Smart Box III

Instruction Manual

Introduction:

The Smart Box is designed to work with progressing cavity pumps. You will find this latest generation Smart Box is versatile and easy to use.

The Smart Box prevents lost production and down time by ensuring that pumps remain within proper operating limits. When combined with our Isolator Ring this system works with viscous fluids, suspended solids, abrasive, corrosive, and volatile liquids.

The Onyx Isolating Ring fits between standard pipe flanges allowing unobstructed fluid flow. No drilling, tapping, or special tools are required. Sensing pressure over the entire pipe circumference ensures that coating, settling or material bridging will not affect pressure readings.

Progressing cavity pumps handle an incredible range of viscous and abrasive fluids; however, they can be severely damaged by three factors:

1. High pressure over the design limit can burst the discharge end of the pump, stall or burn out the motor, or break the universal joints.

2. Run dry conditions interrupt the flow of liquid the pump needs to dissipate frictional heat, melting the stator.

3. Seal flush failure burns up the shaft seal causing the stuffing box to leak.

Some pumps use the process fluid to cool the stuffing box, so your pump may or may not need an external seal flush system. Refer to the pump manufacturer's instruction sheet to see if your particular pump needs an external seal water flush.

If an external flush is required but has not been provided, a complete seal water kit is available from Onyx Valve Company. This seal water kit is designed to interface with your pump and the Smart Box. Contact our factory for details.

In order to protect the pump properly, the Smart Box needs three things:

1. It has to monitor the pressure at the pump discharge.

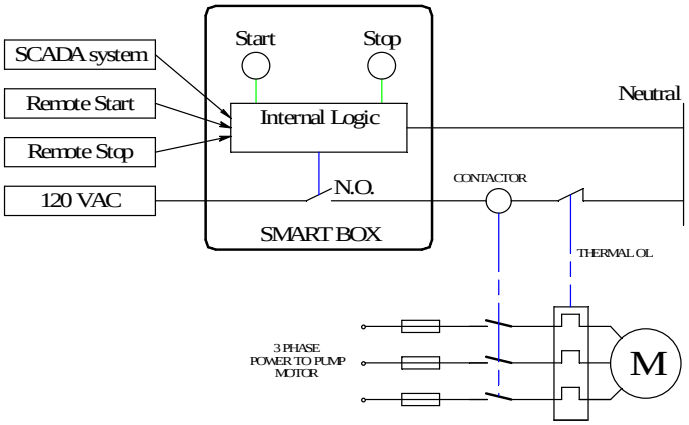
2. It has to know when the pump is running

3. It has to have the final authority to stop the pump if it detects a malfunction condition.

Operating Modes:

There are several ways to ensure that these three conditions are met. The first decision you have to make is the Operating Mode. There are three possible operating modes:

1. Master Control Mode with fixed speed pump:

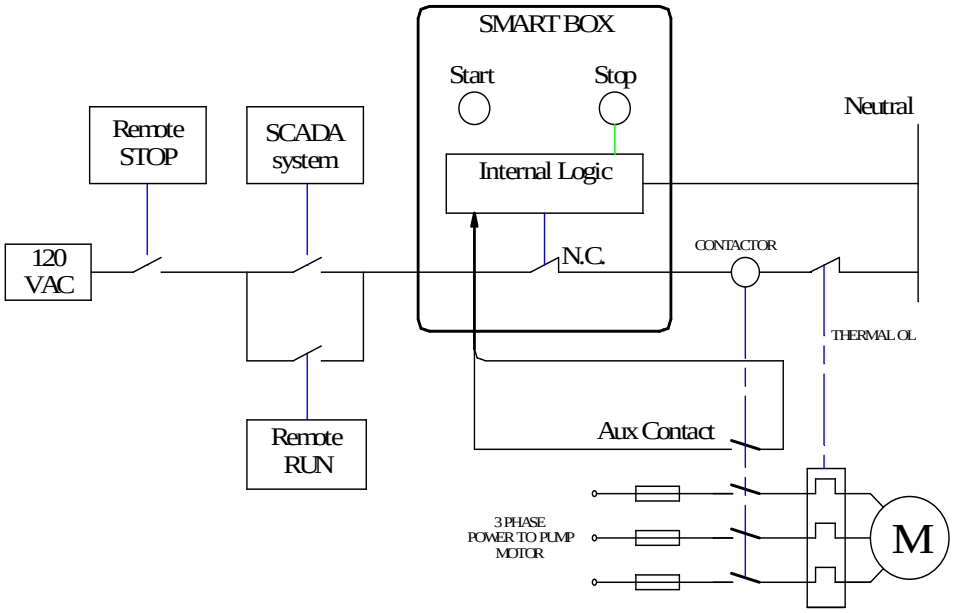


All START and STOP commands (manual and automatic) are routed *to the Smart Box*, and the Smart Box is the only device that starts and stops the pump.

