CPC-1: Closed Loop Controller Manual

CE

Manual available online at wkfluidhandling.com

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1. System Recommendations

1.1 Precautions

DO NOT OPEN CONTROL BOX
Do not open the control box. White Knight is not responsible for any damage caused by opening the Control Box.
Grounding
All electrical components must be grounded to minimize risk of sparks. Follow proper procedures for grounding all products in the system.
Non-stock Items Needed
The Closed Loop Control system makes use of several off the shelf items that White Knight does not supply. There is a large variety of products and suppliers and the end user may obtain their preferred product. See section 3 of this manual for detailed descriptions of needed parts.
System Limitations
The CPC controls the parameters of the system based off of the selected pump and would not protect system components that are not rated as high as the pump the controller is programmed to control.

1.2 System Environment Recommendations/Requirements

Environmental Temperature
This product is rated to withstand environmental temperatures up to 70°C.
Flow and Pressure
White Knight recommends the installation of a pressure transducer as well as a flow meter to allow for increased monitoring as well as the ability to switch between flow and pressure control within a system without any addition or change to system components.

1.3 Installation Advantages

Flow and Pressure Monitoring
The CPC-1 is able to take in both a pressure transducer and flow meter signals at the same time. While only one is needed for the desired control process, the other can be input for monitoring and troubleshooting purposes.

1.4 Getting Started

Installing the CPC-1 for the first time it is recommended that you follow these steps:

1) Verify that you received all of the components that you ordered. Note: cables and breakout board for the controller are options that can be selected at the time of purchase.
2) Check that you have a compatible power supply to power the controller. See Section 5.3.1
3) Check that you have a compatible communication cable for setting up the controller. See Section 6
4) Download the setup software from www.wkfluidhandling.com/cpc-1.
5) Verify that your computer is able to connect to the controller.
   a) Power up the controller with correct power source
   b) Connect the communication cable correctly. (Ethernet cables should go from the controller to a network switch, not your PC)
   c) Install and launch the Smart Control Software.
   d) The connections dialog should appear at launch. Verify that your controller appears on the list and click the connect button. See Section 7.2
   e) Once connectivity is verified disconnect from the software, and disconnect power and communication cable.
6) Install CPC-1 in the desired location.
7) Connect 44 pin and 26 pin connectors and use the wiring guide in Section 5.3.2 and 5.3.3 to connect system.
8) Connect to controller (same as before) and configure the CPC-1 settings to match your system needs.

2. Parts List

#	Description	Part Number	Component
2.1	Control Box	CPC-1	Standard
	Power Adapter With Crimp Pins		Standard
2.4	44 Pin HD D-Sub to Screw Terminals	8600-XX-0018	Optional
2.3	44 Pin HD D-Sub to wire leads Cable 1-Meter	8600-XX-0013	Optional
2.4	26 Pin HD D-Sub to Screw Terminals	8600-XX-0019	Optional
2.3	26 Pin HD D-Sub to wire leads Cable 1-Meter	8600-XX-0014	Optional
2.5	24 Volt Power Supply - 60 Watt	8600-XX-0015	Optional

* For size of items in parts list see section 12

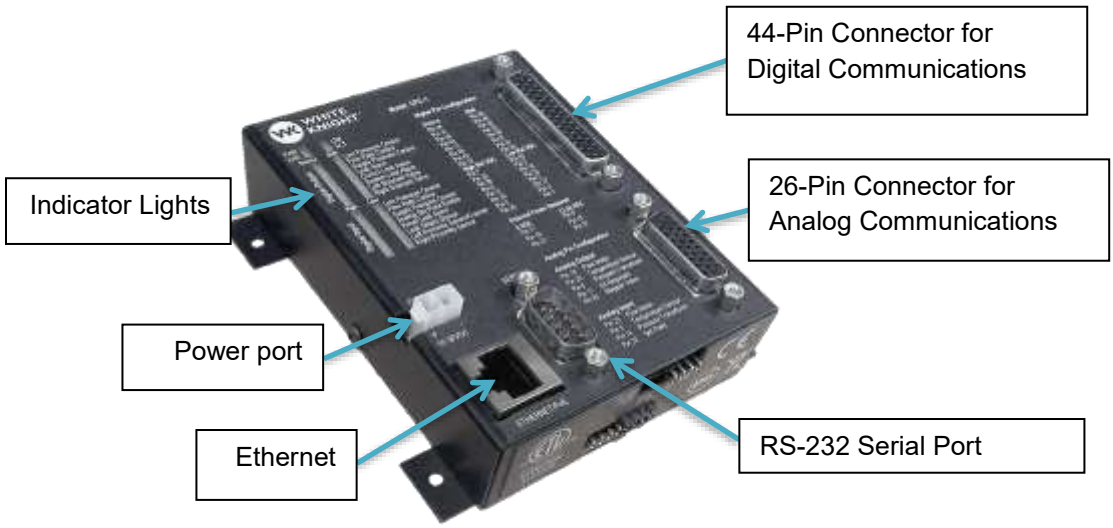
2.1 CPC-1 Closed Loop Controller

The CPC-1 control box is a small I/O communication device that controls the supply air pressure to the pump in order to maintain either flow or pressure changes. The control box has:

- 44-pin HD D-Sub Connector: Sends and receives digital signals.
- Indicator Lights: Show when each digital signal is active.
- 26-pin HD D-Sub Connector: Sends and receives analog signals.
- Power Port: Takes 18-36 VDC input to power the controller.
- Ethernet Connector: Can be used by the setup software to configure the controller.
- RS 232 serial communication: Can be used by the setup software to configure the controller.

Figure 1 shows an image of the CPC-1 controller. Note: the production version will come with a din rail mount, where the beta version does not.

Figure 1: The CPC-1 Controller and its communication ports.



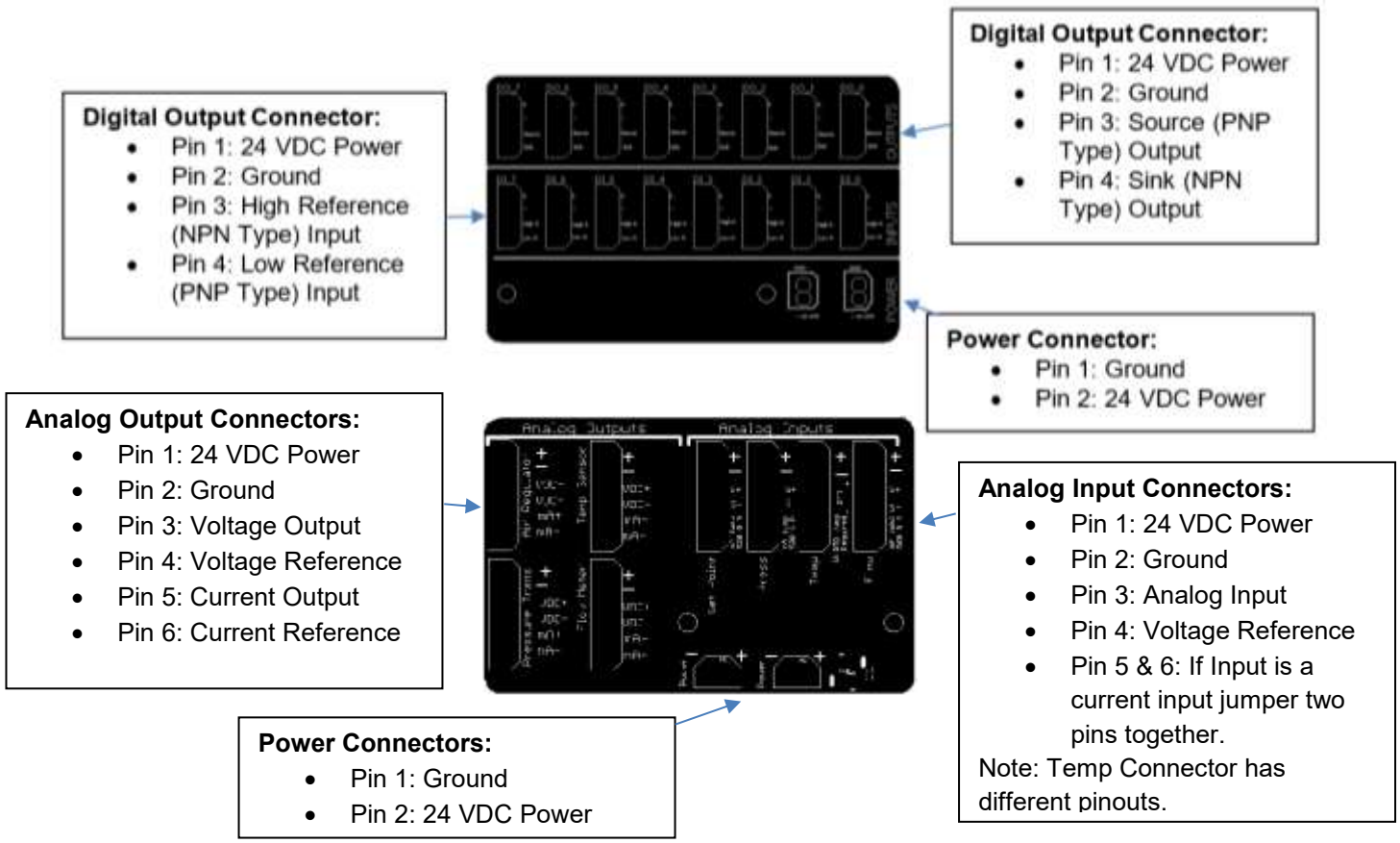
2.2 Power Adapter with Crimp Pins

2.3 Cable: 26 Pin & 44 HD D-Sub to Wire Leads

2.4 Breakout Board: 26 Pin HD D-Sub to Screw Terminals

2.5 Din Rail Power Supply

2.6 Quick connect boards. Using field wire-able connectors to make connections easier.



3. Non-Stock Items Needed

The Closed Loop Control system makes use of several off the shelf items that White Knight does not supply. There is a large variety of products and suppliers so the end user may obtain their preferred products. Below is a brief description of these components and the CPC-1 interface requirements.

3.1 I/P Air Regulator

An electronic proportional air regulator is required for the closed loop control system. Minimum specifications for I/P air regulator are:

- Supports a pressure range from 0 to 100 PSI.
- Supports air flow requirement for selected WK pump. (See pump's manual)
- Ability to set pressure using analog signal*.

