

**System Considerations for the Application of
Pneumatically Actuated Reciprocating Compressor Cylinder Unloaders
ACI Services, Inc.
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Introduction

ACI Services, Inc. pneumatically actuated fixed volume clearance pockets, bypasses and deactivators are applied to a wide range of reciprocating compressor models, speeds and operating conditions. These devices are an efficient and effective means for unloading compressors by reducing their capacity.

For a given set of operating conditions, the capacity or throughput of a reciprocating compressor cylinder is dependent on the cylinder's swept volume (i.e., piston cross-sectional area x piston stroke), the number of active ends (i.e., head end and/or crank end for a double-acting cylinder) and the built-in fixed clearance volume inside the cylinder when the piston is at the end of the compression stroke closest to the cylinder head.

Often it is desirable to change the capacity of a compressor to accommodate changes in operating conditions, driver power ambient rating or downstream demand. Large permanent shifts in capacity may necessitate physically altering or replacing the cylinders to provide a different bore size to accommodate different operating conditions than the original cylinders were designed for. For temporary demand shifts on compressors with variable speed drivers, capacity can be changed by changing speed within the specified speed and power limits of the compressor and driver.

The capacity of a cylinder end can also be changed by changing the clearance volume of the cylinder. Adding clearance volume reduces capacity and reducing clearance volume increases capacity.

Several devices are commonly used to add clearance to the built-in clearance volume of a reciprocating compressor cylinder. These include head end manual variable volume clearance pockets, pneumatically actuated head end fixed volume clearance pockets and pneumatically actuated valve pocket fixed volume clearance pockets. Other common unloading devices include valve deactivators, head end bypasses and combination devices such as ACI's Duplex™, Multi-Pocket™ head end unloaders, and hydraulically actuated head end variable volume clearance pockets.

Head End Manual VVCP

One very common device, usually limited to application on the head (outboard) end, is the manually actuated variable volume clearance pocket (shown on the left-hand cylinder in Figure 1). It can be used to adjust the clearance volume over a predetermined range. The

addition of clearance volume reduces the capacity or throughput and power consumption. The head end variable volume clearance pocket (HE VVCP) is an effective capacity and load control device, but it must be operated manually, usually with the compressor shut down. Therefore it is not suited for automatic control of a compressor.

Pneumatically Actuated FVCP

In the case of a fixed volume clearance pocket (shown on the right-hand cylinder in Figure 1), the device, when actuated by a control signal from a PLC or other control system, adds a predetermined amount of fixed clearance to the built-in clearance volume of the reciprocating compressor cylinder end. This addition of clearance volume effectively reduces the capacity of the cylinder end and therefore the required power or load on the driver. A much larger fixed volume clearance pocket (HE FVCP) is shown on the head end of the cylinder in Figure 2.



Figure 1: Head end unloaders

The optimal FVCP volume is determined and engineered when the compressor is applied, so the size of the devices varies widely. They are commonly applied to the head (outboard) end of the cylinder.

Pneumatically actuated FVCPs can also be located on the compressor cylinder valve pockets as shown in Figure 2. The amount of clearance volume that can be added at the valves is generally much less than what can be added on the head end of the cylinder, however these devices are commonly used when more than one step of unloading is required per cylinder and when unloading is required in relatively small steps. Valve pocket FVCPs are commonly used to enable a compressor to cover a wide range of operating conditions.

Pneumatically Actuated End Deactivators

Cylinder end deactivators are also often located on the valve pockets. These may be pneumatically actuated finger type unloaders that hold the valve plates off the valve seat or plug type unloaders that open a bypass hole in the valve seat. In either type, when actuated by a control signal, flow is internally bypassed from a cylinder end back into the compressor cylinder suction manifold. This reduces the volumetric efficiency of the cylinder end so that

the cylinder end has very minimal capacity and power consumption.

Pneumatically actuated bypasses may also be mounted on the head end of cylinders as shown in Figure 3. This type of bypass, when actuated by a control signal, connects the head end compression space of a reciprocating compressor cylinder end to the compressor suction manifold by means of an external pipe run.

In most cases, the pneumatically actuated devices are custom engineered for the specified application conditions of the compressor and the specific cylinder to which the device is applied.

