DON'T DROP THE BALL

By Daniel Pascoe, General Manager, Vacuforce Inc.

This article is intended to offer the user a better understanding of vacuum handling systems and therefore is based on vacuum lifting as its general reference. As with any engineering installation, professional consultation should be sought to ensure a correct selection of components.

In the majority of vacuum handling or lifting applications, vacuum venturi are utilized (compressed air-powered venturi systems) to provide a simple and initial cost-effective lifting solution. Of course this is perfectly fine as long as certain criteria are met. This could be ongoing cost of ownership, maintenance requirements, and more importantly, the safety of the system. This article concentrates on basic safety tips of vacuum handling, as well as highlighting products and methods that can be employed to minimize vacuum system failure.

Using vacuum to handle products such as paper sheets, small packages, and small food products is straightforward enough. However, vacuum is often used in the pick-up and transfer of heavy products such as marble slabs, sheet metal for automotive manufacturing, concrete formed products, wooden door panels, and other large items. These types of applications require a safety consideration. The worst thing that could happen when lifting something heavy is to drop it. Obvious enough, but rarely is this event accommodated for in vacuum lifting systems.

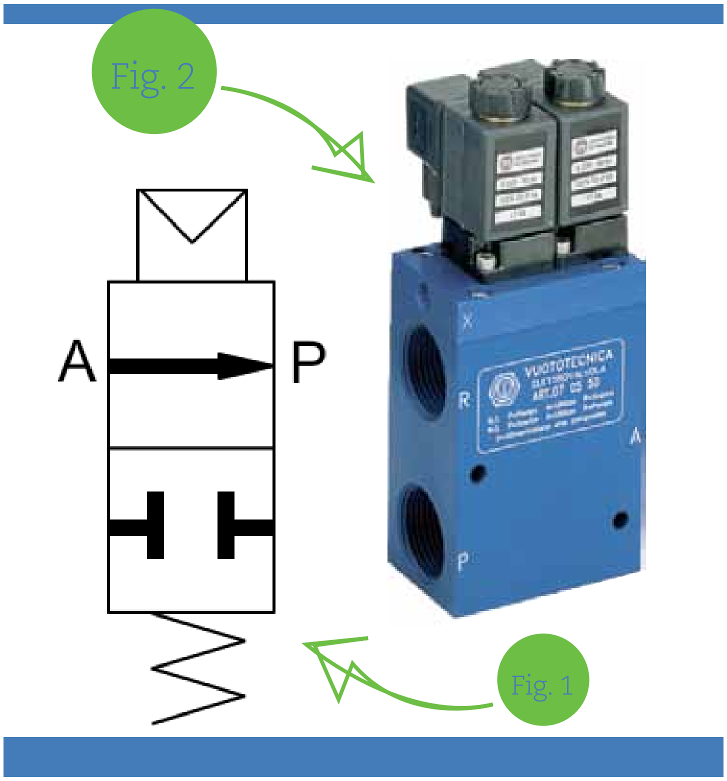
Consider an application that involves gripping a 1,000-lb marble slab and then maneuvering this enormous load across a walkway with an overhead crane (which of course is not recommended). As the designer of the vacuum lifting system, would you be prepared to stand underneath it? The design engineer would certainly have to be confident in the vacuum circuit if he was prepared to do so. If the system consisted of a bunch of vacuum generators attached directly to individual vacuum cups, this would probably not be the case. If this was the design, the following unscheduled events could result in vacuum lift failure:

- Loss of compressed air pressure
- Loss of electrical control to pneumatic control valves for the venturi
- Loss of vacuum cup seal due to cup condition
- Blocked filtration, and
- Emergency stop condition ("E stop").

The best vacuum lifting system is designed to allow for every possible mechanical and electrical failure. Of course, human error or incompetence offers the designer the real challenge, but even that can be accommodated for to a certain degree.

Most vacuum lifting systems utilize a compressed air-powered vacuum generator. This is because most fluid power or pneumatic manufacturers and distributors offer this technology instead of a motor-powered vacuum pump as they are small, cheap, and easy to sell alongside pneumatic product lines. It is very easy to design a system utilizing vacuum venturi as they are compact, simple to operate, and readily available. The vacuum venturi requires compressed air to generate a vacuum. If the compressed air fails, the vacuum generation stops. However, there are vacuum venturi available from many manufacturers that offer certain fail-safe features in case of emergency stop conditions or power failure, but these units are limited in respect to their application suitability. They also are generally inefficient in respect to compressed air consumption versus vacuum flow. Furthermore, for larger vacuum applications, multiple units are required as the maximum vacuum flow offered by these units is limited.