If you elect to use this mode, it is imperative that there are no other devices in the system that can start the pump.

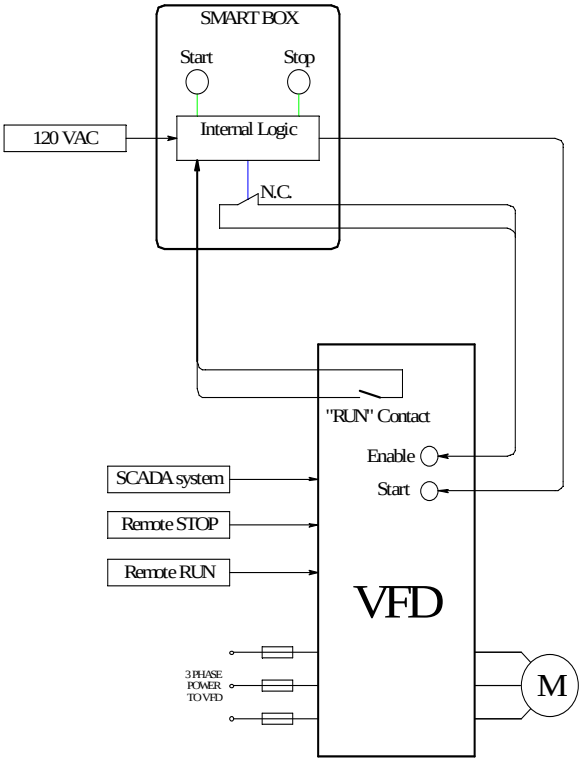
This minimizes the wiring necessary to operate the pump.

2. Slave Mode with fixed speed pump:



The pump starter can be directly energized by any number of devices throughout the plant. The Smart Box monitors pump conditions and opens a N.C. contact in the event of a malfunction.

3. Monitor mode with VFD variable speed pump.



This is the most commonly operating mode for use with a VFD (variable speed) pumping arrangement. This operating mode makes it possible to control the pump with the keypad on the face of the VFD.

In this arrangement, the Smart Box is connected to the “Enable” and “run” circuits inside the VFD.

Commands for the SCADA system or other remote control devices can interface directly with the VFD.

PRINCIPLE OF OPERATION

In order for the Smart Box to protect pumps from over pressure and run dry conditions, a 2-stage pressure switch must be installed at the pump discharge.

Set the high pressure switch to the highest safe operating pressure for the process system.

If discharge pressure exceeds the high pressure setting, the Smart Box stops the pump and displays a "High Trip" message on the front of the control box.

The pump will remain stopped until the “Reset" button (F3) is pressed. The Smart Box will not allow the pump to restart until excess discharge pressure has been relieved.

This system protects pumps against run dry damage by monitoring the discharge pressure. It is important that the low-pressure switch is properly set.

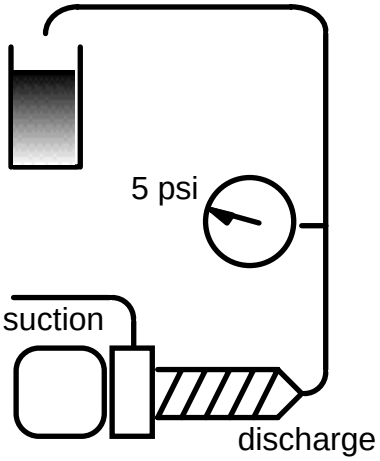
To set this switch, it is necessary to understand the differences between static pressure, friction pressure, and total pressure.

Static pressure results from the piping being filled with liquid and is present even when the pump is idle.

Static pressure is *not* influenced by pipe size, number of fittings, or viscosity. Static pressure is determined solely by fluid density and the difference in height between the pressure switch and the outlet of the pipe.

In the example in figure 1, the outlet of the discharge pipe is 12 feet higher than the gauge, so static head is 12 feet, which equals 5 psi.

Friction pressure results from the flow of liquid through a pipe and is present only when the pump is running. It depends on flow rate, size and length of pipe, number of fittings, and fluid viscosity.



Pump Off.