* The CPC-1 only supports analog voltage analog outputs (0-5 VDC, 0-10 VDC), if an analog current signal (0-20 mA or 4-20mA) is required then the 4-20 mA Expansion Board or a signal conditioner is required.

3.2 Pressure Transducer

A pressure transducer is only required for systems in which pressure control is desired. However, for systems that are using flow control a pressure transducer can be added into the system for system monitoring. The minimum specifications for the pressure transducer are:

- Support the full range of system pressures up to 100 PSI
- Output pressure reading via analog signal*
  * If the pressure transducer outputs an analog current signal then a 500 ohms resistor or smaller can be connected between the signal and ground connections to convert the signal to a voltage signal. (The 4-20 mA Analog Expansion Board will already have a 250 ohm resistor correctly placed for this conversion)

3.3 Flow Meter

A flow meter is only required for systems in which flow control is desired. However, for systems that are using pressure control a flow meter can be added into the system for system monitoring. The minimum specifications for the flow meter are:

- Support the full range of system flows.
- Output flow reading via analog signal*
  * If the flow meter outputs an analog current signal then a 500 ohms resistor or smaller can be connected between the signal and ground connections to convert the signal to a voltage signal. (The 4-20 mA Analog Expansion Board will already have a 250 ohm resistor correctly placed for this conversion)

4 System Overview

Closed loop control is a self-monitoring system that will maintain one process variable independent of changes in the system. The CPC-1 closed loop controller has two different control modes:

Pressure Control – Uses feedback from a pressure transducer to maintain a set line pressure at a desired point in the system. Pressure transducers are able to detect small changes in the system with little to no time delay. Thus a pressure controlled system is more responsive to changes in the system, such as a point of use with multiple valves that open and close frequently. A pressure control system can also be used to maintain flow in the system where a fixed pressure through a fixed orifice can result in a steady flow.

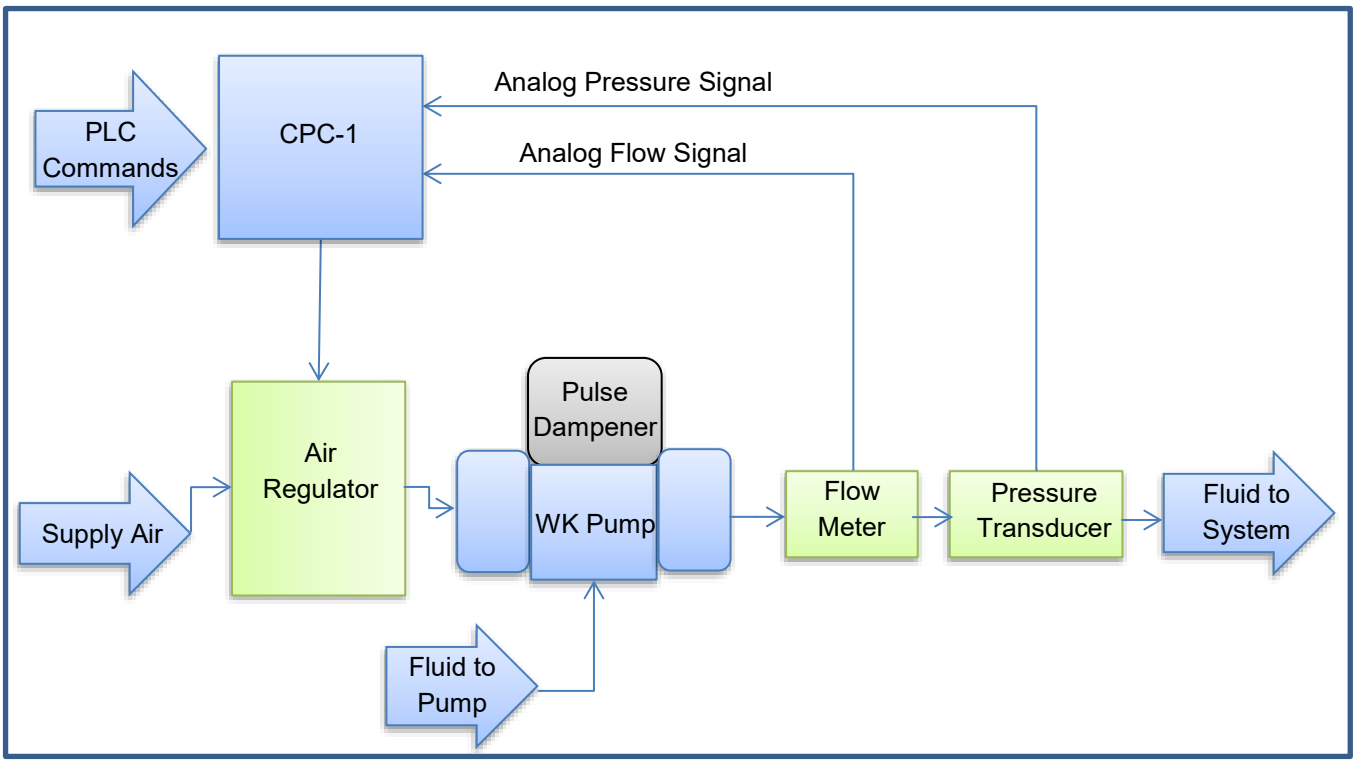
Flow Control – Uses feedback from a flow meter to maintain a desired flow rate in the system. Flow meters generally use a rolling average to detect flow in the system, which results in a less responsive sensor.

Thus a flow controlled system is slow to respond to changes in the system. Flow control processes are frequently used in plating or mixing operations where the flow doesn't change, but where the filter may clog over time. The flow control will slowly adjust the pressure as flow restrictions build up in a filter. Using flow control can lengthen the usable life of a filter because the control will maintain the correct flow.

The CPC-1 is able to take in both a pressure transducer and flow meter signals at the same time. While only one is needed for the desired control process, the other can be input for monitoring and troubleshooting purposes.

Note: White Knight does not supply pressure transducers or flow meters. See Non-Stock Items Needed for more information about selecting a pressure transducer and flow meter.

Figure 2: Control Process diagram where elements shown in green can be obtained from a third-party distributer. Note: Depending on which model of I/P Air regulator is selected they may be two separate components or they may be one consolidated unit.



5 Setup

5.1 Plumbing the system

Assemble the system plumbing as normal and include the correct sensors that are required for the closed loop control process; a pressure transducer for pressure controlled systems or a flow meter for flow controlled processes. These sensors should be placed in the critical path close to the point of use. In some cases it may be advantageous to add both sensors into the system; this will allow additional flexibility for implementing closed loop control allowing the end operator to monitor both sensors, and have the ability to switch control methods.

5.2 Supply Air Pressure

The supply air going into the closed loop control system should be set to 100 PSI. The supply air is then directed into the air regulator. The air regulator controls how much air is supplied to the pump and pulse dampener. See Figure 2 for illustration of the air flow.

5.3 Wiring Setup

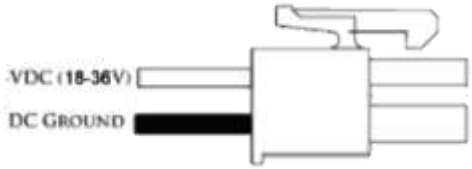
The CPC-1 has the following on device connections interfaces:

- 18-36 VDC Power Connector
- Ethernet/PoE Connection
- Serial to RS-232 connection
- 44 Pin HD D-Sub connection for Digital Communications
- 26 Pin HD D-Sub connection for Analog Communications

5.3.1 Powering the CPC-1

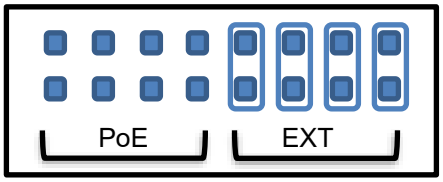
There are two methods of powering the CPC-1: 18-36 VDC power connector and Power over Ethernet, PoE. By default the CPC-1 is setup to use the external power adapter. Simply connect an appropriate DC power to the connector as shown in Figure 3.

Figure 3: External Power Connector



To setup PoE find the jumpers on the bottom face of the controller that are labeled EXT and PoE, see Figure 4. Move the jumpers from EXT to PoE locations. Now the Power over Ethernet connection can be used.

Figure 4: External power / Power over Ethernet Selection jumpers.



Default setup supporting external power shown.

5.3.2 Digital Connections

5.3.2.1 Power Digital Ports:

The digital ports are not powered by the controller. An external power supply is required in order for the digital ports to be active. Use Table 1 for digital port power connections.

Table 1: Wire connections for powering the digital ports. All ports should be connected.

Pin Name	Pin #	Wire Color	Designation	Levels	Notes
Power: Source Outputs	15	Red/ Black Stripe	Power Source	12-24 VDC	The voltage input into these pins power all of the source type outputs. * The voltage input will equal the voltage output from these ports.
	27	Red/ White Stripe	Ground Reference	0 VDC	
Power: Sink Outputs	8	Green	Power Source	12-24 VDC	The voltage input into these pins will power the sink type outputs.
	11	Orange	Ground Reference	0 VDC	

Power: Input High	37	Violet/ Red Stripe	Reference Voltage High	12-24 VDC	The Voltage input into this pin will be the reference for all digital high inputs.
Power: Input Low	19	Orange/ Black Stripe	Reference Voltage Low	0 VDC	The Voltage input into this pin will be the reference for all digital low inputs.

5.3.2.2 Digital Input Ports

Digital inputs by default are set to receive signals from a high voltage reference connection. However each digital input can be configured to receive the signal from the low voltage reference. To configure high or low voltage reference ports use the desktop software.