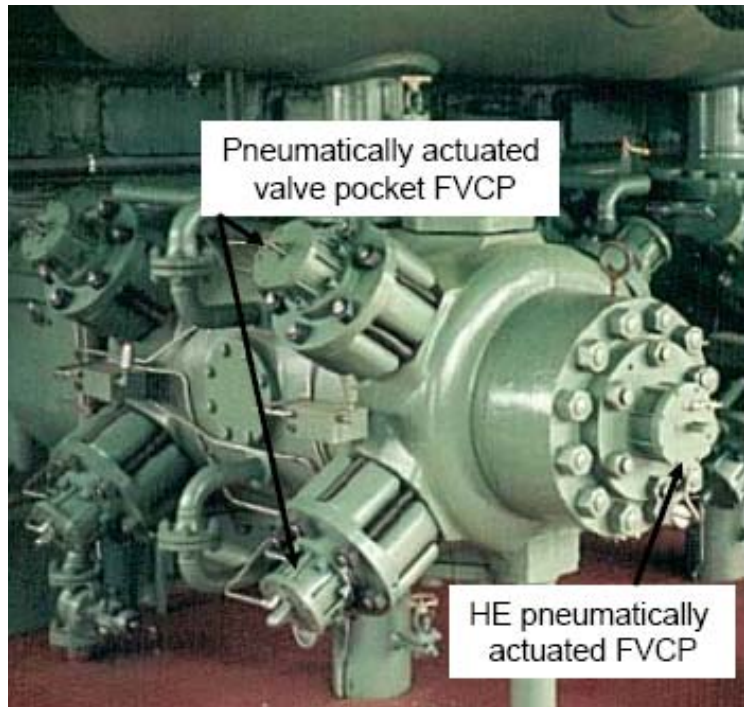


Figure 2: Pneumatically actuated fixed volume clearance pockets

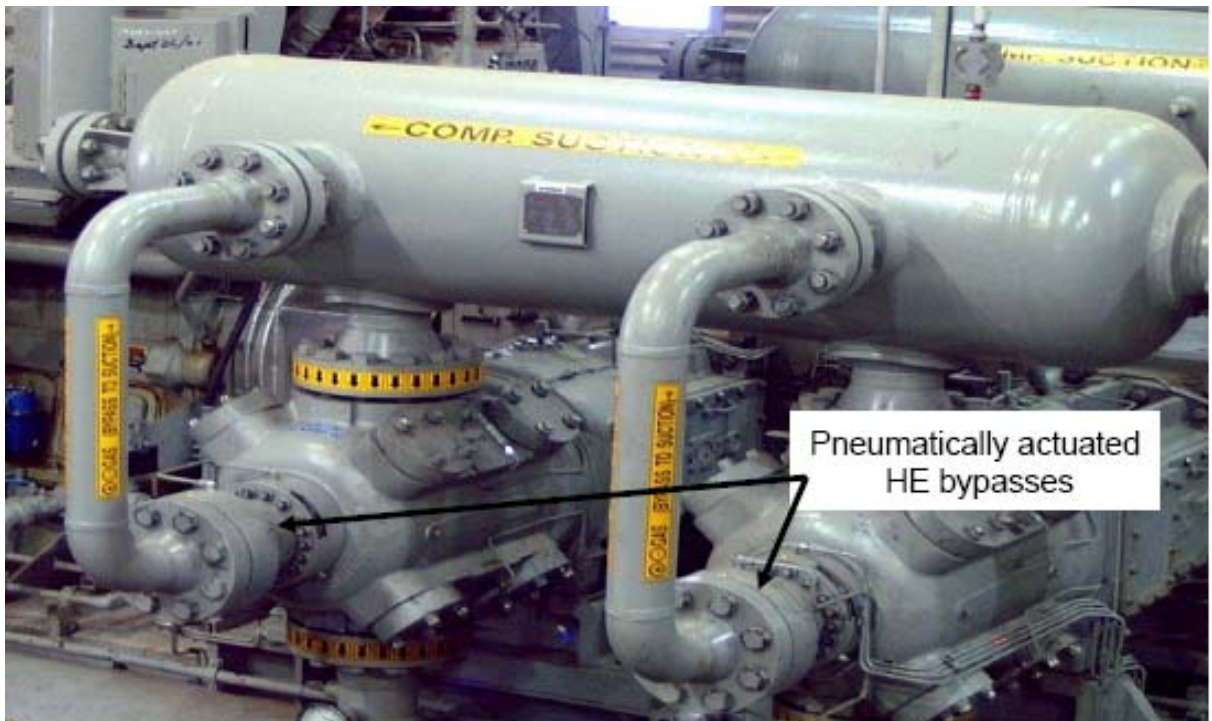


Figure 3: Pneumatically actuated head end bypass unloaders

Operating Principals

ACI pneumatically actuated unloaders employ a balanced plug actuating cylinder assembly mounted on a special cylinder head that contains a customized internal volume as shown in Figure 4. The actuator strokes a balanced plug that seals off the internal volume during normal operation and exposes the internal volume to the head end cylinder clearance volume when in “unloaded” operation.

Major Components

ACI pneumatically actuated unloaders typically include a number of the standard features shown in Figure 5, including the aforementioned special head end cylinder head, an outer head or bonnet that forms the outboard end of the unloader volume cavity, a chrome-plated pneumatic cylinder, a single pneumatic cylinder control media supply port, an air (or other control media) actuator piston, a stainless steel actuator shaft, a stainless steel seal cartridge with double seals, a visual shaft position “Pindicator” with a clear plastic cover, high temperature Viton® elastomer seals, vent connections for the cavity behind the actuator piston and for the shaft seals, a balance piston and stem, and a balanced pressure plug.