The easiest way to allow for compressed air failure is to install a large compressed air reservoir or vessel at the actual machine. Therefore, if the plant air fails, the machine, depending on the size of the compressed air reservoir, can maintain a compressed air supply to a vacuum venturi for a number of seconds or minutes before vacuum fail-



ure. Of course, this is not ideal, as the reservoir in some cases will have to be enormous if the compressed air demand of the generators is large. However, during this air supply failure, a pressure switch can sense that the air supply pressure is falling and indicate to the user via an audible or visual alarm that the vacuum system is about to fail. What the user should do during this period is ensure that personnel are clear of the working area and take the necessary action to save the product from damage.

An alternative to this method is to utilize a "vacuum lock" device supplied by various manufacturers. If the compressed air fails, this device, which is placed near or directly on the vacuum cup connection, seals the vacuum between the vacuum cup face and the vacuum lock device upon compressed air failure. This unit employs a small vacuum reservoir, which holds the product in case of compressed air failure. However, this device can only be used on non-porous product where the vacuum will not decay. Furthermore, if the vacuum cup is not in perfect condition, the vacuum level will fall and eventually (and this could be seconds, not minutes) drop the part.

An alternative to the vacuum lock device would be to use a normally closed pilot-actuated vacuum valve in the vacuum line. The generator creates vacuum, and the valve is placed between the generator and the cup. If compressed air fails, the pilot pressure to the valve stops and the valve closes, maintaining vacuum between the valve and the cup. This is the same operating principle as the vacuum lock device, of course, but the valve can be installed far away from the vacuum cup so that the amount of "vacuum reserve" in the connecting hose between the valve and the cup acts as a reservoir and offers a considerably longer decay time compared to the self-contained vacuum lock device. The vacuum lock feature is utilized in the multifunction vacuum generators and for this reason, these generators have the same potential flaw. Of course, if the vacuum cup is in perfect condition and the product is not porous, such as steel sheet, then this method is satisfactory. However, this article and its recommendations are based on the "real" world where not everything is perfect. Fig 1 demonstrates this basic schematic where the vacuum source (venturi) is connected to Port P and the application (cups) is connected to Port A.

Normally the control valves for the vacuum generator are solenoid-powered (electrical actuation) with a spring return. This type of valve will close, shutting off the compressed air feed to the venturi when electrical power is lost. If during this power loss, the vacuum generators and cups were gripping the load, the cups would release and the load would fall. To prevent this, a normally closed control valve could be used such as in Fig 1 (but with a solenoid actuator), which would close, sealing the vacuum between the cups and the valve during electrical failure. During normal operation, this valve would be energized continuously to remain open to the vacuum source.

Up to now, we have discussed a compressed air-powered venturi. When an electrical vacuum pump is used, there are instances where the pump could break down, and vacuum is lost to the application. In this case, a vacuum switch could detect this vacuum loss or a circuit in the controller could detect that the pump is not running. The controller could de-energize the normally closed vacuum control valve and seal the vacuum between the cups and the valve.

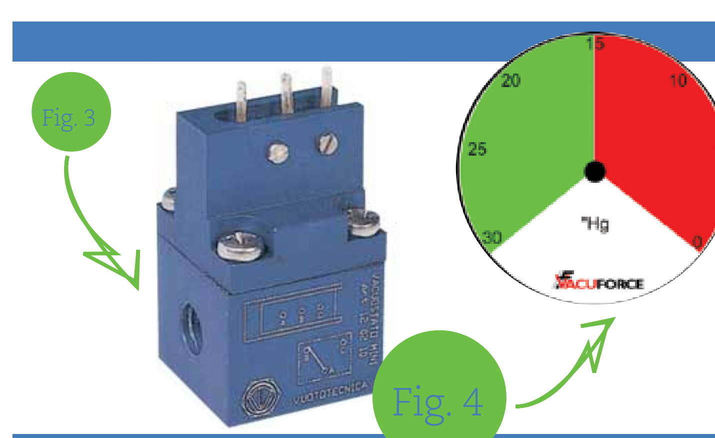
A good solution for any heavy lifting application is to control the vacuum to the application with a bi-stable control valve such as the double solenoid unit shown in Fig 2. This valve, a 3-port/2-position unit, remains in its last controlled state until the second state is actuated by the controller. Consequently, during an electrical control failure, this valve will not change condition.

One of the basic components to use in a heavy vacuum lift system is some type of alarm circuit. This alarm is normally visual or audible and facilitated by the control system rather than an actual vacuum component. However, a switch on the vacuum circuit is what the control system uses as its metering or switching device.