Table 2: Digital Input Connection Table, Continued on next page

Pin Name	Pin #	Wire Color	Designation	Levels	Notes
Digital Input: Line Pressure Control On/Off [DI_0]	**7**	Brown	Reference High VDC	24 V = Not Active, Off 0 V = Active, On	These Three digital inputs control how the controller will operate. In the case that multiple signals are received by the controller, then the system will chose the operations mode in the following priority: 1. Line Pressure Control 2. Flow Rate Control 3. Supply Pressure Control The priority system allows the user to setup a Pressure or Flow control operation during active process, and a basic supply pressure control to operate when the system is inactive to keep the fluid moving.
	33	Light Green/ Red Stripe	Reference Low VDC	0 V = Not Active, Off 24 V = Active, On	
Digital Input: Flow Rate Control On/Off [DI_1]	**22**	Gray/ Black Stripe	Reference High VDC	24 V = Not Active, Off 0 V = Active, On	
	3	Red	Reference Low VDC	0 V = Not Active, Off 24 V = Active, On	
Digital Input: Supply Pressure Control On/Off [DI_2]	**36**	Yellow/ Red Stripe	Reference High VDC	24 V = Not Active, Off 0 V = Active, On	
	18	Green/ Black Stripe	Reference Low VDC	0 V = Not Active, Off 24 V = Active, On	
Digital Input: Analog Set Point On/Off [DI_3]	**6**	Blue	Reference High VDC	24 V = Not Active 0 V = Active	The set point for each operation mode can be set though the set point analog port. This digital input tells the controller to use the analog port to as the set point for the active control mode.
	32	Gray/ Red Stripe	Reference Low VDC	0 V = Not Active 24 V = Active	
Digital Input: Reset Leak Alarm [DI_4]	**21**	Brown/ Black Stripe	Reference High VDC	24 V = Not Active 0 V = Active	Once a leak has been detected by the system, the controller will shut off the pump. This digital port is used to deactivate the leak alarm so that normal pump operation can continue.
	2	White	Reference Low VDC	0 V = Not Active 24 V = Active	

Pin Name	Pin #	Wire Color	Designation	Levels	Notes
Digital Input: Leak Detect Input [DI_5]	**35**	Pink/ Red Stripe	Reference High VDC	24 V = Not Active 0 V = Active	Send leak detect inputs into this digital port
	17	Violet/ Black Stripe	Reference Low VDC	0 V = Not Active 24 V = Active	
Digital Input: Left Proximity Sensor/ Counter [DI_6]	**5**	Violet	Reference High VDC	24 V = Not Active 0 V = Active	If operating a pump with end stroke detection instead of a shuttle operated pump the left and right proximity sensor inputs need to be connected to these digital ports. The left proximity switch input will be used to count cycles. For those using a shuttle pump and want the controller to preform cycle counting, then a pressure switch can be connected to the pump. See pump's owner's manual for details.
	31	Blue/ White Stripe	Reference Low VDC	0 V = Not Active 24 V = Active	
Digital Input: Right Proximity Sensor [DI_7]	**20**	Blue/ Black Stripe	Reference High VDC	24 V = Not Active 0 V = Active	
	1	Black	Reference Low VDC	0 V = Not Active 24 V = Active	

5.3.2.3 Digital Output Ports

The CPC-1 is able to send out digital communication to other devices. There are two types of digital outputs: voltage sink and voltage source. By default the voltage source outputs are active. Each digital communication can be configured to the voltage sink output using the desktop software.

Table 3: Digital Output Communications Table, Continued on next page

Pin Name	Pin #	Wire Color	Designation	Levels	Notes
Digital Output: Line Pressure Control Status [DO_0]	**26**	Orange/ White Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	These digital outputs have been designated to notify the user which mode the controller is operating in. If none are on, then the controller has been turned off.
	44	Light Green/ Green Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Flow Rate Control Status [DO_1]	**40**	Red/ Green Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	
	14	White/ Black Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Supply Pressure Status [DO_2]	**10**	Light Blue	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	
	29	Brown/ White Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Leak Alarm [DO_3]	**25**	Pink/ Black Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	This output is to notify the user that a leak has been detected.
	43	Light Blue/ Green Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	

Pin Name	Pin #	Wire Color	Designation	Levels	Notes
Digital Output: Control Limit Alarm [DO_4]	**39**	Orange/ Green Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	This alarm is to indicate to the user when the system is operating outside of the defined control limits.
	13	Pink	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: System Limit Alarm [DO_5]	**9**	Gray	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	This alarm is to notify the user that the system is operating near the maximum capacity of the system. This often occurs when the system has an obstruction that has built up over time.
	28	Violet/ White Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Left Solenoid Valve [DO_6]	**39**	Orange/ Green Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	These outputs are designated to operate a pump with end stroke detection. Each digital port will open an air valve that will shift the air in the pump.
	13	Pink	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Right Solenoid Valve [DO_7]	**9**	Gray	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	
	28	Violet/ White stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	

5.3.3 Analog Connections

Each analog connection is configurable 0-10 VDC Input/output. To configure the analog ports to the specific application use the desktop software.

5.3.3.1 Common Ground

The CPC-1 uses one common ground for all analog signals. Connect one of the common ground connections to the system's common ground, and then the others can be used as grounds for external devices.

Table 4: Table of ground references for analog signals

Pin Name	Pin #	Wire Color	Designation	Default Setup	Note
Reference: Common Ground	15	Red/ Black Stripe	Ground	0 VDC	These connections are for referencing a common ground. At least one should be connected to your system's common ground. And the others can be used for your sensors.
Reference: Common Ground	12	Light Green	Ground	0 VDC	
Reference: Common Ground	9	Gray	Ground	0 VDC	
Reference: Common Ground	6	Blue	Ground	0 VDC	

5.3.3.2 Supplemental low power supply

Some sensors will need a 12 VDC power that may not be available on the existing equipment. A 12VDC power supply is available for purchase from White Knight.

Pin Name	Pin #	Wire Color	Designation	Default Setup	Note
Power Output: +12 VDC	2	White	Power source	12 VDC	These are low current power supplies that can be used to power sensors if necessary.
Power Output: -12 VDC	20	Blue/ Black Stripe	Power Source	- 12 VDC	

5.3.3.3 Analog Inputs

All analog inputs are expecting a 0-10 VDC signal. Using the desktop software these ports can be configured for one of three different configurations: 0-5 VDC, 0-10 VDC, or 4-20 mA with a resistor bridging the signal and common ground. 4 - 500 ohm resistors have been included with the beta order for the purpose of converting 4-20 mA signals to voltage signals.

Table 5: Table of analog input values used

Pin Name	Pin #	Wire Color	Designation	Default Setup	Note
Analog Input: Flow Meter Signal [AI_0]	23	Light Blue/ Black Stripe	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	Analog input for flow control mode process variable.
Analog Input: Pressure Transducer Signal [AI_2]	14	White/ Black Stripe	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	Analog input for pressure control mode process variable.
Analog Input: Set Point Signal [AI_3]	22	Gray/ Black Stripe	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	Analog input for setting process
Analog Input: Temperature Signal [AI_1]	5	Violet	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	Analog input for temperature sensor.

5.3.3.4 Analog Outputs

All analog outputs have been configured to 0-10 VDC outputs. These outputs can be configured to a 0-5 VDC or 0-10 VDC using the desktop software. If a 4-20 mA output is required then an external signal conditioner will be required (not supplied by White Knight).

Pin Name	Pin #	Wire Color	Designation	Default Setup	Note
Analog Output: Flow Rate Signal [AO_0]	18	Green/ Black Stripe	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	These analog outputs echo out the current value of each sensor. In the configured output signal condition.
Analog Output: Temperature Signal [AO_1]	26	Blue/ White Stripe	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	
Analog Output: Pressure Signal [AO_2]	8	Green	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	
Analog Output: Air Regulator Signal [AO_3]	17	Violet/ Black Stripe	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	This signal is to be sent to the air regulator that is to maintain the process.

5.3.3.5 Wiring Summary

Table 6: I/O vs. CPC-1 Function Wiring requirements

Connection	Pin Name	Pressure Control	Flow Control	Supply Air Control	Analog Set Point	Leak Detect	Cycle Counting	Proximity Pump	Stepper Valve Demo	Temperature Input
Digital Input	Line Pressure Control	D								
	Flow Rate Control		D							
	Supply Pressure Control			D						
	Analog Set Point				D					
	Reset Leak Alarm					D				
	Leak Detect Input					X				
	Left Proximity Sensor/ Counter						X	X		
	Right Proximity Sensor							X		
Digital Output	Line Pressure Control Status	O								
	Flow Rate Control Status		O							
	Supply Pressure Status			O						
	Leak Alarm					O				
	Control Limit Alarm	O	O	O						
	System Limit Alarm	O	O	O						
	Left Solenoid Valve							X		
	Right Solenoid Valve							X		
Analog Input	Flow Meter Signal		X							
	Pressure Transducer Signal	X								
	Set Point Signal				X					
	Temperature Signal									X
Analog Output	Flow Rate Signal		O							
	Pressure Signal	O								
	Air Regulator Signal	X	X	X						
	Temperature Signal									O
	Stepper Valve								X	
	Stepper Valve								O	

O - Optional Connections
D - Required for Digital Communications
X - Required for this function

6 PC to CPC-1 Communication:

6.1 Ethernet Connection:

The Ethernet connection is available for PC to CPC-1 communications. These communications are available for setting up the software, and for on screen controls. After the controller has been setup the settings can be saved and disconnected to be run as a standalone unit. The CPC-1 uses two industry standard Ethernet connection protocols TCP/IP and UDP/IP, the controller will automatically respond in the format in which it is connected. When connecting to the WK Controller to a local network. The WK Controller will look to the server to assign it an IP address; this is supported on both DHCP and BOOT-P server protocols.

6.2 RS-232 Connection:

An RS-232 connection can be created through the 9 pin serial port on the box. When opening the software the RS-232 port will show as a COM port and will give two baud rate options, 19200 and 115000. The default baud rate is 115000, however the slower 19200 baud rate can be selected by placing a jumper on the connection labeled 19.2 on the upper left side of the control box.