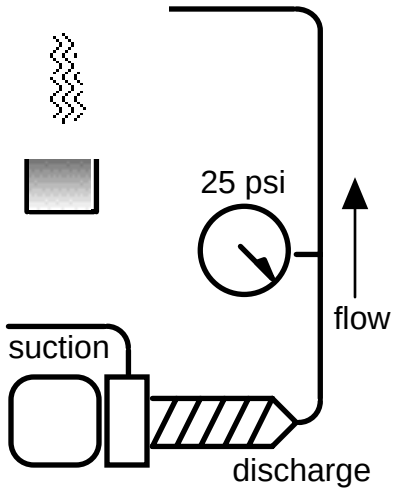
Static head is the pressure that results from the weight of the liquid in the pipe.

Total pressure is the combination of static and friction pressure. This pressure can be observed directly by reading the gauge on the pump discharge. When the pump is idle, the gauge shows static pressure. When the pump is running with flow present, the gauge shows total pressure.

In the example, total pressure is 25 psi.

For run dry protection, the low-pressure switch should be set midway between the static and total pressure.

In our example the correct setting for the low-pressure switch is 15 psi.



Pump On.

Total press = static press + friction head.

When the pump is running correctly, the low-pressure switch signals that flow is present. If the pump runs dry and flow stops, pressure falls back to the static pressure. This causes the low-pressure switch to signal that flow has stopped.

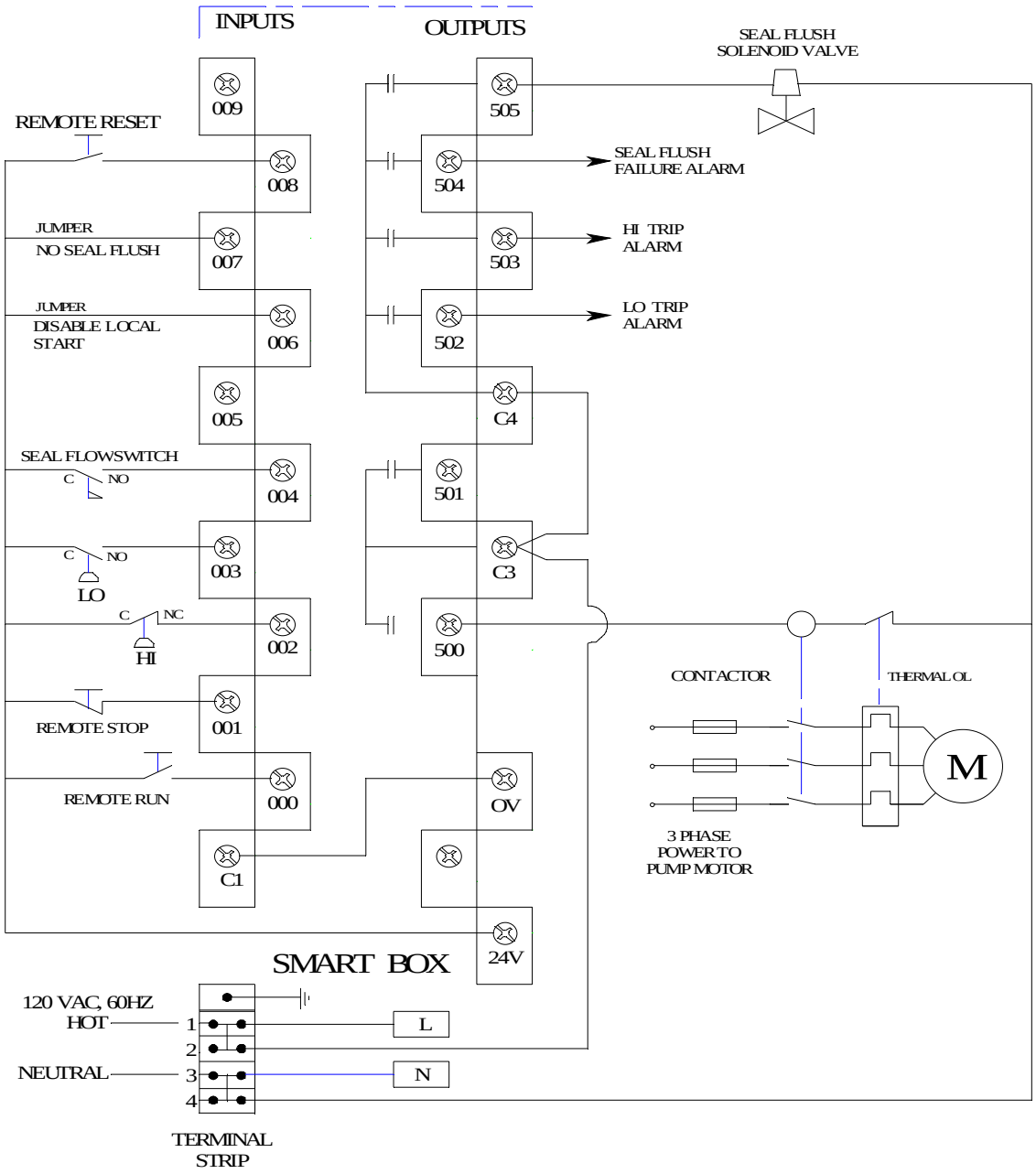
The Smart Box program allows the pump time to prime. Each time the pump starts, the Smart Box waits 90 seconds before checking for run dry conditions.