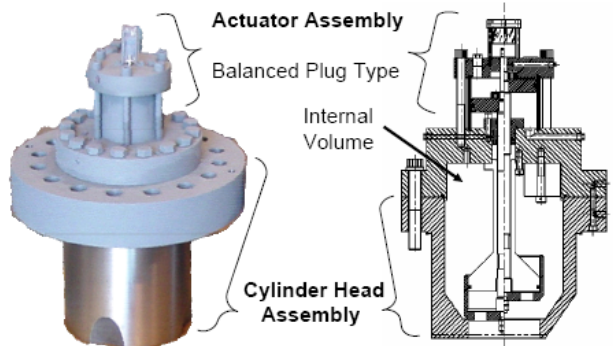


Figure 4: Pneumatically actuated unloader assembly

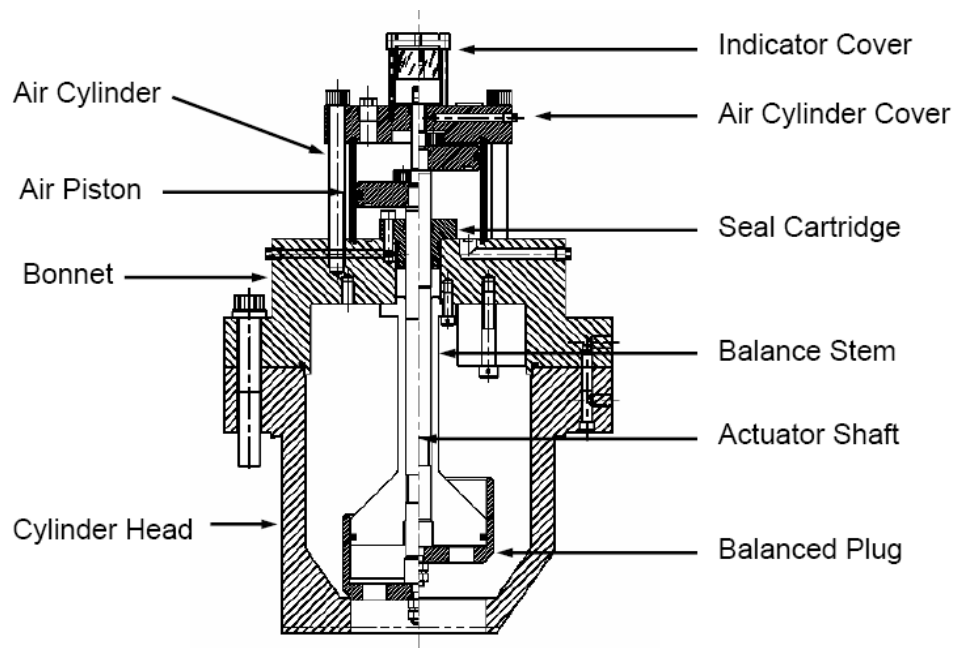


Figure 5: Unloader Major Components

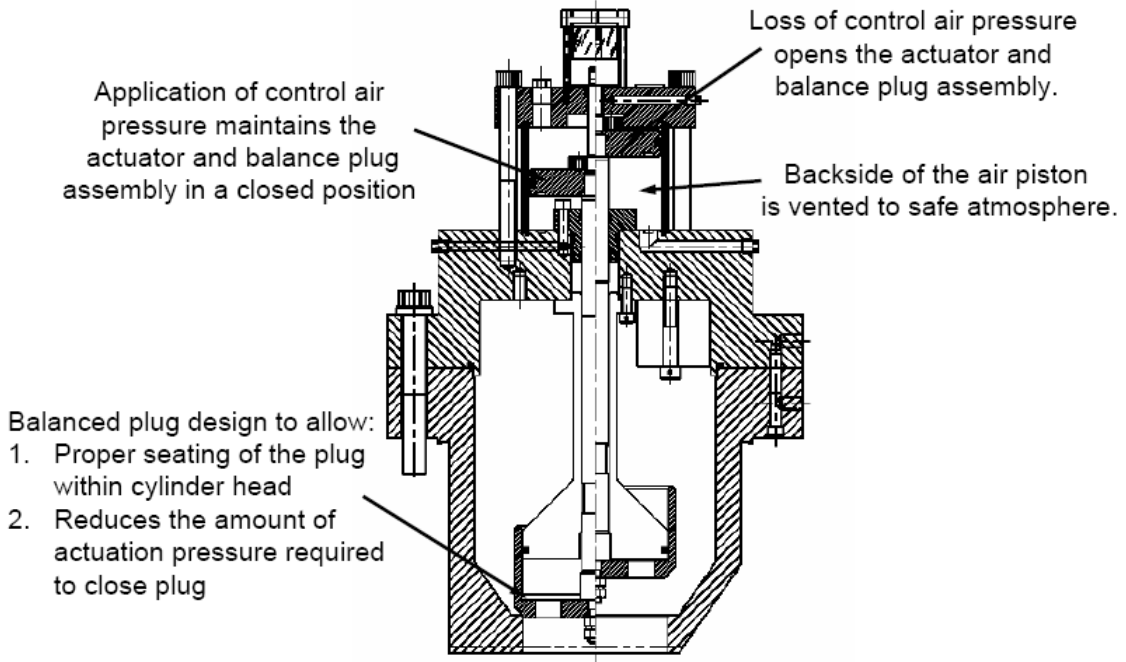


Figure 6: Pneumatically Actuated FVCP Control Philosophy

The unloader assembly is designed so that loss of actuator control pressure will open the unloader plug, add clearance volume and reduce the compressor capacity, therefore reducing the load on the compressor.

In relatively low pressure compressor applications, there may also be a large coil spring under the actuator piston to assist it in opening as shown in the example of the suction valve pocket deactivator in Figure 7.