7 Desktop Software

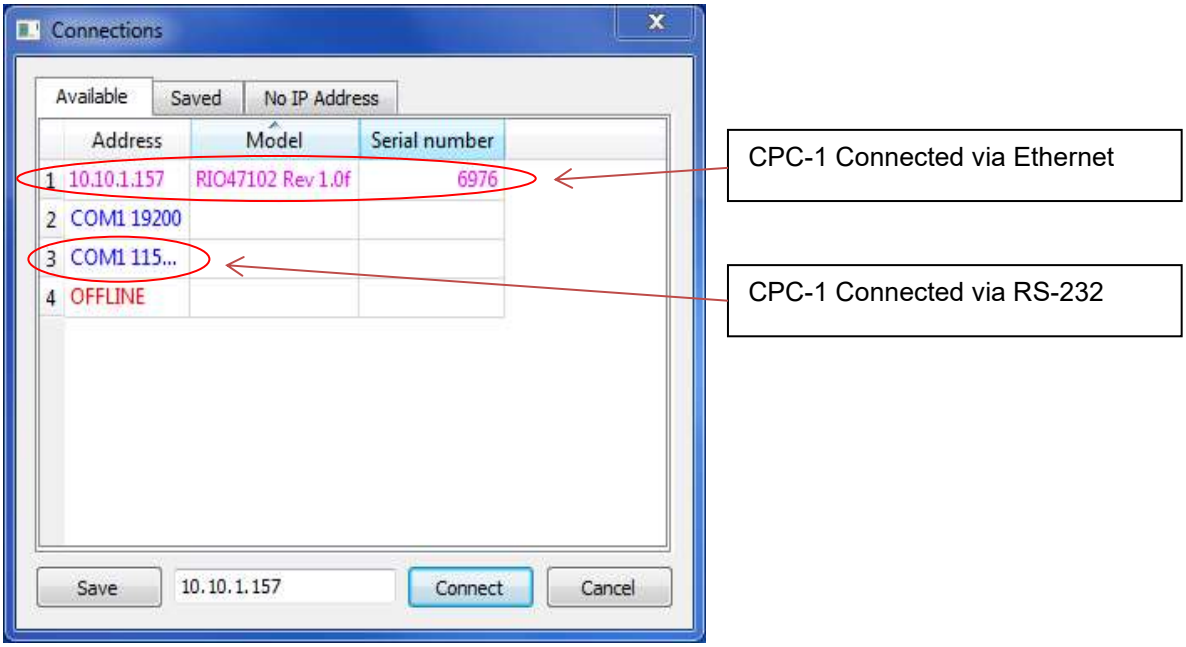
7.1 Installation

Download the WK Smart Control installation software from www.wkfluidhandling.com/cpc-1. Run the installation software by double clicking on the executable, and follow the on screen prompts. Software requires windows XP or newer version of windows.

7.2 Using the software

1. Open “WK Smart Control” software.
2. Wait for connections window to appear, See Figure 5 for a screen shot of the connections window.

Figure 5: Image of Connections Window with examples of appearance



3. Select the CPC-1 from the list (if the controller does not show up, then check that the controller is connected to the correct network. See trouble shooting section for more details. Click cancel and on the controls screen click connect to try connecting again) Note: all active comports will show up in the connections. If connecting via serial port you may want to open the device manager to determine which com port relates to the CPC-1
4. After you have connected to the CPC-1 then the controls window will appear, See Figure 6.

Figure 6: Controls window, showing sensor dials, alarms and process control modes.

7.2.1 Controls Window

The controls window is the main window for the smart control interface. This window shows the current readings from the sensors, the system alarm notifications, the mode controls with set point adjuster, and the main menu.

7.2.1.1 Sensor Gauges

Each sensor gauge displays the current value for that sensor as seen by the controller. The gauge limits are set in the setup window when specifying the analog I/O. Each gauge has a black pointer showing the current value for that sensor, and a small gray marker, that shows what the current set point for the operation mode. Note: When no sensor is connected, then the pointer will stay at a position about 25% of the maximum value.

7.2.1.2 System Alarms

There are four system alarms available through the smart control interface:

- **Control Limit** - Shows when the system is operating outside of the set process control limits defined by the user.
- **System Limit** – Shows when the system is operating near maximum capacity. The point threshold for this alarm is defined by the user.
- **Maintenance Alarm** – Shows when the pump has reached its maintenance limit set by the user. In order for this alarm to function an end of cycle signal needs to be sent to the controller, such as a pressure switch. Note: This alarm is available currently only through the software interface.
- **Leak Detect** – Shows when a leak has been detected by the system. The pump will be stopped by the controller, and will not restart until the leak reset button is pressed (see section 8.1.3).

7.2.1.3 Operation Mode setup

There are three controls for the operation mode; each has a specific roll to play in setting up the control mode.

- **Input Method Switch** – This switch enables the user to change where the controller looks to receive operation mode settings.
    - ***On Screen Controls*** – When the “on screen controls” option is enabled, then the controller will look for operation mode controls from the software interface.
    - ***Digital I/O*** – When the digital I/O is enabled, than the controller will look to the digital inputs to receive its operation mode settings.
- **Operation Mode Dial –** Operation mode sets how the controller will operate. This dial will only be operational if a controller is connected and if the on screen controls are enabled.
    - ***Flow Control –*** Uses the flow meter as the control variable for the system. The user will need to specify the desired set point for flow control operation. The system will vary the supply pressure to maintain the desired average flow rate.
    - ***Pressure Control*** – Uses the pressure transducer as the control variable for the system. The user will need to specify the desired set point for the flow control operation. The controller will vary the supply pressure to maintain the desired average flow rate.
    - ***Supply Air Control*** – This enables an uncontrolled system process to be used. This is specifically helpful when testing a system for leaks, or can also be used for recirculation routines.
    - ***Off*** – When the controller *is not* to send any air pressure to the pump
- **Set Point Dial –** The set point dial is used to modify the set point for each operation mode. The dial limits will automatically be adjusted to the process variable’s limits.

7.2.1.4 Additional Menu Items

From the controls window there are additional controls available.

- **Connect** – Quickly connect when no controller is connected, just select the connect button, and the connection screen will appear.
- **Disconnect** – Quickly disconnect from the current controller. (note: before disconnecting the user should save the current setting if critical changes were made.)
- **Save** – This will save the current settings to the device’s nonvolatile memory, which gets loaded when a power cycle occurs.
- **Setup** – This brings up the setup window which enables the user to specify process, analog I/O, and Digital I/O settings. See section 5 for more details.
- **Maintenance** – This brings up the maintenance window with allows the user to view the current cycle count, cycle rate, and maintenance limits. The user can also modify the maintenance limits.
- **Graph** – This brings up the time lapse graph for the end user to view the current process values as they occur.

- **Stepper Demo** – This brings up a specialized window that was created for testing stepper valves, but can also be used to send a 0-5 analog signal to two other connected devices.
- **Advanced** – This brings up the advanced window which enables the user to modify the PID settings in the controller to get the optimal response for their system. This interface also gives technicians the ability to send messages directly to the controller using the terminal.
- **Modify IP Address** – This brings up an option to modify the IP Address settings for the CPC-1. The CPC-1 Can be configured to have a fixed IP Address specified by the user, or the IP Address can be left open to be set by the DHCP Network.
- **Update Controller Firmware** – In cases where the controller's version does not match the desktop software's version then a controller update may be necessary. The update controller firmware feature will install the controller firmware that matches the software version.

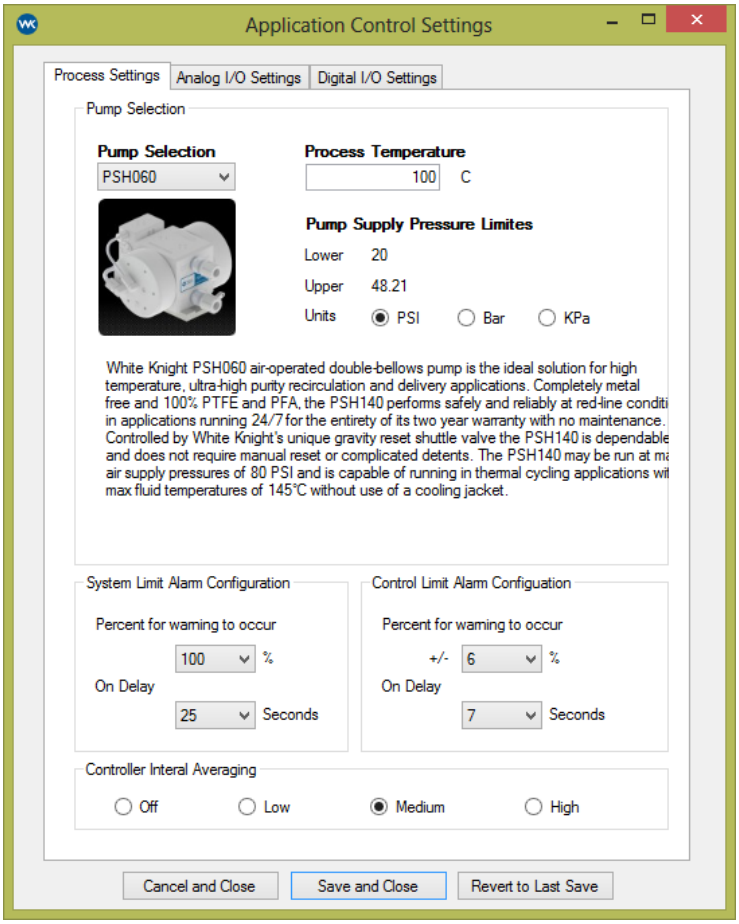
7.2.2 Setup Window

The setup window has 3 main sections: Process settings, Analog I/O Settings, and Digital I/O settings. These settings are for customizing the controller for specific end user needs. To keep any changes to the settings the user will need to select “Save and Close”

7.2.2.1 Process Settings

The process settings window enables the end user to specify the process temperature with the pump in use, and customize the system alarm limits. See Figure 7 for a screen shot of window.