After this time-out period, if the pressure falls below the low-pressure setting (which indicates the pump is running dry) the Smart Box stops the pump and displays a "Low Trip" message. The "Low Trip" state remains until the "Reset" button (F3) is pressed.

Wiring

A qualified electrician should perform wiring. All wiring should conform to national and local electrical codes. Disconnect all electric power to this box before wiring or servicing.

1. Master Control with fixed speed pump:



Terminal	Comments (Master Mode)
TB-1	Connect 120 VAC / 60~ (hot) to #1 on the power strip.
TB-2	If you want to operate the motor starter (and optional seal flush solenoid valve) with the same 120 V that you are using to power the Smart Box, install a jumper wire between TB-2 and #C3.

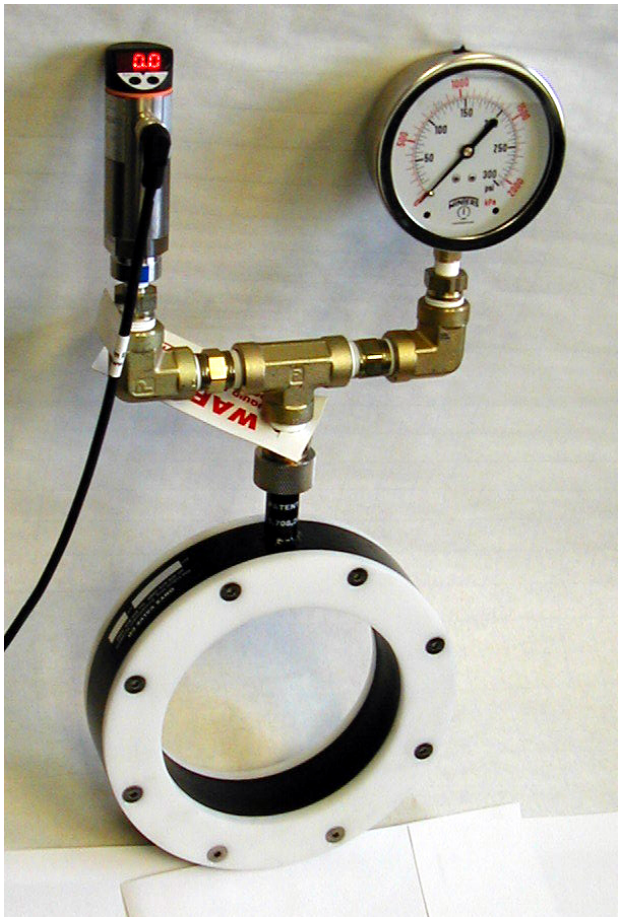
TB-3	Connect Neutral to #3 on the power strip.
TB-4	This terminal provides a neutral point for the motor starter and solenoid valve.
Inputs:	NOTE: All Input signals MUST be powered from terminal "24V" on the Smart Box PLC as shown in schematic #1 above.
000	You can connect an (optional) remote RUN switch to terminal # 000
001	You can connect an (optional) remote STOP button to terminal #001. If you do not connect a STOP button, you must install a jumper wire between "24V" and terminal #001.
002	You must connect the High Pressure Switch (N.C. contact) to terminal #002.
003	You must connect the Low Pressure Switch (N.O. contact) to terminal #003.
004	If you have a seal flush flow switch, wire it to terminal #004.
005	Not used.
006	Disable Local Start. The Smart Box includes a START button (F2) on the front panel. This START button is functional if you leave terminal #006 naked. If you install a jumper wire between 24V and #006, this will disable the START button.
007	If you do NOT have a seal flush flow switch, then you MUST install jumper wire to terminal #007.
008	If the Smart Box goes into an alarm state, it will block all attempts to restart the pump until you perform a reset. You can manually reset the alarm by pressing the Reset button (F3) on the front panel, or can do a remote reset by applying a momentary pulse to #008.
009	Not used.
Outputs:	
C3	Apply power for the pump starter to C3.
C4	Apply power for Alarm circuits and (optional) seal flush system to terminal #C4.
500	Connect to pump motor starter. This circuit closes to operate the pump.
501	Not used in this mode.
502	Run Dry Alarm signal
503	High Pressure Alarm signal
504	Seal Flush Fail Alarm signal
505	Solenoid valve connection.

