Techsys Corporation

APPLICATIONS BULLETIN

STAND ALONE VFD VS PUMP CONTROL SYSTEM

In many cases we are asked to justify the use of a separate control system in lieu of using the “INTELIGENCE” of the Variable Speed Drive.

The additional cost is always the driving force behind this question and it is for very specific reasons that we utilize a separate control system.

BASICS

Variable speed drives are the component that is used to alter the speed of a motor and as such are designed to operate over the full range of possibilities in their applications. The VFD of today has in-built controls such as PID Sleep Mode, Programmable Displays and many other features that allow the VFD to be applied with greater ease than before.

The very fact that the VFD is a component and not a solution is the reason for not using them in specific pumping applications.

PUMP CONTROL REQUIREMENTS

In order to control a pump with Variable Speed it is necessary to have two control points:

- REFERENCE POINT
- FEEDBACK INFORMATION

These two pieces of information are the basics for the control of the speed of the pump.

If the Reference Point is Lower than the Feedback the pump slows down.
If the Reference Point is Higher than the Feedback the pump speeds up.

This concept is very simple however the operation of a pump is extremely complex, as the medium that is affected by the pump is incompressible.

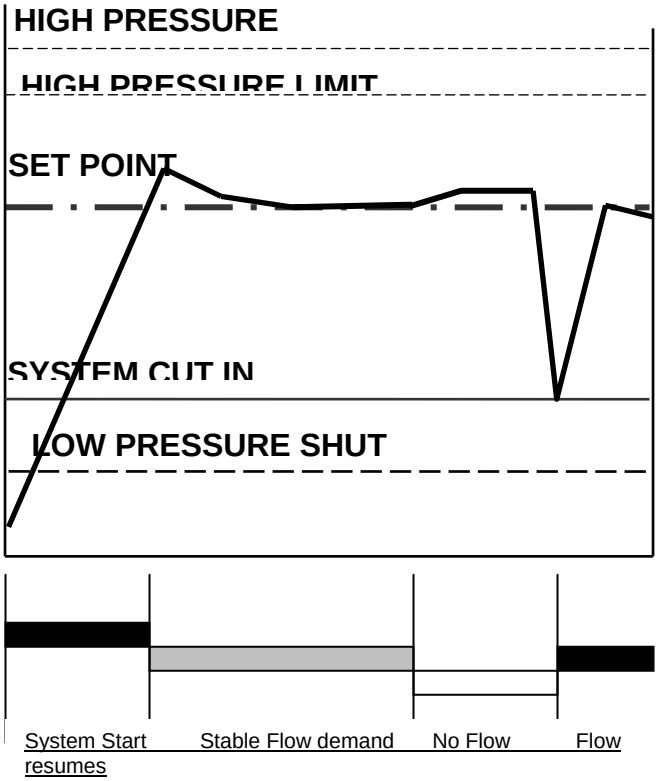
This means that and slight change to the pump speed will reflect in an ***instant variation to the pressure feedback.***

It is due to this fact that the VFD cannot operate as a stand-alone control and the extra requirements can only be satisfied by a separate controller.

REQUIRED PUMP CONTROL REATURES

Hydraulic Protection

Any pumping system is designed to provide pressurized liquid to a process. If the process exceeds the ability for the pump to supply then the pump will break down.
The most basic of hydraulic control allows the system to remain within the capacity of the pump to perform correctly and efficiently.



The basic hydraulic requirements of any VFD Control system requires the ability to protect the pump from damage when used outside its suitable range of operation.

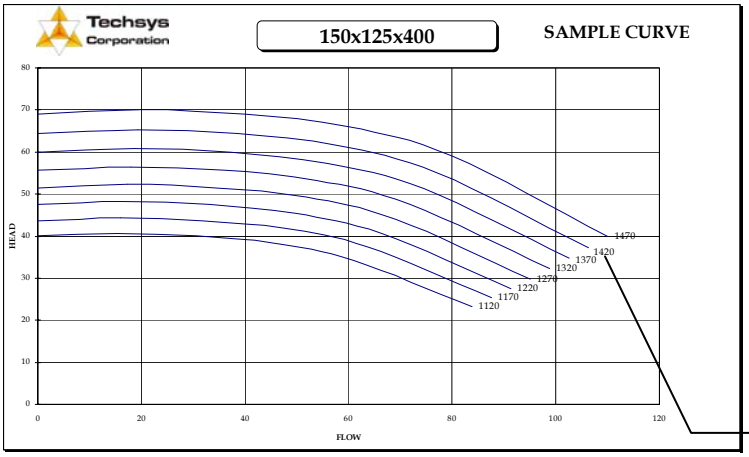
The Hydraulic protection for this is:

