

# VARIABLE FREQUENCY DRIVES AND THE USE OF BYPASSES

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## ABSTRACT

Practice in some vfd applications has been to specify and install a bypass that allows the motor to operate on line power in the event of a failure of the vfd. This bulletin will explore the history of the bypass solution, as well as the pros and cons of the practice of installing a bypass.

## BYPASS DETAILS

A bypass can be supplied in different forms; 2-contactor, 3-contactor and a wide range of input devices and control relay logic. See FIGURE 1, for a simplified single line power diagram of the two different types of bypasses. In each case the purpose of the bypass is to operate the motor via a motor starter in case of a vfd failure. In the case of a 3-contactor bypass the vfd can also be isolated so that the vfd can be serviced while the motor is running in bypass mode. The motor starter, or bypass, includes a contactor, overload and some type of power supply, usually a control transformer, that powers the bypass operation and relay logic.

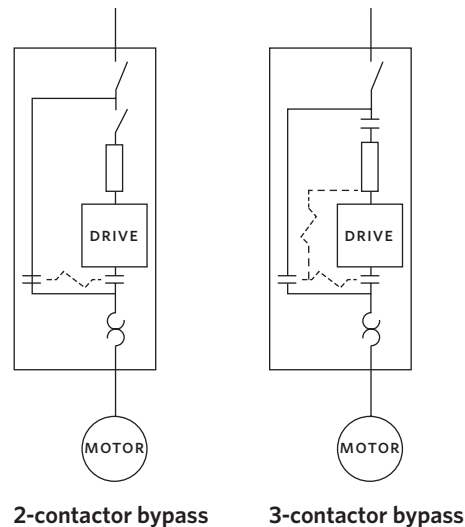
## HISTORY OF BYPASS

Bypass packages came into being during the first generations of vfd development during the 1970's and early 1980's. Though customers could be shown the energy savings potential that

vfd's could supply, high vfd failure rates limited their practical installation. To combat the risk associated with higher failure rates vfd manufactures began offering bypass packages as part of their solution. During this period a bypass was considered a relatively inexpensive method to ensure motor operation if the vfd failed.

Through the years vfd's, like other electronic devices, have become much more reliable, smaller and economical. In Europe today the use of bypasses in the commercial industry is virtually unheard of.

**FIGURE 1.**



## PROS AND CONS OF A BYPASS INSTALLATION

PROS	CONS
Allows the motor to operate on line power if a vfd fails.	Modern vfd's are much more reliable than in the past. In the 1980's vfd failure rates were over 100%! Today rates are in the neighborhood of 0.25%. In many cases it has been found that bypass components fail at a higher rate than vfd's.
Bypass packages allow extra space to provide main or motor short circuit protection, motor disconnect means and other installation options.	vfd's operate over a wider voltage range than motor starter.
Critical applications design in redundancy. Bypass packages add another layer of redundancy.	Redundancy needs must be carefully considered. Many hvac application include a redundant pump such as 2 - 100%, 3 - 50%, 4 - 33%, etc. pumping systems. These systems have redundancy built in. By adding a bypass to each of these pumps the costs are increased substantially. Additional complete pumps for redundancy can be added economically with the use of either twin or dualArm pump configurations.

PROS	CONS
	The integration of two methods of operating the motor complicates control logic.
	VFDs have software protection against voltage issues that motor starters do not possess.
	Many VFD manufacturers offer a solution for short circuit protection and motor disconnect without the need of a bypass.
	Motors started in bypass mode require up to 6 times the starting current resulting in increased power demand charges and high stresses on motor windings and bearing. High starting current is the major cause of broken rotor bars. NEMA standard MG1 limits starts to 1 per hour from hot and 2 per hour from cold. This limitation is not an issue with VFD starting.
	Bypass packages will add substantially to the cost, extending the payback.
	Bypass packages increase the VFD solutions RFI because of the added exposed wiring and higher number of connections.
	Bypass packages increase the size of the solution and decrease the possible mounting locations. A bypass package makes it impractical to integrate the controls within the pumping unit and the benefits of such are lost.
	Pumping systems that are optimized for variable loads cannot operate at full speed continuously. To accommodate the bypass the system must operate in a sub optimized mode for the life of the product. Optimizations which can be compromised include: <ul style="list-style-type: none"> <li>▪ Efficiency and capacity optimization by the use electronic load limiting</li> <li>▪ Utilization of speeds between induction and synchronous (ie 57 vs 60 Hz) or even higher than synchronous (ie 63 Hz) as allowed by applicable motor standard such as NEMA.</li> </ul>
	When an operator changes a VFD to bypass there is the risk that the system will not be returned to VFD mode and the tremendous energy savings is not realized.

**SUMMARY**

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It is understandable how the custom of installing bypasses developed when VFDs had failure rates exceeding 100% in the 1980's. Today, VFDs have reliability rates similar to motors and pumps. In addition, with advancements in control technology and VFD capabilities, there are more disadvantages

when bypasses are used today. Higher energy costs and higher first cost (in some cases) are examples of these disadvantages.

Armstrong does not recommend the use of bypasses with Armstrong VFDs and Design Envelope IVS pumping units.