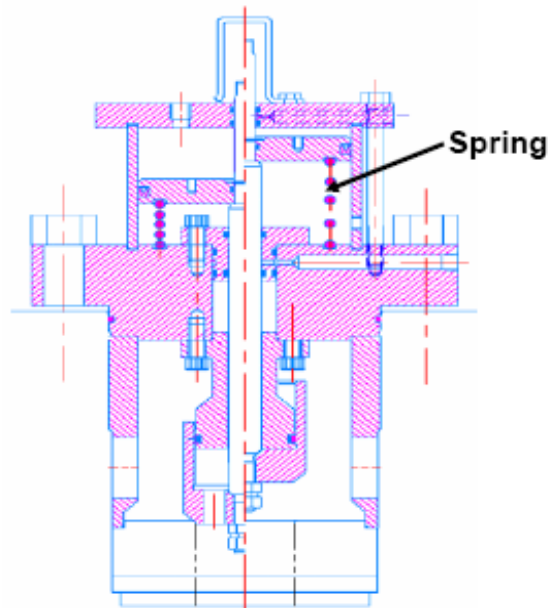


Figure 7: Pneumatically Actuated Suction Valve Pocket Deactivator with Spring Assist

Application of control pressure maintains the actuator and balanced plug assembly in a closed position to load the compressor. The back side of the actuator piston must be vented to a safe atmosphere to prevent the build up of pressure on the back of the actuator piston, which will resist the force exerted by the control pressure. Build up of back pressure will prevent the unloader plug from closing properly and can lead to damage and failure of the unloader.

Required Actuator Control Pressure

The actuator is normally “powered” by clean, dry pressurized air. However, in some cases, clean, dry pressurized gas may be used as the control media instead of air. The device is designed so that actuator control media pressure is required to close the balanced plug to seal off the internal unloader volume to keep the compressor “loaded.” Upon loss of control pressure, the gas forces acting on the compressor side of the plug cause it to lift off the seat into an “open” mode that connects the internal unloader volume and “unloads,” or at least reduces the load on, the compressor.

The control pressure required to operate the unloader will vary with the specific design and the application requirements. Where practical, a control pressure of 150 psig or less is chosen by the designer so that standard plant air compressors can be used to supply the control pressure. However the control pressure may be increased for cylinder pressure applications above 1,200 psig.

The maximum allowable control pressure is specified on the actuator cylinder with a tag, such as the one shown in Figure 8. The required minimum control pressure is dependent on the compressor operating conditions required for each application. The minimum control pressure is specified in the documentation provided by ACI Services with the unloader or, if the unloader is supplied by a compressor OEM, this value is provided with the OEM’s documentation.



Figure 8: Maximum Control Pressure Label

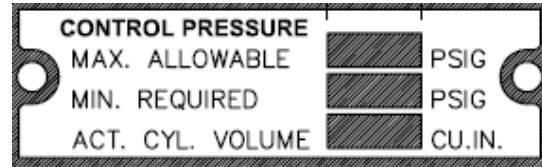


Figure 8a: Control Pressure Label
(For production after June 2005)

For unloaders built after June 2005, both the minimum and maximum control pressures are specified on the actuator cylinder tag as shown in Figure 8a.

It is very important to supply control pressure to the actuator at a value between the minimum required and the maximum allowable control pressure. The specified control pressure is the pressure requirement at the actuator inlet port. Failure to supply adequate control pressure will prevent the unloader plug from seating entirely. Insufficient control pressure may cause the unloader to be activated (opened) unintentionally, or it may also cause the unloader plug to be partially unseated with each compressor stroke. Continuous partial unseating will cause unnecessary stress and/or wear on the unloader components and, in extreme cases, can cause failure of unloader components.

As discussed in the next section, in order to ensure that the required control pressure is provided at the actuator port, the control media system design must take into account the pressure drop between the supply source and the actuator inlet port(s).

Unloader Control Media Supply & Vent System Considerations

The control media supply system and the vent system for the unloader must be properly designed and connected for the unloader to operate safely and effectively throughout the full range of compressor operating conditions. Figure 9 shows the typical connections provided on most ACI pneumatically actuated unloaders.