High Pressure Shutdown and Limit
Low Presure Shutdown

High Pressure Shutdown is designed to protect the reticulation that the pump is operating within. Eg: a Class 12 pipe can only sustain pressures of 1200kPa for a short period. If the pump is locked on to operate over this pressure without protection then the pipeline will burst.

There are two protection requirements for this operation; they are “SHUTDOWN” and “LIMIT”. Shutdown will turn off all pumps after a delay period and the Limit will force the pump speed down to compensate for the overpressure.

The “Limit” control is achieved by changing the reference point to an artificial low point until the system stabilizes. This function is critical due to the fact that most liquids will create significant pressure waves in pipeline system and the ability to stop resonance and massive “Water Hammer” must come from removing the cause of the pressure increase.

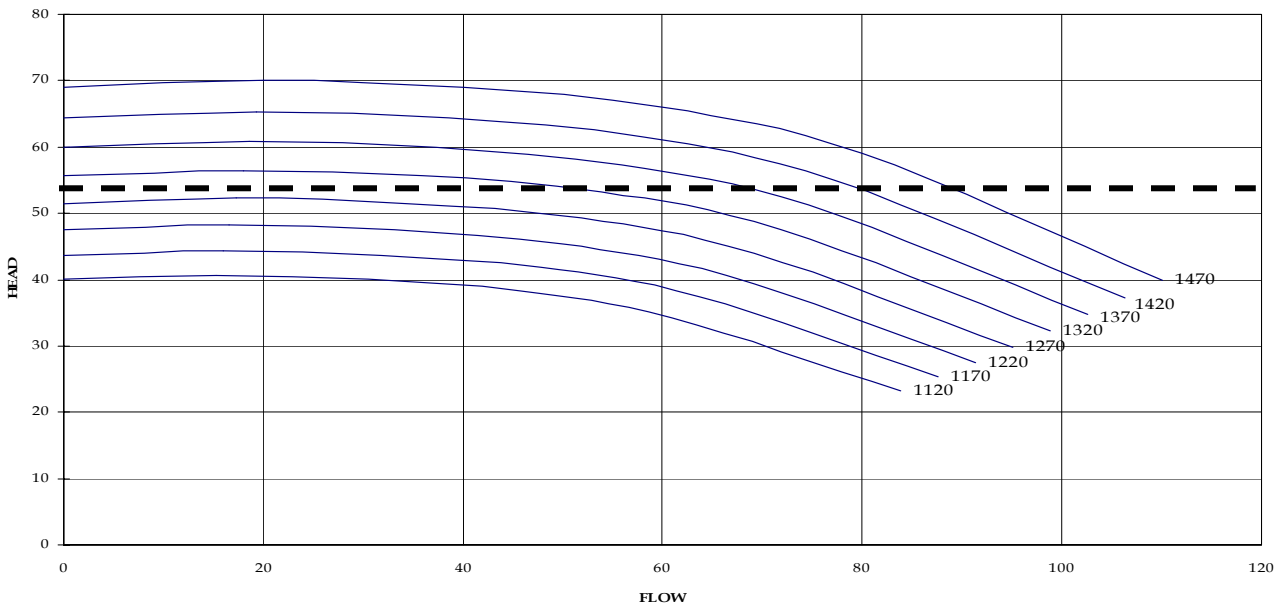


Low Pressure Shutdown is designed to protect the pump from operating past its end of curve point. When pump operate at pressure lower than their rate capacity they will CAVITATE and fail very rapidly.

End Of Curve

Minimum Frequency

A pump operating with a VFD will operate from approximately zero flow rate to the pumps capacity at a given “SET POINT PRESSURE”.



If the system requirement drops to **zero flow** the pump will continue to rotate and attempt to maintain the SET POINT PRESSURE. The speed that the zero flow occurs is known as the **minimum speed** of the pump at the specific Set Point.