The simplest type of switch is a basic mechanical diaphragm unit. These units can be installed in a normally closed or open condition. Fig 3 shows a typical diaphragm switch. The user will set the point at which the switch will change condition, either breaking or making an electrical contact inside the switch (normally open or normally closed setting). If the system is safe at >25"Hg for example, then the trip point on the switch should be set at <25"Hg. This value should be set as close to the safety point as possible to give the user as much time as possible to investigate the cause of the low vacuum condition and take the necessary action to safeguard personnel and product.

What is often overlooked on a vacuum lifting circuit is a vacuum gauge. These inexpensive components offer the user a visual indication of the vacuum level in a system, but surprisingly, these very effective user interfaces are often not installed. Vacuum lifting rig manufacturers sometimes supply a gauge with a red and green section to indicate unsafe and safe. Fig 4 shows this type of dial design with the "safe zone" starting at 15"Hg (50% vacuum). This type of dial design offers clear instruction to the machine operators to warn of potential problems with the vacuum system. A gauge can show decay in operating vacuum level whereas a switch only indicates when the system hits a preset safety level. Vacuum transducers (4-20 mA) can be used to indicate vacuum decay, but these are not visual in themselves unless configured with the machine control panel or are fully self-contained units, which are very expensive in comparison to a simple vacuum gauge.

Self-closing valves offer a good mechanical safety feature



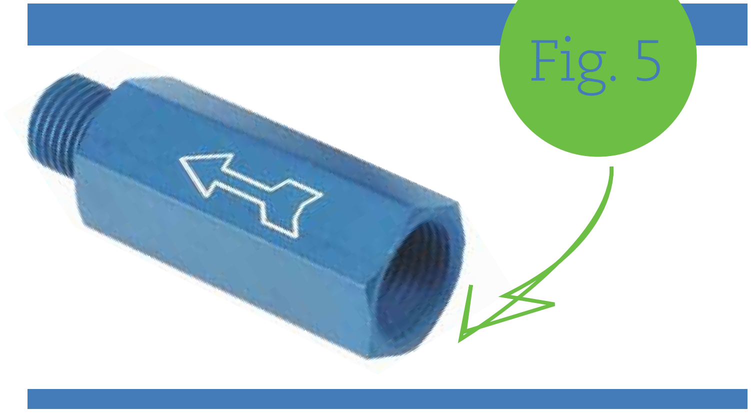


Fig. 5

of a multiple vacuum cup handling system. If the vacuum cup breaks free from the load or indeed does not seal on the load because the cup is not fully covered, the valve will isolate that cup from the rest of the circuit. Consideration of this fact should be made in regards to user interface. If a single vacuum gauge or switch is being used on the system, the user will not know that an individual cup with a self-closing valve is not clamping or gripping the product. Therefore, a gauge or switch should be used on each cup to indicate to the user that a particular cup has failed and needs inspection for cause before the production cycle starts. Fig 5 shows a typical self-closing valve with the arrow indicating the direction of flow.

In an emergency stop condition where the user interrupts the production cycle, the product being gripped by the vacuum system should remain in place. As described before, the multifunction vacuum venturi is a popular choice for this scenario. These vacuum generation devices are very popular in automated handling applications such as robotic part transfer. In this automated environment, it is very important for the vacuum system to retain the parts and when the system restarts for it to be in the same state or condition it was when the "e stop" was made. This way, the production cycle is unaffected. Consequently, if the system was in a vacuum hold condition with vacuum ON, then this is the condition the vacuum venturi will be when the system restarts. The benefit to the "e stop" venturi is to maintain vacuum, cycling on and off automatically while in the "e stop" condition by using an integral control circuit. With a vacuum pump system, the control valve for the vacuum line should be a bi-stable version, as explained before and as shown in Fig 2. This valve will only change condition if made to do so by the control system. Therefore, if the vacuum cups were connected to the vacuum system, they will remain so until the controller changes the valve position. This valve, therefore, will not be affected by an "e stop" event.

In very large lifting applications, the user often installs mechanical fail-safe devices such as hooks and chains, which will be the last line of defense in case of system failure. Even though the product might be damaged by this mechanical apparatus, it guarantees worker safety, and that is the most important aspect of any production environment.

The fundamental methods of retaining the product being handled during power supply failure have been presented in this article. Of course, all applications are different, and therefore, professional independent advice should be sought when selecting components or turnkey vacuum handling systems. The safety requirement of the system should be this: if something unscheduled occurs, be it compressed air or electrical supply failure, the selected vacuum components should accommodate this, based on their integration with each other and with the operator's control system.

For further information please contact Daniel Pascoe at www.vacuforce.com. Vuototecnica USA is a brand of Vacuforce Inc.