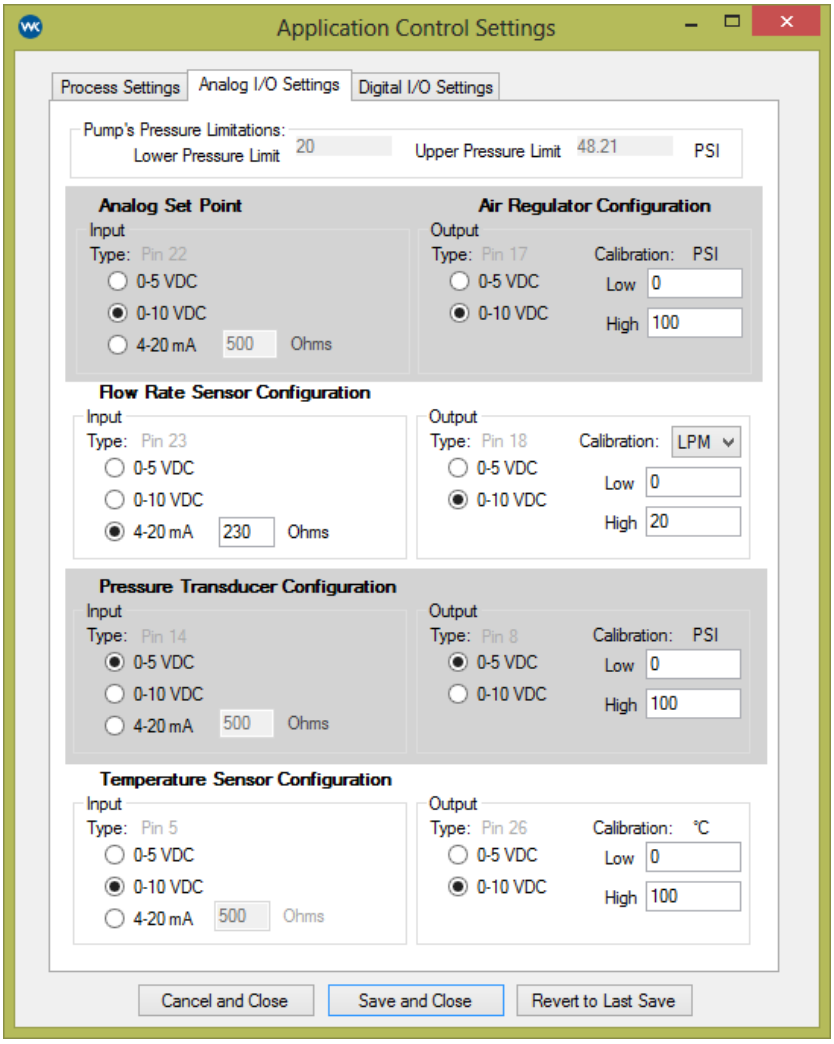
Figure 7: Screenshot of process settings window.



- **Pump Selection** – When setting up the CPC-1 start by selecting the WK pump that will be used in the process. This will enable an accurate pump supply pressure limit calculation.
- **Process Temperature** – Enter the temperature that the process will operate. Then the pump supply pressure limits will be calculated. Once saved the CPC-1 will limit the pump’s pressure to within the valid operation pressures for the operation temperature.
- **System Limit Alarm** – To configure the system limit alarm select the warning threshold and an “on delay” value that is suitable for reducing false alarms.
- **Control Limit Alarm** – To configure the control limit alarm enter a percent of allowable variation and the “on delay” value that is suitable for reducing false alarms.
- **Controller Internal Averaging** – The internal averaging applies the analog signals which are read. By increasing the internal averaging, the system is able to filter out noise in the system and reduce false alarms, and make the signal smoother.

7.2.2.2 Analog I/O Settings

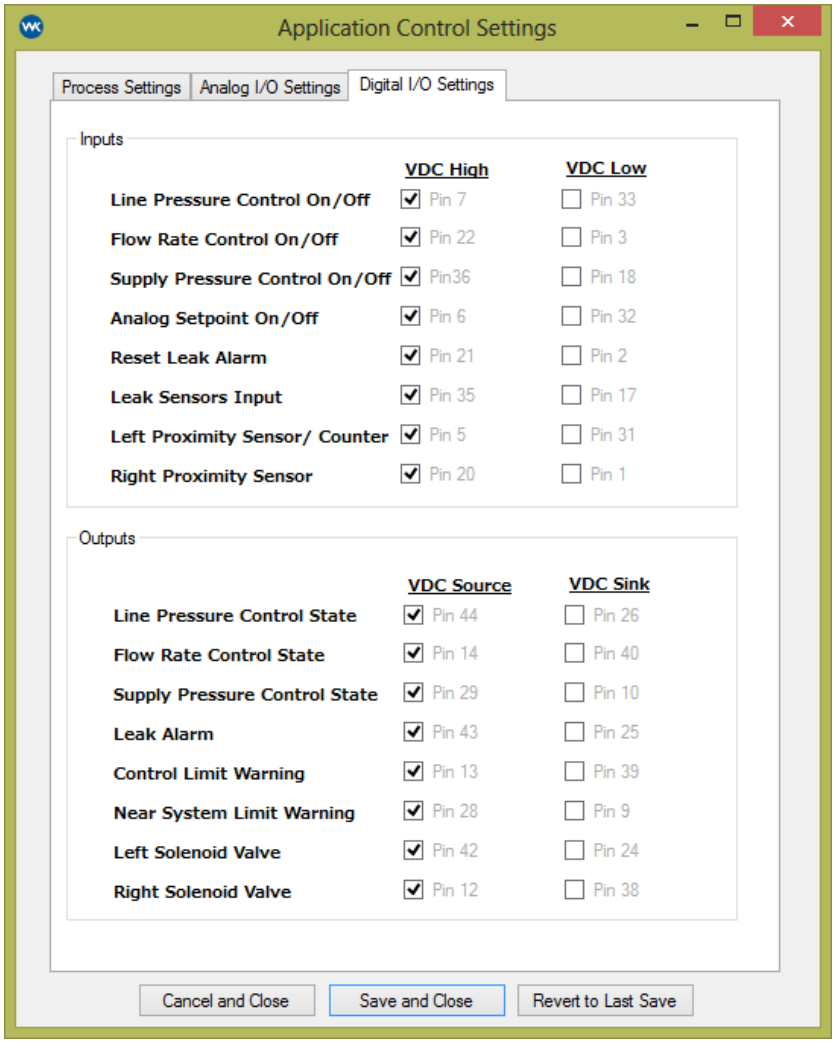
Figure 8: Screenshot of the analog I/O setup



- **Pump's Pressure** Limitations – This section shows the current pressure limits as determined by the process settings. Note: these values are not editable; they are set by the pump selection and process temperature specified. They are included on this page as a convenience for the user.
- **Analog Set Point** – This is to configure how the analog set point should be read into the system. The analog signal input is used by the digital port "Analog Set Point" which is a way to remote assign the set point using the digital ports
- **Air Regulator** – Configures how the controller will send out the air regulator signal, and set what pressure limits the air regulator has.
- **Flow Rate Sensor** – Use this section to configure how the flow meter will be read by the CPC-1, how the CPC-1 will echo out the signal, and what the flow meter is rated for.
- **Pressure Transducer -** Use this section to configure how the pressure transducer will be read by the CPC-1, how the CPC-1 will echo out the signal, and what pressure it is rated for.
- **Temperature Sensor** – The temperature sensor supports an analog input signal. Use this section to configure the analog input and output signals.

7.2.2.3 Digital I/O Settings

Figure 9: Screenshot of the digital I/O setup window

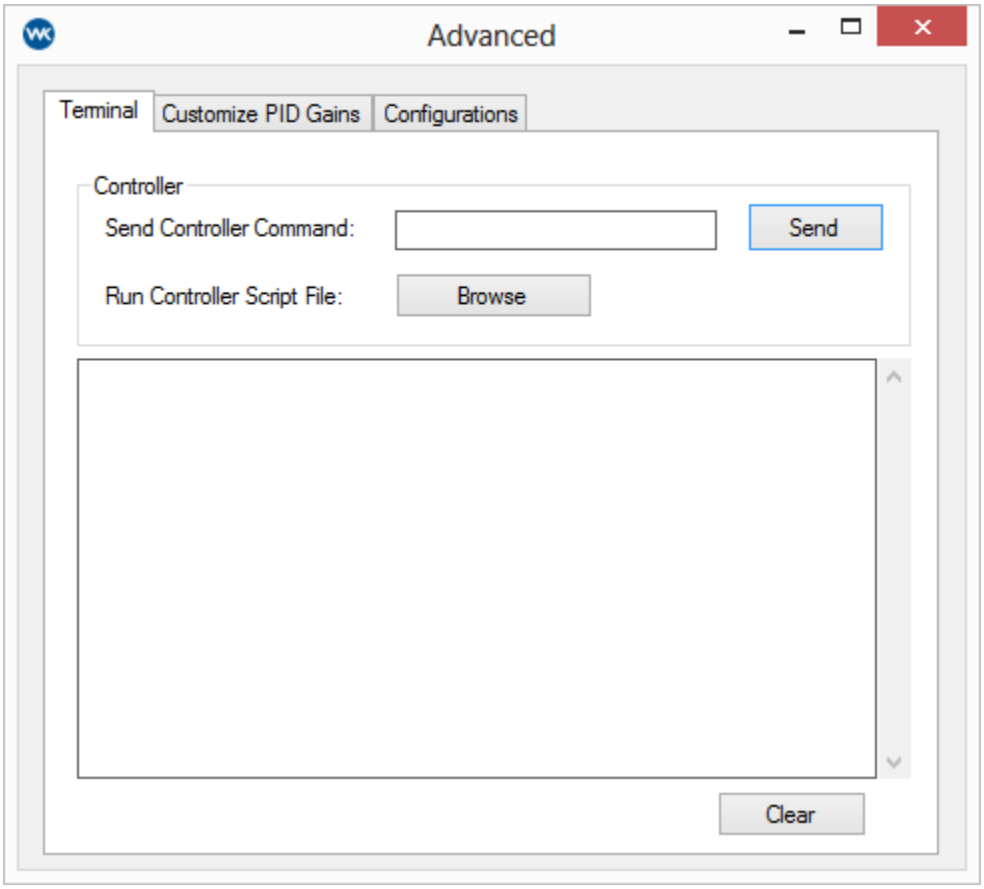


- Digital Inputs – For each digital input the input signal can be configured to be referenced to a high voltage reference or a low voltage reference. Simply check the corresponding box to and connect the pin # specified to the correct digital signal.
- Digital Outputs – For each digital output the output signal can be configure to be a voltage source or voltage sink. Simply check the corresponding box and connect the pin # to the correct signal.

7.2.3 Advanced Window

The advanced window offers some special features that may help in trouble shooting the controller.