This speed is defined by the following formula:

$F_{min} = 50 \times \sqrt{} H_{sp} / H_{so}$

F_{min} - Minimum Frequency in Hz
H_{sp} = Set point pressure
H_{so} = Shut off pressure

If the system set point is changed the minimum frequency also changes. This requires an input into the stand-alone VFD systems to adjust the “Minimum Frequency”

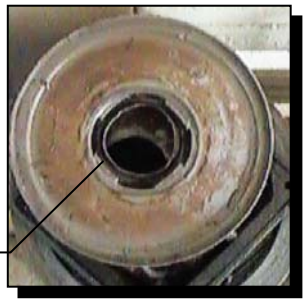
The pump control system needs to be able to define this speed and shut down the system in when a no flow condition occurs. All Techsys Corporation controllers determine the minimum frequency via the use of at least three checks:

1. Flow rate
2. VFD Speed
3. System requirement check – (Boost Pressure and check demand)

VFD system can only operate on the frequency that can be read from the VFD. This is NOT AN ACCURATE way of determining the pump minimum frequency and will cause pump failure due to operating at a low frequency for extended periods.

Most pump failures with VFD systems are cause by the pump running with no flow passing through. The typical failure modes are:

- Seal Failure
- Bearing failure due to over temperature
- Cavitation due to operation at the first 10% of flow on the curve

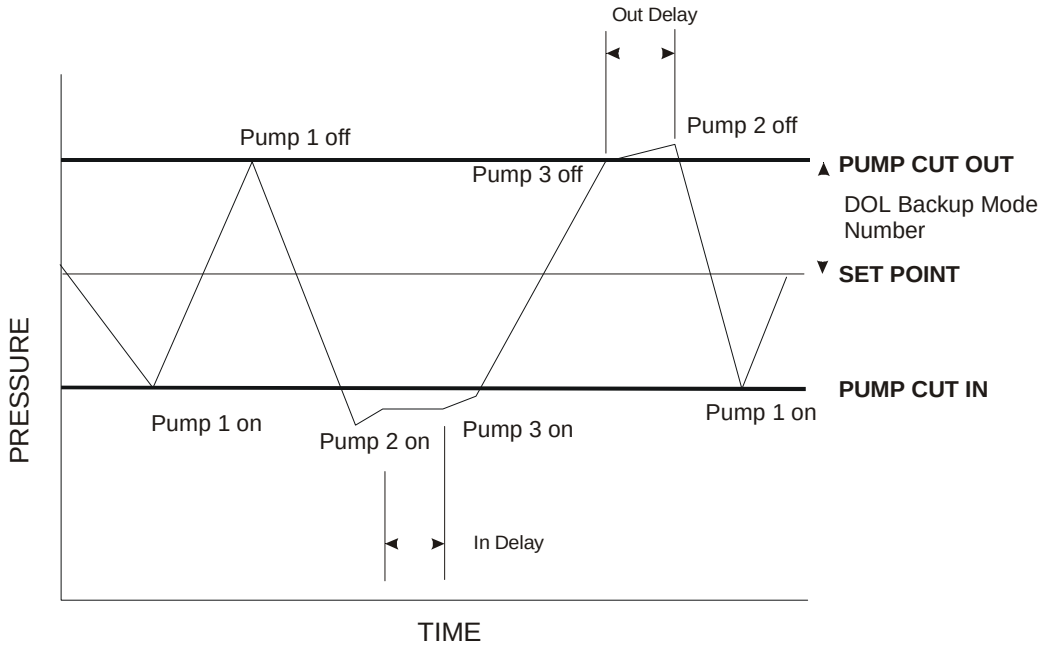


Bearing Failure of a Grundfos CR64-70 due to over temperature

VFD Failure Modes

If the Variable Speed Drive malfunctions the system needs to be able to either reset the VFD or operate the pump without the VFD.
Most pump control systems have the ability to operate the system in case of VFD failure via either Manual Operation or Pressure Control.

The MPCSV has a VFD failure Mode that allows the system to operate as a stand-alone fixed speed pressure controller in the event of a VFD failure.



This feature is designed to maintain pumping capacity when a failed VFD is not recoverable.

This is not available with any stand-alone VFD system.

Cavitation Protection

Pumps cannot operate outside of their “CURVE”. If you run a pump with either too much or too little flow, in time it will fail.

All pump control systems should have a CAVITATION protection system. Some VFD manufacturers say that detection of current from the pump motor is sufficient but this is definitely not the case as the cavitation current in most cases is the same or greater that the operating current. The only suitable way of protecting pumps from cavitation is to maintain them within the pump capability curve.