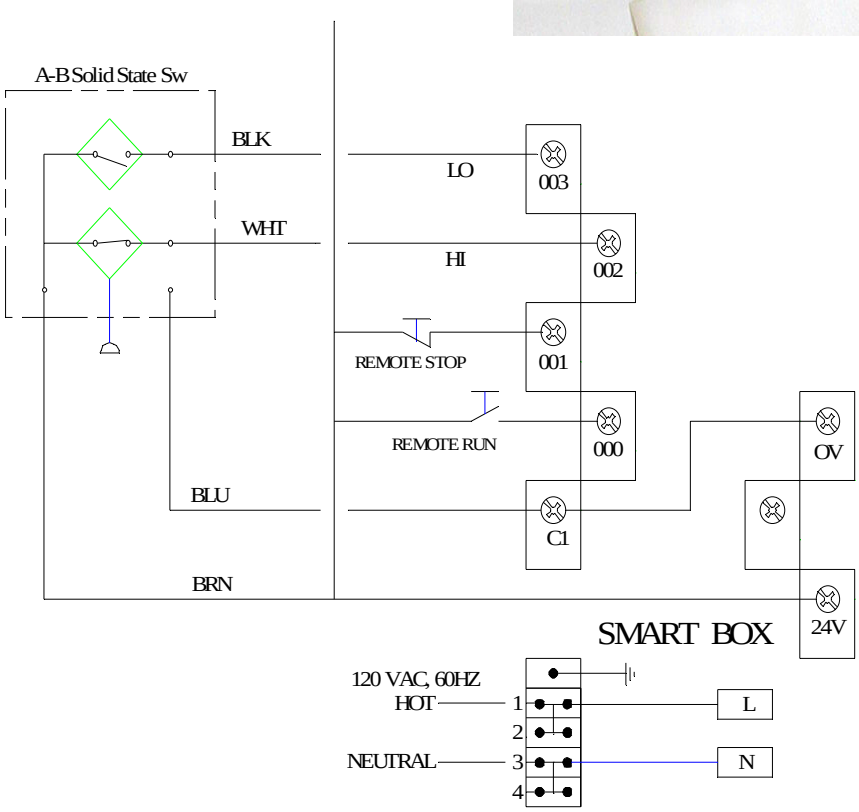
Note on Solid State Pressure Switches

The Onyx Smart Box-3 can interface directly with a Solid State Pressure Switch such as the Allen Bradley 836E series.