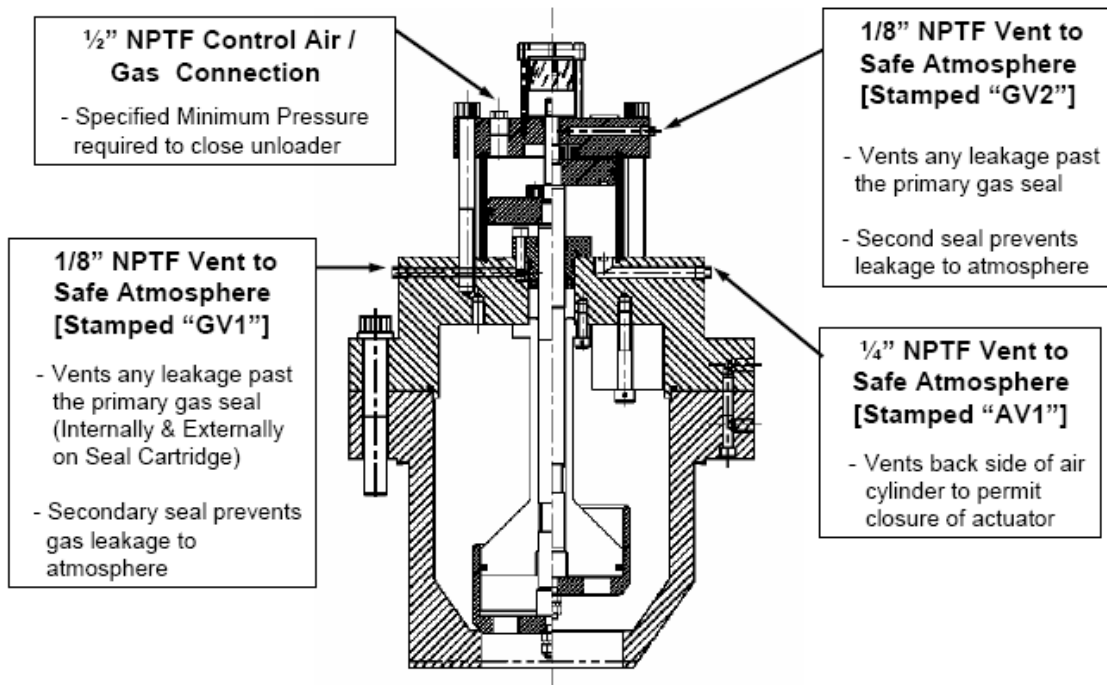


Figure 9: Unloader Connections

In addition to the control media supply connection, which must be supplied with the specified control pressure, there are three separate vent connections on the typical ACI pneumatically actuated unloader. Unloader vent connections must be made by the packager or systems integrator, and all are critical to the proper operation and durability of the unloader, as well as to safety. The unloader vent lines should be at least 3/8" tubing, and it may be necessary to use larger diameter tubing or pipe for long vent lines. Unloader vent lines may be connected to a common, larger diameter manifold if necessary, but the unloader vent system should not be connected to rod packing or other component vents that may be pressurized during operation of the compressor.

All vents must be installed in such a manner as to prevent the collection of liquids that could cause the build up of either gas or liquid in the vent line. Drip legs should be included at low points in the vent system to collect liquid and condensation that might otherwise accumulate and create back-pressure in the vent system. When a heavier than air gas is involved, the vent line must be designed to minimize the back-pressure caused by heavy gas or drop-out of condensate in the vent line.

It is critical, for safe operation of the compressor, to ensure that all vents are open, functional and, if necessary, tubed off of the skid or out of the compressor building to a safe atmosphere. Depending on local site climate and insect population, it may be necessary to install screens over vents to ensure that they do not become blocked. This can be essential if the compressor is shutdown for a long period of time.

Control Media Connection and Supply System Piping

A ½” NPT threaded port is normally provided in the top of the actuator cylinder cover for supplying control air or gas to the actuator. Some smaller actuators may have a smaller supply port size. The required control pressure level is discussed in the section entitled Required Actuator Control Pressure. As noted there, it is very important to supply control pressure at a level between the minimum required and the maximum allowable control pressure. The specified control pressures are the requirements at the actuator inlet port.

In order to ensure that the required actuator control pressure is provided at the actuator port, the control media system design must take into account the pressure drop between the control pressure supply source [P_s in Figure 10] and the actuator inlet port(s) [P_a in Figure 10]. Other

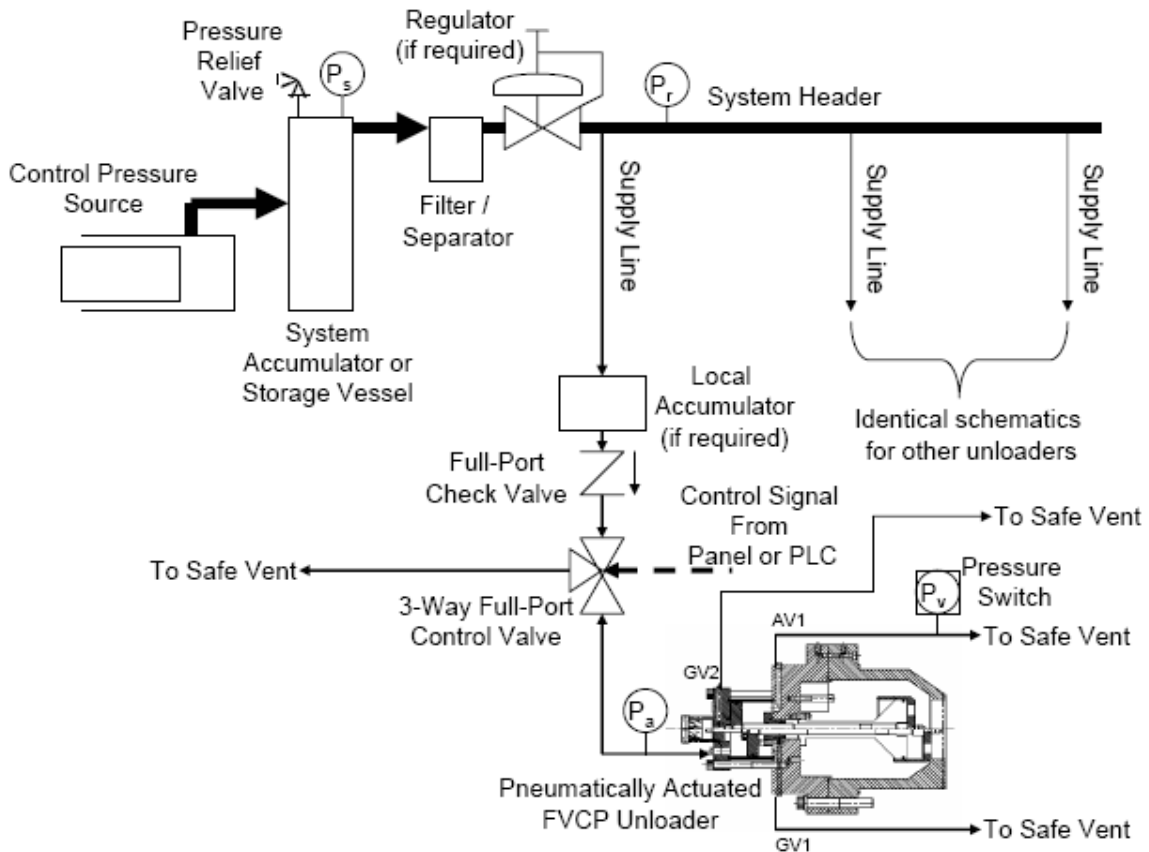


Figure 10: Recommended Actuator Control Media Schematic

demands drawing on the control pressure supply source must be taken into account to ensure that the required control pressure is provided to the actuators at all times.