Figure 10: Advanced Window



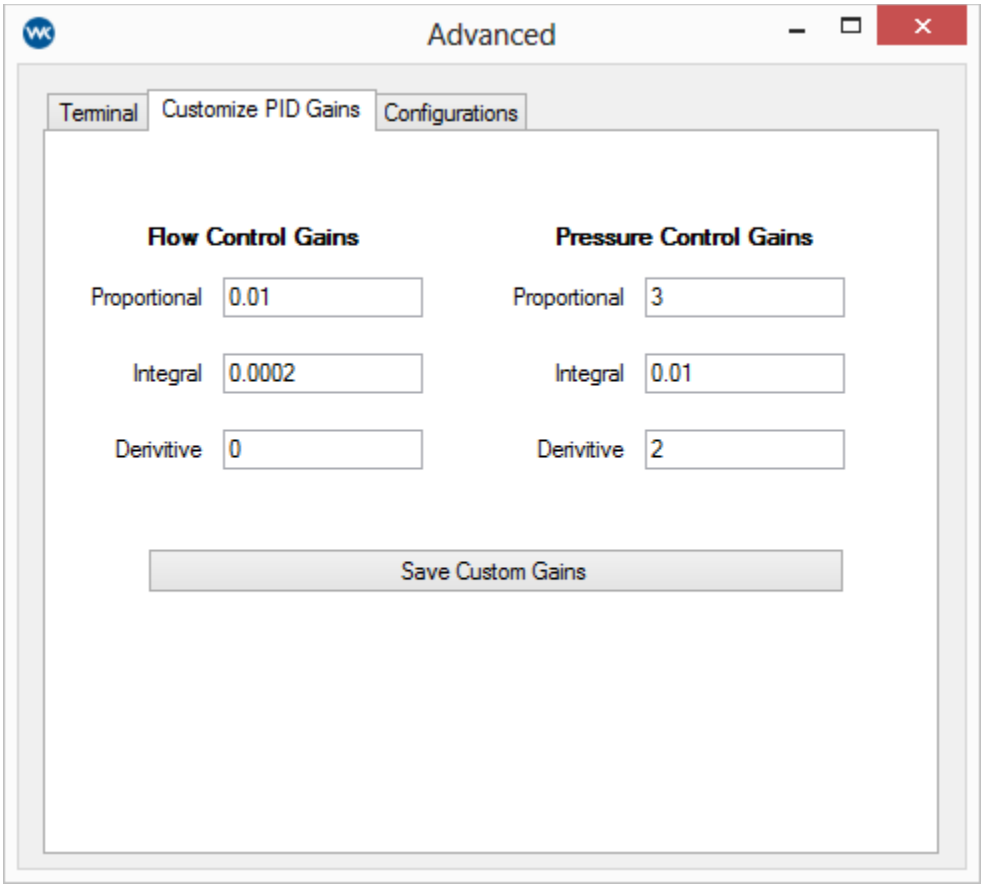
7.2.3.1 Terminal Tab

The command line terminal is a tool that can come in handy when talking to customer support. This is an interface that will allow a user to enter specific commands to the controller and see the response. Also, there might be situations where there is a problem where customer support may want a script run. In those situations use the browse button to search and run the script. See Figure 10 for a screenshot of Terminal tab.

7.2.3.2 Customize PID Gains Tab

PID gains modify the performance of the control system. Since every system will have a slightly different performance response, the ability to modify the PID gains has been built into the software. For those who are unfamiliar with modifying PID gains then please refer to section “9.3 - Issues with Stable Flow” for help in modifying the PID gains. For those familiar with setting PID gains you should know that the CPC-1 does not use true PID control; the PID algorithm has been modified to achieve optimal performance from the pump system. It is recommended to be conservative in tuning the PID gains. The minimum value for any PID gain is .0001, and number less than .0001 will be interpreted as a 0 by the controller. See Figure 11 for a screenshot of the Customize PID Gains tab.

Figure 11: Customize PID gains in Advanced window



7.2.3.3 Configurations Tab

The Configurations tab allows the user some advance setting specific to the software log and update frequency of the dials on the main control page. These setting can help keep log files small if they become too large for the computer. However, if problems arise then it is helpful for customer support to have more detailed log files. This will help in diagnosing problems.

8 Standalone Operation

After the CPC-1 has been wired and configured to communicate correctly with connected devices both analog and digital, then standalone operation can be used. Before standalone operation is used; be sure to do the following on the setup software.

- If not using the analog set point to assign the process set point, make sure the current process set points are correct for the process.
- Verify that the switch input method switch is set to Digital I/O
- Save the settings, so that the controller will keep the current settings as the default setup in the event of a power cycle.

8.1 Using Digital Communication

In using the digital communications to operate the pump during standard operation, there are 5 digital inputs and 1 analog input that can be used to send commands to the CPC-1. These inputs are listed below:

- Digital Input:
    - Pressure Control On/Off
    - Flow Control On/Off
    - Supply Pressure Control On/Off
    - Analog Set Point Enable On/Off
    - Leak Reset
- Analog Input:
    - Set Point

8.1.1 Operation Mode

There are 4 operation modes that the CPC-1 can operate:

- **Pressure Control** – Uses feedback from a pressure transducer. It is fast to respond to change in the system. To turn pressure control on, turn on the Pressure Control signal. The pressure control operation has the highest priority of all the operation modes, meaning that even if other signals are on; then pressure control will still take precedence.
- **Flow Control** – Uses feedback from a flow meter. It is slow to change because most flow meters are slow to respond. Turn this mode on by sending a signal to the Flow Control On/Off digital input. Flow control has second priority, and will override supply air control.
- **Supply Air Control** – This control mode does not use any feedback and will send a fixed air pressure to the pump. Supply air control has the lowest priority for the system.
- **Recirculation Operation Mode -** For some processes it is required that the fluid always move. There will be some situations where a process control mode is desired when the machine is on, and when the system is off a low air consumption fluid recirculation is desired. Rather than changing set points during operation for the control modes, two of the above modes can be used in conjunction to achieve the same effect.
    - **Example** - Send a pressure control signal on and the supply air control signal on at the same time, when the controlled portion of the process is complete and the system needs to go into a recirculation mode simply turn off the pressure control signal, and immediately the system will switch to supply air control. This creates a two stage process operation mode, and recirculation mode. This operation mode is possible because of the system priorities. When the system needs maintenance and the pump needs to be turned off completely then turn off both signals and air will shut off.
- **System Off** – To turn off the system do not send any operation signals.

8.1.2 Set Point Modification

The set point can be modified while the system is in standalone operation by turning on the “Analog Set Point Enable” digital port. When this port is active then the current control mode will take on the new set point as a percentage of the max value. Once the “Analog Set Point Enable” is turned off then the last analog signal received before the port was turned off will be kept as the new set point for that operation mode. Some systems may want to modify the set point on the fly during the operation. This can be done by leaving the “Analog Set Point Enable” digital port on during the operation. When this is done then the set point will be continuously updated to the current analog signal input.

8.1.3 Leak Detect Reset

The CPC-1 is able to detect leaks in the system during operation, this is done by connecting a leak sensor(s) to the leak detect sensor digital input. If the leak sensors are connected to the CPC-1 then it is necessary to be able

to send a reset command to the pump. When leaks are detected, an alarm will be sent out and the supply air to the pump will be cut off. The pump must be manually reset by the operator after the system leak has been resolved. It may be beneficial to connect a physical button near the pump so that the operator can easily reset the system after leaks have been resolved.

9 Troubleshooting

9.1 Issues connecting to CPC-1 via Ethernet, preform the actions below

- Check that all wires are connected correctly.
- Check that network is assigning an IP Address. (contact system administrator for help)
- Press reset button on the controller and wait for system restart.
- If still unable to connect contact White Knight at Courtney.Parsons@wkfluidhandling.com

9.2 Issues Connecting to CPC-1 via RS-232, preform the actions below

- Make sure that wires are connected correctly.
- Make sure that serial port uses RS-232 connection protocol.
- Go to the device manager on your computer.
    1. Verify that your computer assigned a COM port for the device.
    2. Verify that the COM port is set to a baud rate of 115000
- Press reset button on the controller and wait for system restart.
- If still unable to connect contact White Knight at Courtney.Parsons@wkfluidhandling.com

9.3 Issues with Stable Flow

Every system is different and may require some adjustments to the get optimal system performance. Here are some helpful hints:

- **Be sure to have sufficient back pressure in the system:** If the I/P Air regulator turns on and off frequently during operation this is a sign that there needs to be more back pressure in the system to run at the desired set point. This can easily be fixed by placing an inline restrictor before the sensors. Low flow applications may require the pump to have a significant back pressure, see the pump's manual for pressure vs. flow curves.

  Note: *If you do not know what PID gains are, you may consider contacting White Knight for assistance with tuning PID gains*
- **Tune the PID gains for the operation:** When operating in flow or pressure control modes, and the controller oscillates from sending high supply pressure to low or no pressure supply pressure in rapid successions then this would be an indication that the control PID gains are set too high. Here are the steps for adjusting the PID gains:
    1. **Switch to supply pressure control:** Before doing anything check that the issues go away when operating in supply pressure control.
        - If the problems go away then continue to next step
        - If the problems persist, then check the electrical system for grounding issues, power supply issues, or other problems.
        - Press the reset button on the CPC-1.

(Section continued on next Page)

2. **Switch back to the flow / pressure control mode:** Now check that the problem persists in the flow / pressure control mode.
    - If the problem still occurs, then continue to next step.
    - If the problem is solved then you may stop
3. **The advanced window has a tab for setting PID gains:** The advanced window is located under “tools” in the menu bar.
4. **Tune the PID gains:** For the specific flow / pressure control find the corresponding PID gains. The ultimate goal is to get the optimal steady state operation, and then to get an acceptable disruption response.
    a. Set all the gains to zero.
    b. Adjust the integral gain up until the steady state response starts to vary noticeably. Take note of this value; generally this value will be the upper limit for the integral gain.
    c. Reduce the Integral gain back down to where the steady state response is reasonable. Take note of this value; generally this is a good integral gain.
    d. Turn the system off and back on. Check for the step response, if the step response is reasonable, then you can stop here.
    e. Increase the proportional gain till an acceptable step response is received. If the system goes unstable, then the proportional gain is too high.
    f. Verify that with the proportional gain added that the steady state response is still acceptable. If acceptable then you can stop here.
    g. Fine tune the proportional and integral gains by making small adjustments to the both until the desired response is achieved. Note: based upon the experimentation preformed at White Knight the derivative gain often has unexpected results, and is not needed for this system. However, the user may experiment with the derivative gain as part of the fine tuning process.
    h. When the process is complete then go to the main screen and save the changes to the system.