Low Pressure detection is the only suitable method.

Shut Down

The ability to detect the NO FLOW situation and to stop the system whilst there is no demand is essential. All Techsys Corporation controllers use hydraulic test and detection methods to ascertain if the pump system is required to operate.

Most stand-alone VFD systems only use a a “MINIMUM FREQUENCY” setting to determination if the system is required to operate. This is not suitable and will cause failure of the pumps.

End suction pumps will aerate the volute in cases of no flow, causing the minimum frequency to rise over time. This time is as short as 5 seconds, so the detection of a minimum frequency cannot truly determine a No-flow situation.

All Techsys Corporation controllers detect the minimum frequency on shut down and recalculate this every time. This accounts for the wear in the pump or changing suction conditions.
Couple this with the hydraulic testing that confirms a NO FLOW scenario and the ability of the Techsys Corporation controller to shut down is 100% foolproof.

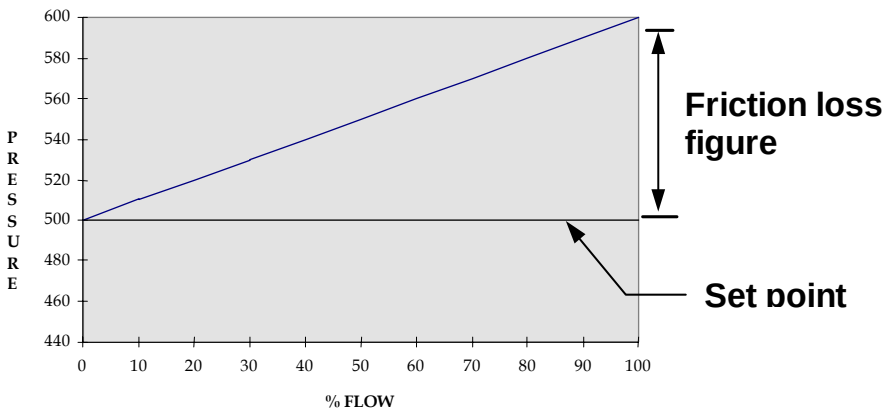
Set Point Change

The ability to easily change the set point of operation is generally required to adapt the system to changing hydraulic conditions.
All Techsys Corporation controllers are able do this.

VFD stand-alone systems will not allow this, as the system needs to have inputs for the new minimum frequency every time the Set Point is changed.

Friction Loss Compensation

When long pipelines or convoluted reticulations are required to maintain a set point pressure, there is the need to change the Set Point to match the flow rate as it increases. The Friction Loss calculation does this and compensates for added hydraulic losses in the system.



Interface

Most stand-alone VFD systems are designed to allow the operator to see the full range of menus available. These generally confuse the average person who is only interested in seeing the items relevant to the operation of the “PUMP SYSTEM”. They are not interested in the flux boost % or the slip compensation factors.
Through user surveys we have determined that the majority of users only want to see:
Operational Parameters such as Flow Rate, Pressure and Set Point
Fault Conditions if active

To expect a pump operator to be able to transit the range of menu options available in a modern VFD is impossible and not constructive.

All Techsys Corporation controllers have a two-section approach:

- PUMP SYSTEM DISPLAY
- HIGHER LEVEL ACCESS VIA PASSWORD

This makes the operation of the pump system very simple.

Flow Rate and Totaliser

One of the major factors associated with pumps is the Flow rate of the pump itself. The Techsys Corporation controller displays the flow rate on the display screen for the operator to view. This tells him that the system is either fully operational or not.
All flow rates are totaled as well, which allows for detailed reporting and logging of operations. These flow rates are determined by the Techsys Corporation flow log system that uses hydraulic input to calculate the full system flow over the full range of operating speeds. This has proved to be accurate $\pm$ 5% from site comparison.

The flow rate is varied as the pump health changes so the operator can see when the system needs attention.

Hour Run Meter

Each pump has an in build Hour Run meter that operates only when the pump is called to function. This meter is relevant to the pump not the VFD operation. Stand-alone VFD systems cannot determine which pump is running for the purpose of run hours.

Sensor Calibration

The Techsys Corporation control system recognizes that most operators are not conversant with the high science of sensor analogue inputs. It is for this reason that the sensor calibration routine is designed to operate with any type of sensor.