It is desirable that the actuator closes and opens quickly, preferably in 1 to 2 seconds, but does not slam too hard into the seat. In no event should the actuation require more than about 30 compressor revolutions, as this could lead to premature failure of unloader components. The maximum actuation time [t_M] for 30 revolutions can be calculated using equation {1}:

$$\text{Maximum actuation time (seconds)} = t_M = 1800 / \text{rpm, or 2 seconds, whichever is less.} \quad \{1\}$$

For example, this equates to a maximum actuation time of 1.5 seconds for a 1200 rpm compressor. In the case of closing the unloader to load the compressor, the control pressure inside the actuator must increase from atmospheric pressure to the minimum required control pressure within this time. In the case of opening the unloader to unload the compressor, control pressure inside the actuator must decrease from the minimum required control pressure to atmospheric pressure within this time.

Most ACI actuators have a 5 in. or 4.5 in. diameter actuator piston. These actuators will typically require average flow rates in the range of 10 to 15 SCFM to fill the unloader actuator cylinder and move the actuator piston to a closed position in 1 to 2 seconds.

When air is used as the control media, the following equation can be used to estimate the system control air flow rate required to close or open the unloader in 1 to 2 seconds.

$$\text{Control Flow Rate (SCFM)} = Q_c = 0.005 \times V_a \times (P_{\min} + 14.7) / t_M \quad \{2\}$$

where V_a = Actuator cylinder volume (in^3)

P_{\min} = Minimum required actuator control pressure (psig)

t_M = Maximum actuation time (seconds) from equation {1}

The actuator cylinder volume [V_a] will normally be provided with the documentation supplied with the unloader and stamped on the unloader actuator tag for unloaders supplied after June 2005. When it is not available in the supplied documentation, contact ACI Services for assistance in determining the actuator cylinder volume for a specific unloader. For many applications the value of V_a will be in the range of 24 to 32 in^3 .

When gas or any control media other than air is used, contact ACI Services for assistance in estimating the control flow rate for the control media system design.

This control flow rate [Q_c] and the minimum required actuator control pressure [P_{\min}] can then be used to design/select the supply source and system. Note that when more than one actuator is actuated simultaneously, the required system flow rate will be the sum of the individual actuator flow rates. The pressure drop [$P_s - P_a$] through the control media supply system,

when the control media is flowing at the required control flow rate [Q_c], will determine the minimum supply pressure [P_s] that must be sustained at the control media source. Excessive pressure drop in the supply system or a supply source that droops in pressure will result in a slower control flow rate and a longer actuation time than desired. It is the packager or systems integrator's responsibility to properly design and install the supply and vent systems consistent with the requirements discussed in this document. However, ACI Services offers the following general guidelines that may be helpful.

The length of the line from the control media supply header to the unloader actuator supply port should be as short as possible. As a general guideline, ACI recommends using a minimum tubing size of 3/8" O.D. for the control media supply line from the header to each actuator. Restrictions in the line should be kept to an absolute minimum.

If necessary to reduce the supply pressure to stay below the maximum allowable actuator supply pressure, a regulator should be placed upstream of the control pressure supply line to the actuator as shown in Figure 10. In some cases, it may be advisable to install an accumulator in each control media supply line upstream of, but close to, the control valve. The MWP of the accumulator should be properly rated for the control media system and must be at least equal to the pressure rating of the unloader actuator cylinder.

Each control line should have a full port check valve to prevent back flow of process gas into the control supply system in the event of a major seal failure inside the unloader. The port size and flow coefficient [C_v] of the check valve must be compatible with the 1 to 2 second system response requirements as discussed on the next page. The MWP of the check valve should be properly rated as explained later in this document.

Next in the line should be a three-way control valve that permits the flow of control media into and out of the actuator as the unloader is closed (compressor loaded) and opened (compressor unloaded), respectively. This is often a solenoid valve that receives a control signal from a compressor control panel or PLC that has the compressor unloading sequence pre-programmed into it. The control valve for each actuator must have a port size and flow coefficient [C_v] that are compatible with the 1 to 2 second system response requirements as discussed on the next page. The MWP of the control valve should be properly rated as explained later in this document.

In cases where multiple unloaders are controlled from one control line and one control valve, the combined flow rates of all actuators must be considered in sizing the system. It is recommended that no more than 4 unloaders be controlled from one control line and that the control line does not exceed 40 ft. in length from the control valve to the last unloader on the line. Longer runs to unloaders or situations where more than 4 unloaders need to be controlled from one line may require the use of slave valves, slave valves in the control lines close to the actuators, and/or location of the control media supply lines in closer proximity to the unloaders.