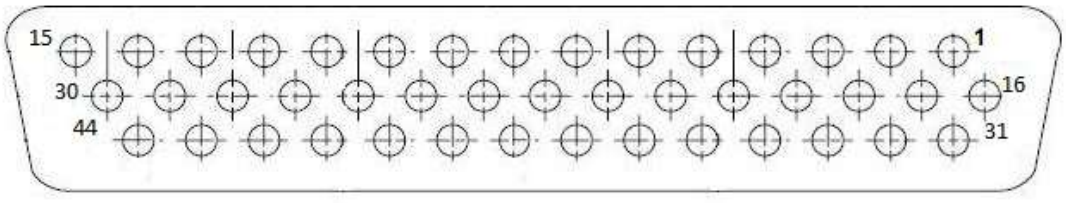
10 Appendix 1: 44 Pin D-Sub Connection Table

Pin Name	Pin #	Wire Color	Designation	Levels	Note
Power: Source Outputs	15	Red/ Black Stripe	Power Source	12-24 VDC	The voltage input into these pins will be the voltage output for all Source type output pins.
	27	Red/ White Stripe	Ground Reference	0 VDC	
Power: Sink Outputs	8	Green	Power Source	12-24 VDC	The voltage input into these pins will power the sink type output pins.
	11	Orange	Ground Reference	0 VDC	
Power: Input High	**37**	Violet/ Red Stripe	Reference Voltage High	12-24 VDC	The Voltage input into this pin will be the reference for all digital high inputs.
Power: Input Low	**19**	Orange/ Black Stripe	Reference Voltage Low	0 VDC	The Voltage input into this pin will be the reference for all digital low inputs.
Digital Input: Line Pressure Control On/Off [DI_0]	**7**	Brown	Reference High VDC	24 V = Not Active, Off 0 V = Active, On	These Three digital inputs control how the controller will operate. In the case that multiple signals are received by the controller, then the system will chose the operations mode in the following priority: 1. Line Pressure Control 2. Flow Rate Control 3. Supply Pressure Control The priority system allows the user to setup a Pressure or Flow control operation during active process, and a basic supply pressure control to operate when the system is inactive to keep the fluid moving.
	33	Light Green/ Red Stripe	Reference Low VDC	0 V = Not Active, Off 24 V = Active, On	
Digital Input: Flow Rate Control On/Off [DI_1]	**22**	Gray/ Black Stripe	Reference High VDC	24 V = Not Active, Off 0 V = Active, On	
	3	Red	Reference Low VDC	0 V = Not Active, Off 24 V = Active, On	
Digital Input: Supply Pressure Control On/Off [DI_2]	**36**	Yellow/ Red Stripe	Reference High VDC	24 V = Not Active, Off 0 V = Active, On	
	18	Green/ Black Stripe	Reference Low VDC	0 V = Not Active, Off 24 V = Active, On	
Digital Input: Analog Set Point On/Off [DI_3]	**6**	Blue	Reference High VDC	24 V = Not Active 0 V = Active	The set point for each operation mode can be set though the set point analog port. This digital input tells the controller to use the analog port as the set point for the active control mode.
	32	Gray/ Red Stripe	Reference Low VDC	0 V = Not Active 24 V = Active	

Pin Name	Pin #	Wire Color	Designation	Levels	Note
Digital Input: Reset Leak Alarm [DI_4]	**21**	Brown/ Black Stripe	Reference High VDC	24 V = Not Active 0 V = Active	Once a leak has been detected by the system, the controller will shut off the pump. This digital port is used to deactivate the leak alarm so that normal pump operation can continue.
	2	White	Reference Low VDC	0 V = Not Active 24 V = Active	
Digital Input: Leak Detect Input [DI_5]	**35**	Pink/ Red Stripe	Reference High VDC	24 V = Not Active 0 V = Active	Send leak detect inputs into this digital port
	17	Violet/ Black Stripe	Reference Low VDC	0 V = Not Active 24 V = Active	
Digital Input: Left Proximity Sensor/ Counter [DI_6]	**5**	Violet	Reference High VDC	24 V = Not Active 0 V = Active	If operating a pump with end stroke detection instead of a shuttle operated pump the left and right proximity sensor inputs need to be connected to these digital ports. The left proximity switch input will be used to count cycles. For those using a shuttle pump and want the controller to preform cycle counting, then a pressure switch can be connected to the pump. See pump's owner's manual for details.
	31	Blue/ White Stripe	Reference Low VDC	0 V = Not Active 24 V = Active	
Digital Input: Right Proximity Sensor [DI_7]	**20**	Blue/ Black Stripe	Reference High VDC	24 V = Not Active 0 V = Active	
	1	Black	Reference Low VDC	0 V = Not Active 24 V = Active	
Digital Output: Line Pressure Control Status [DO_0]	**26**	Orange/ White Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	These digital outputs have been designated to notify the user which mode the controller is operating in. If none are on, then the controller has been turned off.
	44	Light Green/ Green Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Flow Rate Control Status [DO_1]	**40**	Red/ Green Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	
	14	White/ Black Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Supply Pressure Status [DO_2]	**10**	Light Blue	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	
	29	Brown/ White Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	

Pin Name	Pin #	Wire Color	Designation	Levels	Note
Digital Output: Leak Alarm [DO_3]	**25**	Pink/ Black Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	This output is to notify the user that a leak has been detected.
	43	Light Blue/ Green Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Control Limit Alarm [DO_4]	**39**	Orange/ Green Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	This alarm is to indicate to the user when the system is operating outside of the defined control limits.
	13	Pink	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: System Limit Alarm [DO_5]	**9**	Gray	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	This alarm is to notify the user that the system is operating near the maximum capacity of the system. This often occurs when the system has an obstruction that has built up over time.
	28	Violet/ White Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Left Solenoid Valve [DO_6]	**24**	Light Green/ Black Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	These outputs are designated to operate a pump with end stroke detection. Each digital port will open an air valve that will shift the air in the pump.
	42	Brown/ Green Stripe	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	
Digital Output: Right Solenoid Valve [DO_7]	**38**	Gray/ Green Stripe	**Sink:** Connect To ground when closed	Relay Open = Not Active Relay Closed = Active	
	12	Light Green	**Source:** Connect to power when closed	Relay Open = Not Active Relay Closed = Active	

Figure 13: Pin out diagram for 44 pin connector

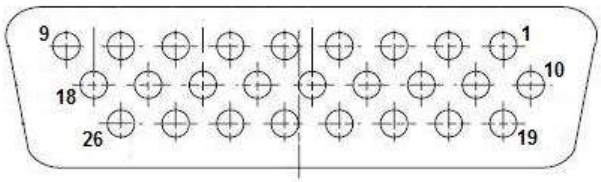


11 Appendix 2: 26 Pin HD D-Sub Connection Table

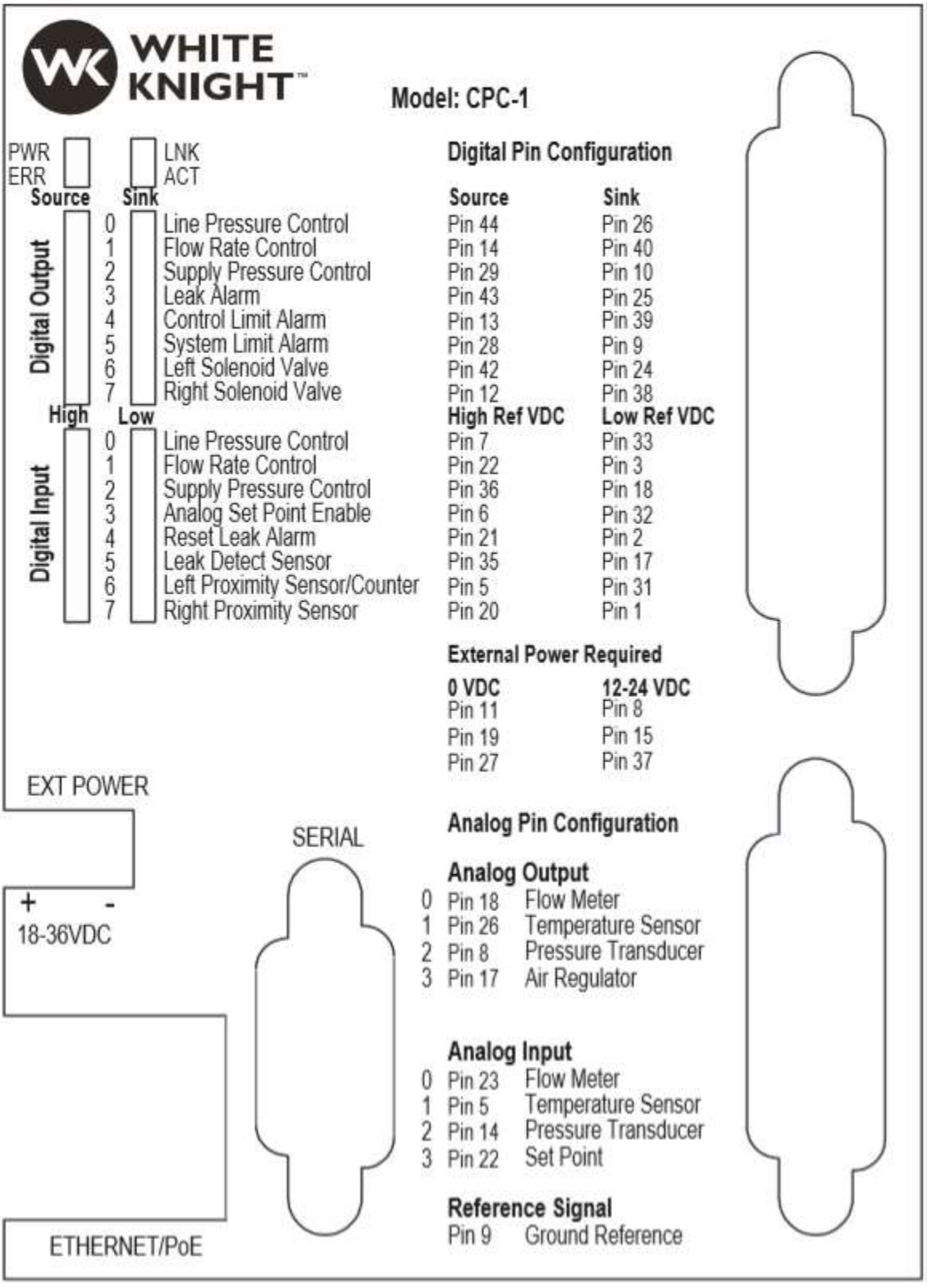
Pin Name	Pin #	Wire Color	Designation	Default Setup	Note
Analog Input: Flow Meter Signal [AI_0]	23	Light Blue/ Black Stripe	Customizable 0-10 VDC Input	0..5 VDC = 0..100%	Analog input for flow control mode process variable.
Analog Input: Pressure Transducer Signal [AI_2]	14	White/ Black Stripe	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	Analog input for pressure control mode process variable.
Analog Input: Set Point Signal [AI_3]	22	Gray/ Black Stripe	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	Analog input for setting process
Analog Input: Temperature Signal [AI_1]	5	Violet	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	Analog input for temperature sensor.
Analog Input: Unused	4	Yellow	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	These analog inputs are currently not used. If there is additional sensor readings that the user would like to input into these ports then please contact WK.
Analog Input: Unused	13	Pink	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	
Analog Input: Unused	21	Brown/ Black Stripe	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	
Analog Input: Unused	3	Red	Customizable 0-10 VDC Input	0..10 VDC = 0..100%	
Analog Output: Flow Rate Signal [AO_0]	18	Green/ Black Stripe	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	These analog outputs echo-out the current value of each sensor in the configured output signal condition.
Analog Output: Temperature Signal [AO_1]	26	Blue/ White Stripe	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	
Analog Output: Pressure Signal [AO_2]	8	Green	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	
Analog Output: Air Regulator Signal [AO_3]	17	Violet/ Black Stripe	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	This signal is to be sent to the air regulator that is to maintain the process.
Analog Output: Unused	25	Pink/ Black Stripe	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	These analog outputs are not currently used. If there is additional