All that is required is for the operator to zero and adjust the pressure to a gauge reading and the system is tuned. This will work for sensor with:

- 0-10VDC
- 4-20mA
- 0-20mA
- 0-5VDC
- 0-250mV

The stand-alone VFD system requires detailed information about the sensor input. Then the operator needs to go to the relevant analogue input data screen and adjust the Zero offset figure and the span figure against no known information. Once this is done it needs to be checked and the redone many tines before the sensor reading can be confirmed to be accurate.

There is no DIRECT FEEDBACK FROM THE SYSTEM to tune the sensor input.

Individual pump Protection

In order to make a system reliable plus fully protected the pumps within that system must he fully protected from damage. A fully dedicated input is required to protect the pump from hydraulic situations such as:

Loss of Prime
Over temperature of the bowl
Thermostat sensor
Loss of flow

A Stand-alone VFD system cannot do this.

Inputs – Outputs

To fully control a pumping system there is the requirement to control a number of hydraulic and motor related functions.
Most VFD's have 6 digital inputs and 2-3 digital outputs.
In order to operate the system virtually all of these inputs and outputs are taken up and do not allow for the extra inputs and outputs required for full protection and control from the hydraulic sensors.

Techsys Corporation controllers have:

12 Inputs with 8 being programmable and 4 fixed function
14 outputs, 4 with change over contacts and programmable to one of thirteen options.

A Stand-alone VFD’s do not have sufficient I/O capacity to fully protect the pump system.

SUMMARY

Function	Techsys Corporation controller	Stand-alone VFD
Hydraulic Protection	Yes	No
Low Pressure Shutdown	Yes	Sometimes
High Pressure Limit	Yes – reticulation protection guaranteed	No
High Pressure Shutdown	Yes	Sometimes
Hydraulic fault retries	Yes – will restart after a hydraulic fault condition is programmed	No
Variable System restart Pressure	Yes	No
Adaptive Minimum Frequency	Yes	No-fixed at commissioning for one set point
Cavitation Protection	Yes – Pump protection guaranteed	No
Flow rate calculation	Yes	No
Totaled Flow	Yes	No
Friction loss compensation	Yes	No
No Flow detection	Yes	No
Individual pump protection	Yes	Partial
Cavitation protection	Yes	No
VFD failure backup	Yes	No
Shut down capacity	Yes	No
Set Point change	Yes	Not readily- usually requires operator calculation
Operator friendly interface	Yes	Not pump display designed
Hour run meter per pump	Yes	No
Sensor calibration to know pressure	Yes	No
Inputs	12 inputs – 8 programmable 4 fixed function	6 Inputs
Outputs	10 – 4 Changeover programmable	3 – None available for external use

GENERAL

In the early days of developing VFD pumping systems we considered to option of using a Stand Alone VFD with the smarts built in. We found that the main problems were:

- Operator interface was confusing (Generally 150+ menu items)
- No ability to detect hydraulic feedback
- No possibility of backup in case of VFD failure
- Insufficient I/O to fully operate the pump system
- No ability to detect hydraulic conditions such as no flow and cavitation

It is for these reasons that we manufacture dedicated pump control systems.

FEEDBACK FROM THE ROCKWELL SITE FROM END USERS

http://www.ab.com/support/abdrives/UBB/cgi/forumdisplay.cgi?action=topics&forum=Ac+Drives&number=1&DaysPrune=1000&LastLogin=

SENSOR SCALING

Andy Sherrill
Associate Member
Posts: 1
From:Batesville, AR USA
Registered: Mar 2001

We are having problems with the "HI" and "LO" scaling parameters on analog outputs. As I understand it, these parameters should be set similarly to "zeroing" and "spanning" an old transmitter. This means setting the drive at the minimum of the particular parameter, then adjusting the LO, then setting the drive at the maximum and setting the HI, then back and forth until the outputs are accurate. We use an output for current most of the time and don't have a way of taking the drive to the maximum current level in order to adjust the HI parameter. Do you have any suggestions?

PTTOP
Associate Member
Posts: 1
From:Jakarta, Indonesia
Registered: Apr 2001

I've got a problem to scaling analog output LO. Since the default analog output 0 - 20ma, what should I do to change to 4 - 20ma ?
I've already tried to set analog out LO-20%.