Estimation of the Minimum Required Control System Flow Coefficient [C_v]

When air is used as the control media, the following equation {3} can be used to estimate the minimum required control system flow coefficient [C_v] required to close or open the unloader in 1 to 2 seconds.

$$\text{System Flow Coefficient} = C_v = \frac{0.0088 \times V_a \times (P_{\min} + 14.7)}{t_M \times [P_{\min} \times (P_{\min} + 14.7)]^{1/2}} \quad \{3\}$$

where V_a = Actuator cylinder volume (in³)

P_{min} = Minimum required actuator control pressure (psig)

t_M = Maximum actuation time (seconds) from equation {1}

The minimum required system flow coefficient calculated in equation {3} must include the effects of the entire system control line from the pressure source to the unloader actuator. Each element of the control line will have a flow coefficient and the system flow coefficient is determined by the following equation.

$$\text{System Flow Coefficient} = C_v = \frac{1}{[(1/C_{v1})^2 + (1/C_{v2})^2 + \dots + (1/C_{vn})^2]^{1/2}} \quad \{4\}$$

where C_{v1}, C_{v2},.....C_{vn} are the individual coefficients of each device, fitting and control line segment from the supply source to the actuator.

Often, if the control line sizes are kept to reasonably short lengths, the control line sizes are 3/8 in. diameter or larger, fittings are full port fittings, and no unusual restrictions (valves, regulators, orifices, filters, etc.) are placed in the system downstream of the control header, the C_v of the check valve and the C_v of the three-way control valve will be the critical factors in determining the control system response. In this case, as a general guide when the actuator volume is no more than 32 in³, the required system C_v will typically be about 0.20.

An Excel spreadsheet [SYSGUIDE] for calculating equations {1}, {2}, {3}, and {4} can be downloaded from www.aciservicesinc.com under “ACI Files” at the bottom left of the home page

Control Line Device Maximum Working Pressure [MWP]

Choosing the appropriate MWP of the control system devices and fittings will depend on the end user’s operating philosophy and their optimization of risk management. There are at least four alternatives to consider:

1. As an absolute minimum, the control system devices and fittings must be rated above the maximum relief valve setting of the control media supply system and at least equal to the maximum allowable control pressure specified on the actuator cylinder. This approach has

- worked historically for many applications, however, it may not be adequate in the event of a complete failure of the primary seal cartridge within the unloader.
2. As a next step in risk mitigation, the control system pressure ratings of the previous section 1 may be deemed adequate if the actuator vent line [AV1] is monitored with a low-range pressure switch that provides a means for early detection of process gas leakage before it progresses to an unsafe situation. This approach requires sufficient hydraulic length of vent tubing downstream of the pressure gauge in order that a small back pressure is built up in the event of leakage flow through the vent line. The pressure switch must be placed relatively close to the unloader and comparatively distant from the open (atmospheric) end of the vent line. The pressure switch should be part of the compressor unit's emergency shutdown system, which, as a minimum, causes the compressor to be stopped, isolated from the inlet and discharge piping, and internally de-pressurized by venting to a safe atmosphere or flare.
 3. For even better risk mitigation, the control system devices and fittings may be rated at the MWP of the compressor cylinder that the unloaders are mounted on.
 4. Combination of the vent pressure monitoring switch from section 2 with the MWP rating philosophy of section 3 will provide the absolute best risk mitigation.

Suggested Control System Devices

ACI Services cautions the packager or systems integrator to carefully consider all aspects of the control supply and vent system in designing and installing the control system to provide safe and reliable operation of the unloaders. Control devices must be selected consistent with the requirements outlined in previous sections of this document. Proper consideration must also be made for area electrical classification requirements, applicable regulatory codes and environmental factors such as temperature, wind, contaminants, vibration, etc.

The following lists of suggested devices are not all-inclusive and are provided only as general guidelines. Final selection of appropriate devices shall be the responsibility of the packager or systems integrator. Contact the control device manufacturer, the compressor OEM or ACI Services for technical assistance as necessary.

Check Valves

Manufacturer	Series/Type	MWP	C _v	Comments
Swagelok www.swagelok.com	8CP	3000	1.20	Should handle most cases
	CH8	6000	1.80	Preferred when MWP>3000
	CH16	6000	4.70	Option for very high flow.
Circle Seal www.circle-seal.com 909-270-6200	1PP	3000* 6000**	1.60	* 200 series **H200 series
	2PP	3000* 6000**	2.70	* 200 series **H200 series
	3PP	3000* 6000**	3.50	* 200 series **H200 series

Since there is a wide selection of full port check valves available, it is usually best to select a check valve with a C_v that is 5 to 10 times larger than the required system C_v . This allows use of a more economical solenoid valve with a comparatively smaller C_v .

Solenoid Valves

Manufacturer	Series/Type	MWP	C_v	Comments
ASCO www.ascovalve.com 800-972-2726	8320 1/8" orifice	300	0.21	Low pressure rating only.
	8320 1/8" orifice	300	0.25	Low pressure rating only.
	8320 1 1/64" orifice	300	0.35	Low pressure rating only.
Circle Seal www.circle-seal.com 909-270-6200	SV-30	3000	0.46	
	SV-430	3000	0.80	
	SV-460	6000	0.64	
Peter Paul www.peterpaul.com 860-229-4884	Series 70 3/32" orifice	4000	0.22	
	Series 70 1/8" orifice	4000	0.35	
	Series 70 5/32" orifice	4000	0.45	

Vent Pressure Switches (for port AV1)