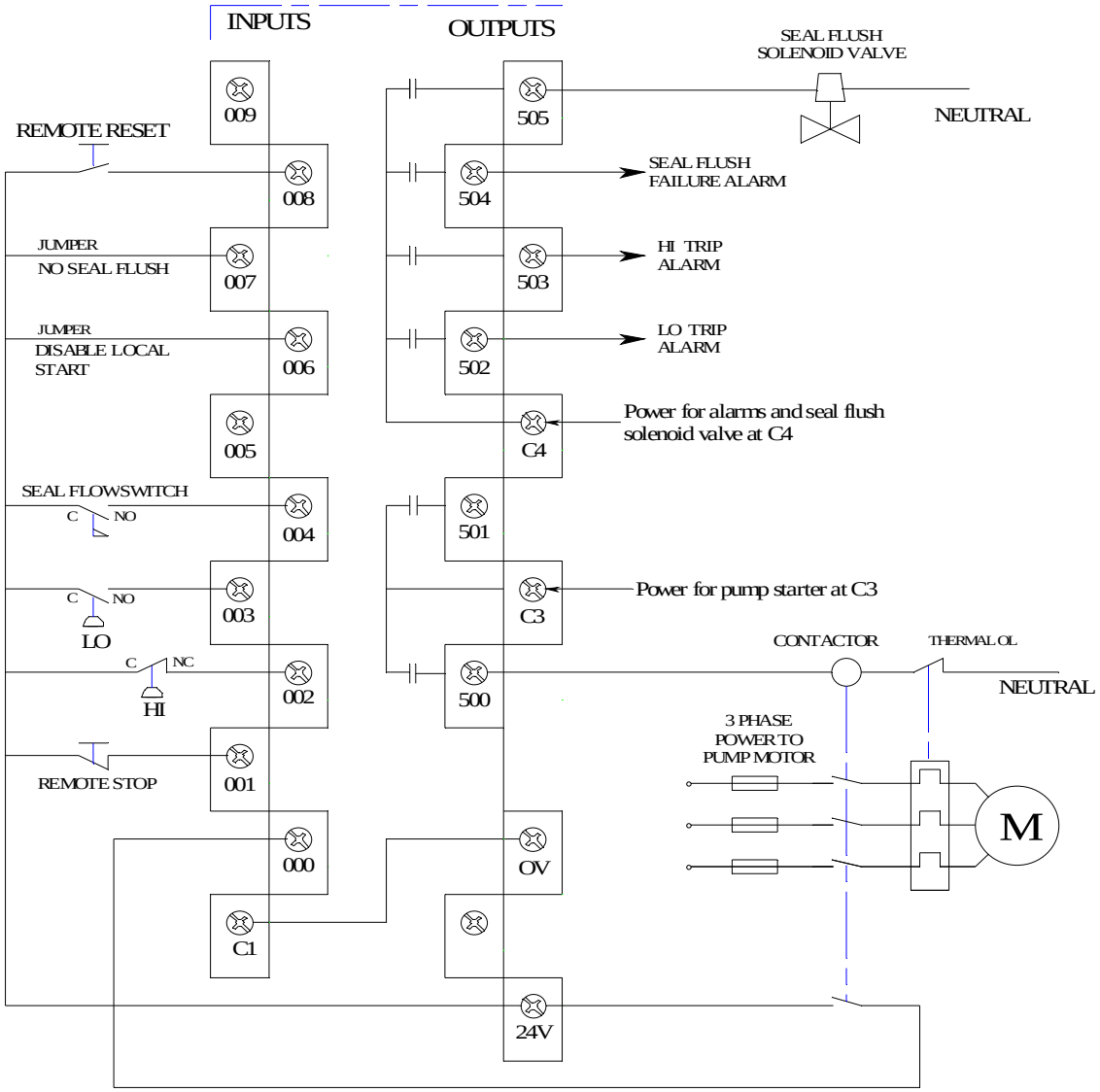
The Smart Box-3 comes standard with an internal power supply to drive the pressure switch.

The pressure switch cable has 4 wires inside each with a different color. Wire the switch into the circuit as shown in the diagram below.





2. Slave Control with fixed speed pump:



Terminal	Comments (Slave Mode)
TB-1	Connect 120 VAC / 60~ (hot) to #1 on the power strip.
TB-2	Not used in this mode.
TB-3	Connect Neutral to #3 on the power strip.

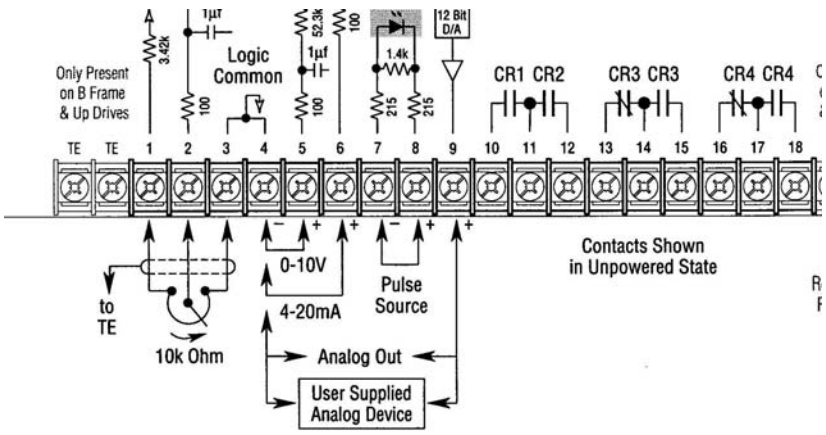
TB-4	This terminal provides a neutral point for the solenoid valve.
Inputs:	NOTE: All Input signals MUST be powered from terminal "24V" on the Smart Box PLC as shown in schematic #1 above.
000	You **MUST** connect a motor starter auxiliary "run" contact to terminal #000, and it MUST be powered by terminal 24V on the Smart Box PLC as shown. This signal tells the Smart Box when the pump is running so it can begin to monitor high pressure and run dry conditions. Failure to correctly install this circuit will result in the loss of all pump protection which could cause personal injury or serious equipment damage.
001	You can connect an (optional) remote STOP button to terminal #001. If you do not connect a STOP button, you must install a jumper wire between "24V" and terminal #001.
002	You must connect the High Pressure Switch (N.C. contact) to terminal #002.
003	You must connect the Low Pressure Switch (N.O. contact) to terminal #003.
004	If you have a seal flush flow switch, wire it to terminal #004.
005	Not used.
006	This jumper is always required when the Smart Box is being wired for "slave" mode. This mode of operation does not permit the Smart Box to start the pump.
007	If you do NOT have a seal flush flow switch, then you MUST install jumper wire to terminal #007.
008	If the Smart Box goes into an alarm state, it will block all attempts to restart the pump until you perform a reset. You can manually reset the alarm by pressing the Reset button (F3) on the front panel, or can do a remote reset by applying a momentary pulse to #008.
009	Not used.
Outputs:	
C3	The final signal wire to energize the motor starter should be wired here before landing it on the pump starter.
C4	Apply power for Alarm circuits (and optional seal flush system) to terminal #C4.
500	Not used in this mode.
501	Wire to pump motor starter. This contact remains normally closed as long as the Smart Box is powered up and there are no active alarms.
502	Run Dry Alarm signal
503	High Pressure Alarm signal
504	Seal Flush Fail Alarm signal
505	Solenoid valve connection.

