.

11.1.2 Configuration without pressure transducers connected

1. Set 50, with your well depth.
2. Set 10, on time, enter time in hours, minutes, and seconds that you want the well on.
3. Set 11, the sales time, enter all zeroes.
4. Set 12, plunger fall time, enter zero.
5. Set 40, sales adjust, enter zero.
6. Set 41, differential adjust enter zeroes.
7. Set 43, Differential Setpoint, to 0001 PSI.
8. Set 13, maximum off time, enter the time you want the well off hours, minutes, and seconds.
9. Set 20, to clear all the history.

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11.2 Differential Pressure Control

The differential pressure control is the standard means of control for this box. The setup is very straightforward.

1. Set 50, you will enter your well depth here.
2. Set 12, may want to add some time to help well build pressure and may add more sales time.
3. Set 43, if you have a good idea of the differential pressure it will take to run the plunger you can override the zero setting which will pick the differential pressure at the end of Fall Time.
4. Set 44, if you want the well to shut-in on arrival until it is cleaned up you can put a minimum differential pressure here. This will stop the controller from adding Sales Time until it has worked the differential set point down to the minimum.
5. Set 42, you want to adjust the Travel Time for your well conditions. The faster you run it the more differential pressure will be needed. This takes Sales Time away. A good rule of thumb is 750' per minutes.
6. Set 30, you verify that you have the correct transducer rating, 1000 or 1500 PSI normally.
7. Set 35, to set the high kill enter the high-pressure limit here.
10. Set 34, to set the low kill enter the low pressure limit here
11. Set 20, to clear all the history.

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11.3 Hi-Lo Control

The Hi-Lo pressure control can be used with any type of control. It simply is a high and low sales line pressure limit kill. It sometimes is used in conjunction with a tank switch. If you using a tank switch, it would be connect to the kill switch input on the controller. The controller will go to the plunger fall timer when either the high-pressure limit or low-pressure limit is exceeded. In the case of the high-pressure limit the delay timer must count down to zero. This is to allow the well to sell the head gas without the pressure kill shutting in the well.

1. Set 30, to verify your transducer setting
2. Set 16, enter in the amount of Delay Time for the high-pressure kill in seconds.
3. Set 34, enter the high pressure limit
4. Set 35, enter the low pressure limit

11.3.1 Optional Steps for a Continuous Flow Well.

1. Set 10, On Time, to 23 hours, 59 minutes, and 0 seconds.
2. Set 11, the Sales Time, enter all zeros.
3. Set 12, Plunger Fall Time, to 0 hours, 1 minute, and 0 seconds, 00:01:00.
4. Set 13, maximum Off Time, one seconds 00:00:01
5. Set 40, set to zero.
6. Set 41, set to zero.
7. Set 43, to 0001.
8. Set 20, to clear all the history.

11.4 Spike Detection

The spike detection is a method of detecting sister wells on the same sales line. When a well open the motor valve to produce gas and surface a plunger, it will cause the sales line to increase in pressure. In some cases if two wells come on that are sharing the same sales line, one if not both will not be able to surface their plunger because of the increase in sales line pressure. What the spike detection does is allow the controller to see the pressure increase caused by the sister well and delay opening its motor valve until the sister well has surfaced the plunger. Read 24 is used to monitor how the spike detection is working.

1. Set 45, enter the sales line average pressure. The controller will use what you enter has a starting point can continue averaging from there.
2. Set 46, enter the size in PSI of the line increase you will see when a sister well opens its motor valve. This is called the dead band because the well will not take any action until the sales line pressure is greater than the dead band plus the sales line average.
3. Set 47, enter the Delay Time in seconds. This is normally greater than the longest Sales Time of a sister well.

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12 Trouble Shooting

The most common failure in an electronics device is the connection. It is always a good idea to check them first and make sure you have the correct voltage on the battery. A good visual inspection for any mechanical or water damage is also a good first step.

12.1 Will Not See Plunger

There are a number of reasons you may not see the plunger. The following is a short list: worn plunger, high line pressure, stuck plunger, and a bad sensor. The following outlines the steps to check for a bad sensor.

1. Check sensor wiring
    a. Two Wire - #6 White, #7 Black
    b. Three Wire - #5 Red, #6 White, #7 Black
2. Check position of the sensor to ensure the plunger is traveling past the sensor location.
3. With the controller in On Time wave a metal object (wrench) slowly by the sensor. It should be within an inch of the sensor.
    a. If the sensor is a three wire type. You have the ability to increase the sensitivity.
    b. Open front of sensor by removing three of the four screws and rotating the cover out of the way.
    c. Adjust the dial clockwise to increase the sensitivity of the sensor. A little goes a long way.
4. If the above was not successful a new sensor may be needed.

12.2 Bad Pressure Reading

Improper settings or a bad transducer can cause a bad pressure reading. It should also be noted, that the transducers have a 1% to 2% accuracy rating. A normal gauge on a well has an accuracy rating of 5% to 20%. This can cause the transducers in the controller not to match the well gauge exactly.

1. Check Transducer scale "Set 30". This should match the rating on your transducer normally 1000 PSI or 1500 PSI.
2. Check the measured 5 volt setting "Set 31". This should be set to 0500.
3. Check the transducer poll rate " Set 32". This should be set to 0005 seconds.
4. Check the transducer on time "Set 33". This should be set to 0003.

12.3 Will Not Add Sales Time or Afterflow

The reason the controller will not add afterflow is the opening pressure required (differential set point - Set 43) is not being met in the plunger Fall Time or the automatic adjustment is disabled (maximum Sales Time adjustment - Set 40).

1. Check Set 40 to make sure it is not zero.
2. Check Set 42 to ensure the travel speed is between 500 and 750 feet per minute.
3. Check Plunger for signs of wear.
4. Check Plunger Fall Time Set 12 to ensure it is set between 100 and 250 feet per minute.

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12.4 Motor Valve Failures

1. Check Supply gas to for a clean, dry, and constant supply.
2. Check the supply pressure. It should be between 28 to 48 PSI.
3. Check the supply gas going to the controller.
4. If the supply is dirty, disassemble and clean the latch valve.
5. Check the wiring of the latch valve, #12 Black, #13 Green, and #14 Red.
6. Check the battery to make sure it is above 5.5 volts.

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13 SMI Differential Pressure Well Controller Specifications

13.1 Package Size

Fiberglass box - 7.6" x 7.6" x 4.55"

13.2 Package Rating

Designed to NEMA 4, 4X specifications

13.3 Valve Control

Solenoid Pneumatic actuator

13.4 Operating Temperature

Operating Temperature Range is -40F to +185F, excluding the LCD

13.5 Communications Port

RS232 9600 baud, No Parity, One stop bit, Modbus Protocol, Modbus Address 1

13.6 Battery

6V Lead Acid. 4.5 Ahr @ 20hrs (approximate 30 days w/o recharge – ideal conditions)

13.7 Valve Actuator

125 PSI rated, all brass ¼ pipe thread connections

13.8 Pressure Transducers

3 x 0-1000 to 0-10,000 PSI transducers. Tubing, Line, and Casing

13.9 Solar Panel

7.5V @ 300mA

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