Manufacturer	Series/Type	Range	Comments
Ashcroft www.ashcroft.com 203-385-0217	Type 400 B Series	0 to 15 psig	Mount close to unloader vent connection. Only an effective safety device for vent lines having more than about 20 hydraulic feet of 3/8" tubing downstream of device in order to create a measurable back pressure when leakage occurs. Settings should be about 1.0 psig for an alarm and 2.0 psig for a shutdown.
	Type 700 B Series	0 to 15 psig	
Altronic www.altronicinc.com 972-494-0522	DPS-1591	0 to 50 psig	
	45PHL	0 to 30 psig	

Note that a vent pressure switch will only be an effective safety device if there is sufficient flow resistance downstream of the device to create a back pressure when the vent is flowing. ACI Services recommends a minimum vent system line size of 3/8" tubing. A vent pressure switch will not be an effective safety device if it is placed too close to the open, atmospheric, end of the vent line. To be effective, it must be placed comparatively close to the source of the leakage. The vent pressure switch should be set so that it causes an alarm at about 1.0 psig and a shutdown at about 2.0 psig.

Actuator Vent Connection and System Piping

A 1/4" NPT connection [stamped "AV1"] on the unloader bonnet communicates with the back side of the actuator cylinder. This connection allows any control media or process gas trapped behind the actuator piston to escape to a safe vent when the actuator piston is closed. Trapped control media or process gas behind the actuator piston will prevent it from developing enough force to completely seat the unloader plug when the control pressure is applied.

When shipped from the factory, this connection is plugged with a plastic plug to keep dirt and liquid from contaminating the actuator cylinder until it is installed and the control lines connected. The plug must be removed for proper operation of the unloader.

Even though air may be used as the control medium, any process gas leakage past the actuator shaft or seal cartridge seals must be vented through this connection to a safe atmosphere or flare. As discussed in previous sections, monitoring of the back pressure [P_v in Figure 10] in this vent line is recommended as a safety measure to mitigate risk in the event of an internal unloader seal failure.

Unloader Bonnet Vent Connection, System Piping and Monitoring

A 1/8" NPT connection [Stamped "GV1"] on the unloader bonnet vents any gas that may leak around the inboard o-ring seal on the primary seal cartridge. This connection must be piped to a safe atmosphere or flare.

When shipped from the factory, this connection is plugged with a plastic plug to keep dirt and liquid from contaminating the actuator cylinder until it is installed and the control lines connected. The plug must be removed for connection of the vent line.

A second or outboard o-ring seal is located between the vent connection and the unloader actuator cylinder. For an optimal safety system, monitoring of this vent line with a low-range pressure switch provides a means for early detection of process gas leakage before it progresses to an unsafe situation.

Actuator Cover Vent Connection, System Piping and Monitoring

A 1/8" NPT connection [stamped "GV2"] on the actuator cover vents any control media that may leak around the inboard o-ring seal on the indicator shaft seal cartridge. It is recommended that this vent be piped to a safe atmosphere or flare when a control medium other than air is used, this connection must be piped to a safe atmosphere or flare.

When shipped from the factory, this connection is plugged to keep dirt and liquid from contaminating the actuator cylinder during shipment and handling. The plug must be removed for connection of the vent line.

As in the case of the primary shaft seal cartridge, a second or outboard o-ring seal is located after the vent connection. For an optimal safety system, monitoring of this vent line with a low-range pressure switch provides a means for early detection of process gas leakage before it progresses to an unsafe situation.

Indicator Shaft Monitoring

A shaft section that is an extension of the main unloader shaft extends through the actuator cover and is visible externally. This “Pindicator” provides a visual indication of whether the unloader is open or closed. It can also be used to observe whether the unloader piston is oscillating with each compressor stroke, although this may be difficult to visualize on high-speed compressors of 900 rpm or above.

An optional electronic sensor is available to sense the position of the unloader, i.e. whether it is open or closed. The sensor can be used to provide positive feedback that the unloader has opened or closed as intended by the control panel or PLC. Use of this type of sensor is especially recommended for remote or unattended compressor installations. Contact the compressor OEM or ACI Services for more information on this available option.

Checking for Proper Operation

Upon initial start-up and commissioning of the compressor or installation of a new unloader system, all unloaders should be checked for proper control pressure [$> P_{\min}$] at the actuator [reference P_a in Figure 10].

At the time of commissioning and at least once a month thereafter as part of the compressor system routine preventive maintenance program, unloader actuation time should be observed and verified to be equal to or less than the time required by equation {1}. The actuation should be smooth, with no hammering, heavy impact or questionable noises from the unloader. Once the unloader is closed on the seat, the Pindicator shaft should be static with absolutely no oscillation. If there is any oscillation, or if the actuation time is longer than required by equation {1}, there may be a leak or restriction in the control system or the control pressure may be less than required. If the actuator slams hard into the seat with a heavy impact, it may be necessary to add a small orifice in the control pressure supply line to slightly dampen the response of the unloader.

Actuator and unloader vent lines should be inspected during routine preventive maintenance to ensure that they are open and are not creating back pressure. Vent pressure switches, if used, should be checked for calibration and proper operation according to the manufacturer’s recommendations.

Any operational problems, including slow closing times, Pindicator oscillation after closing, or unusual noises, should be immediately investigated and corrected. Whenever there are application or operational questions or problems, immediately contact the compressor OEM

or ACI Services for technical support.

ACI pneumatically actuated unloaders have been in service in a wide range of applications and operating conditions for more than 25 years. Properly installed, operated and maintained, these robust devices normally provide safe, reliable unloading and extended service intervals.