3. Monitor Control with VFD variable speed pump.

The first thing you have to do prior to wiring a VFD to the Smart Box is to identify the critical interface terminals in the VFD.

By way of example, we will use the Allen Bradley model 1336 VFD.

Terminal board # TB-2 is shown at the right.



The A-B drive comes with (4) programmable relays labeled CR-1 to CR-4. The Smart Box needs one Normally Open "run" relay. You can use any available relay for this purpose so long as it is N.O. and can be programmed to energize whenever the pump motor is running. In our example we used CR-1 as the run relay, we will connect terminals #10 and #11 in the A-B drive to the Smart Box.

The second step is to identify the relevant terminals on the input side of the VFD.

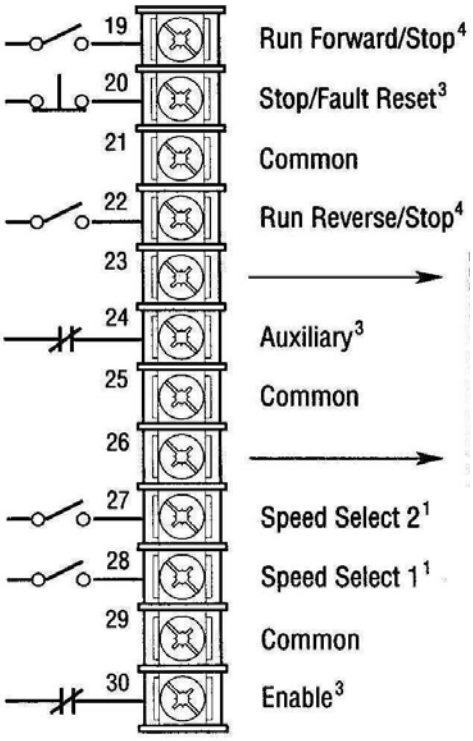
Terminal board TB-3 in the A-B drive is shown at the right.