Pin Name	Pin #	Wire Color	Designation	Default Setup	Note
Analog Output: Unused	7	Brown	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	information that the user would like output from the controller then please contact WK.
Analog Output: Unused	16	Yellow/ Black Stripe	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	
Analog Output: Unused	24	Light Green/ Black Stripe	Customizable 0-10 VDC Output	0..10 VDC = 0..100%	
Reference: Common Ground	15	Red/ Black Stripe	Ground	0 VDC	These connections are for referencing a common ground. At least one should be connected to your system's common ground and the others can be used for sensors.
Reference: Common Ground	12	Light Green	Ground	0 VDC	
Reference: Common Ground	9	Gray	Ground	0 VDC	
Reference: Common Ground	6	Blue	Ground	0 VDC	
Power Output: +12 VDC	2	White	Power source	12 VDC	These are low current power supplies that can be used to power sensors if necessary.
Power Output: -12 VDC	20	Blue/ Black Stripe	Power Source	- 12 VDC	
Unused: No Connection	19	Orange/ Black Stripe	No Connection	No Connection	These wires are not electrically connected to the controller. They are open connections.
Unused: No Connection	11	Orange	No Connection	No Connection	
Unused: No Connection	10	Light Blue	No Connection	No Connection	
Unused: No Connection	1	Black	No Connection	No Connection	

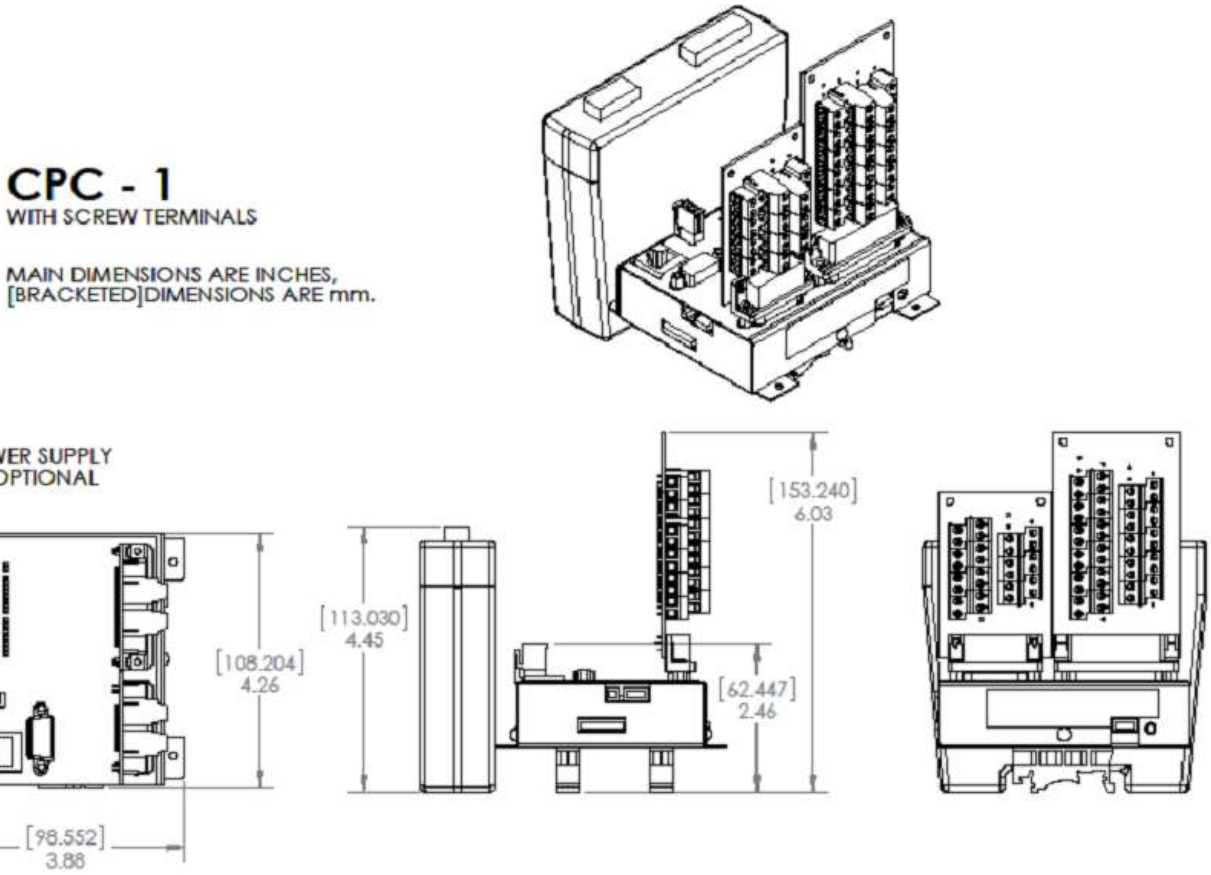
Figure 14: Pin outs for 26 pin connector

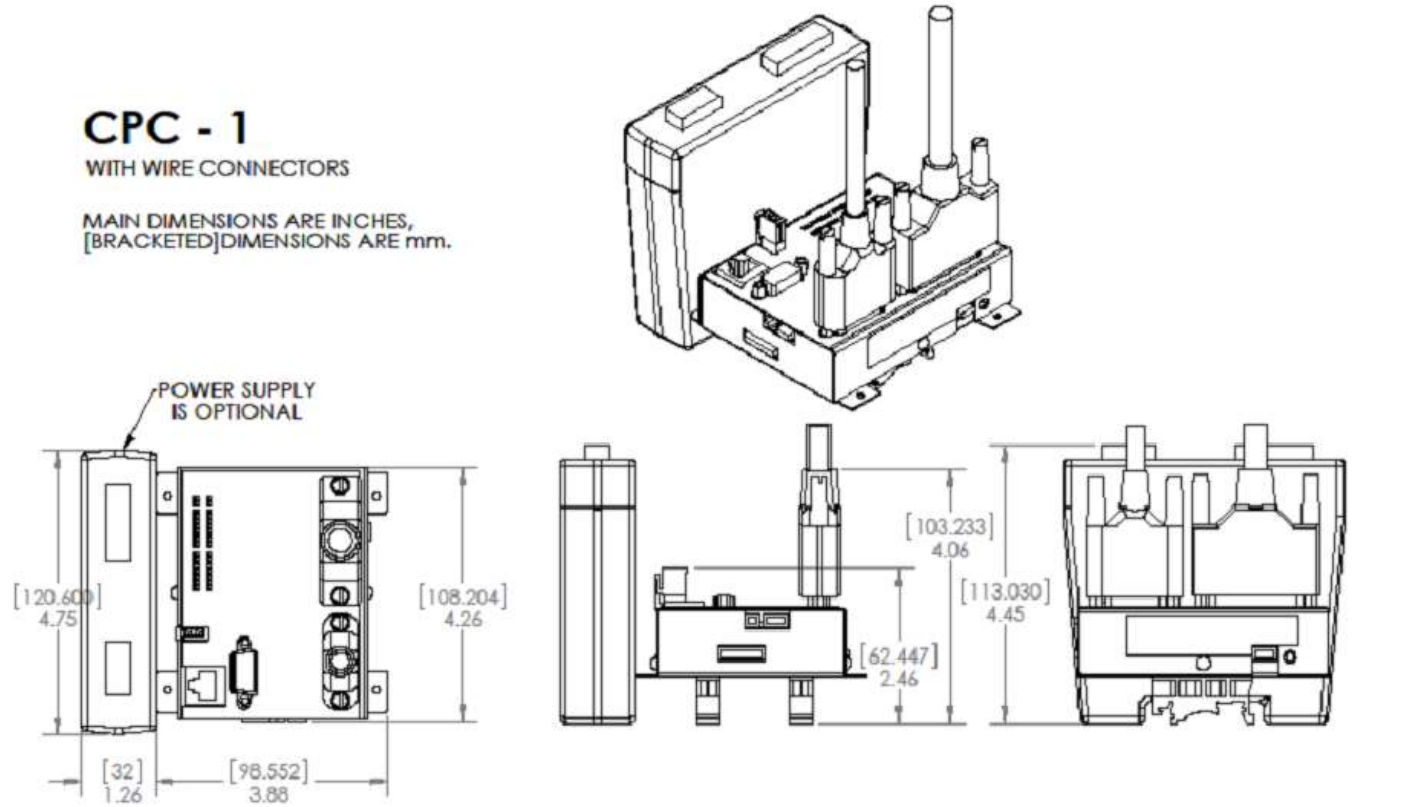


Controller Label



12 Appendix 3: Dimensional Drawings





13 Ordering Instructions

White Knight Fluid Handling

CPC-1 (Closed Loop Controller) Ordering Instructions

Required Configurations		Additional Options				Rev
CPC-1	-	Q ①	-	P ②	-	___ ③

To configure your Closed Loop Controller with different connection methods, a power supply or request a specific revision level, please select options from the appropriate additional options (1-3).

Optional Configurations

① Connection Method

W	= 26 & 44 male pin to 1-Meter Wire Lead Cable 
Q	= Quick Connect Plugs
S	= 26 & 44 male pin to Screw Terminals 

② Power Supply

P	= 24V/60W Power Supply 

③ Revision Level : Contact factory for copy exact code activation information.

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