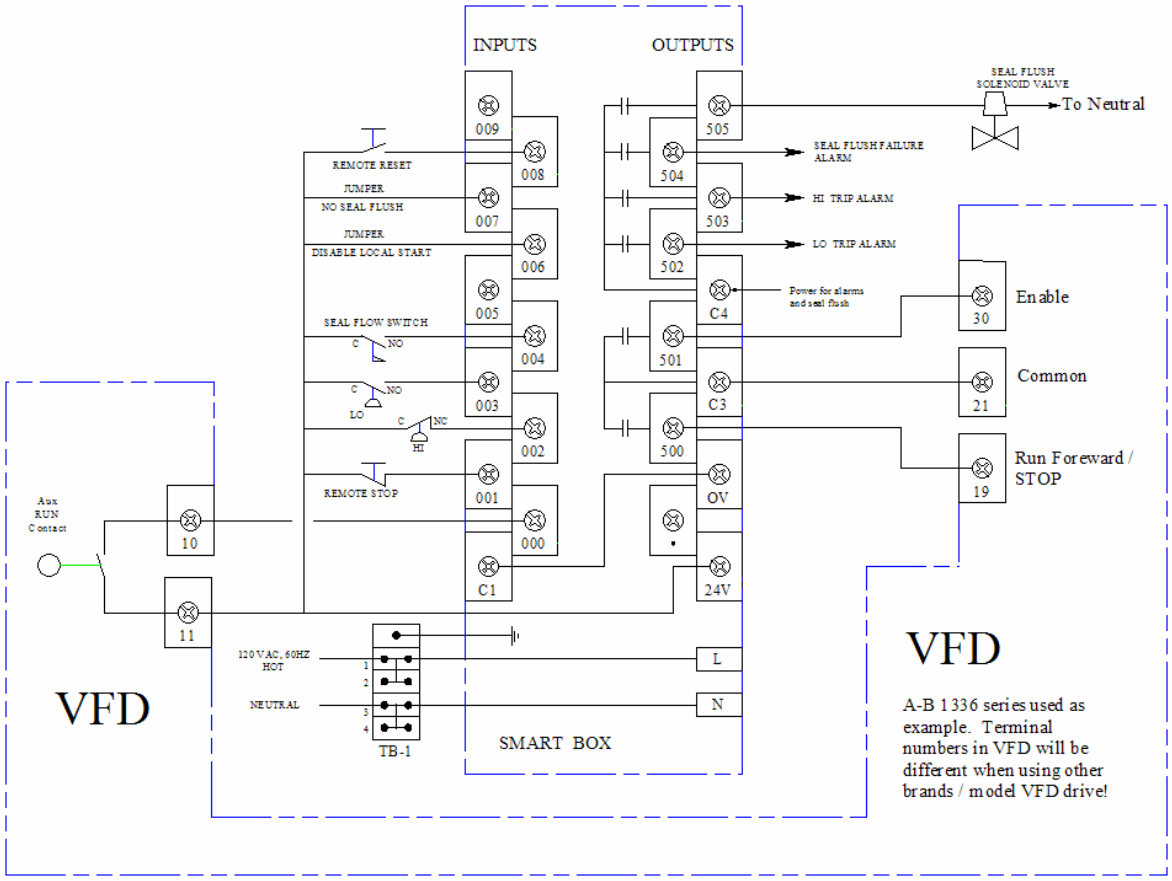
First, we need a "common", so we could use either terminal #21, 25, or 29. (We used #21 in our sample wiring diagram.)

Next, we need an "enable" terminal, which would be #30 in the example A-B drive.

Finally, we need a "Run Forward/Stop" terminal, which is #19 in our example.

Important note: Just because A-B used these numbers in their 1336 VFD does NOT imply that any other drive will have the same terminal numbering system. It is up to the system engineer to determine the corresponding terminal numbers for what ever brand and model drive they specified. If in doubt call or e-mail the Onyx factory for assistance. Don't guess at it if you are uncertain or you could wind up smoking the VFD and the Smart Box.





Terminal	Comments (VFD Mode)
TB-1	Connect 120 VAC / 60~ (hot) to #1 on the power strip.
TB-2	Not used in this mode.
TB-3	Connect Neutral to #3 on the power strip.
TB-4	This terminal provides a neutral point for the solenoid valve.
Inputs:	NOTE: All Input signals MUST be powered from terminal “24V” on the Smart Box PLC as shown in schematic #1 above.
000	You **MUST** connect a VFD auxiliary “run” contact to terminal #000, and it MUST be powered by terminal 24V on the Smart Box PLC as shown. This signal tells the Smart Box when the pump is running so it can begin to monitor high pressure and run dry conditions. Failure to correctly install this circuit will result in the loss of all pump protection which could cause personal injury or serious equipment damage.
001	You can connect an (optional) remote STOP button to terminal #001. If you do not connect a STOP button, you must install a jumper wire between “24V” and terminal #001.
002	You must connect the High Pressure Switch (N.C. contact) to terminal #002.

003	You must connect the Low Pressure Switch (N.O. contact) to terminal #003.
004	If you have a seal flush flow switch, wire it to terminal #004.
005	Not used.
006	Disable Local Start. The Smart Box includes a START button (F2) on the front panel. This START button is functional if you leave terminal #006 naked. If you install a jumper wire between 24V and #006, this will disable the Smart Box START button.
007	If you do NOT have a seal flush flow switch, then you MUST install jumper wire to terminal #007.
008	If the Smart Box goes into an alarm state, it will block all attempts to restart the pump until you perform a reset. You can manually reset the alarm by pressing the Reset button (F3) on the front panel, or can do a remote reset by applying a momentary pulse to #008.
009	Not used.
Outputs:	
C3	Connect to "common" terminal in the VFD.
C4	Apply power for Alarm circuits (and optional seal flush system) to terminal #C4.
500	Connect to "Run Forward / Stop" terminal in the VFD.
501	Wire to the VFD "Enable" terminal. This contact remains normally closed as long as the Smart Box is powered up and there are no active alarms., permitting the VFD to operate.
502	Run Dry Alarm signal
503	High Pressure Alarm signal
504	Seal Flush Fail Alarm signal
505	Solenoid valve connection.

Questions? Need help? Contact:

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