Special Notes per Device Category

Category	Notes
Variable Speed Control	**Pulsation Notes**: Speed is the primary determination of most pulsation issues. **Flow Control**: Smooth capacity control device **Load Control**: Poor load control device. **Other**: Engines often run most efficient at rated speeds. Emissions often best (lowest) at rated speeds.
Suction Pressure Control	**Pulsation Notes**: Not usually a major contributor to pulsation issues. **Flow Control**: Smooth capacity control device. **Load Control**: Poor load control device. **Other**: Many times throttling suction back results in higher loads on the compressor, not lower loads.
Fixed Clearance or Displacement Changes	**Pulsation Notes**: Not usually a major contributor to pulsation issues. **Flow Control**: Stepped capacity control device. **Load Control**: Stepped load control device. Efficient load control device. **Other**: Shut downs required to install/remove devices.
Added Fixed Volume Pocket Clearance	**Pulsation Notes**: Not usually a major contributor to pulsation issues. **Flow Control**: Stepped capacity control device. **Load Control**: Stepped load control device. Efficient load control device. **Other**: Devices usually add a finite amount of additional fixed clearance.
Added Variable Volume Pocket Clearance	**Pulsation Notes**: Not usually a major contributor to pulsation issues. **Flow Control**: Smooth capacity control device (when automated). **Load Control**: Smooth load control device (when automated). Efficient load control device. **Other**: Devices usually add a finite amount of additional fixed clearance.
Cylinder End Deactivation	**Pulsation Note**s: Single-acting modes are primary contributors to pulsation issues. **Flow Control**: Stepped capacity control device. **Load Control**: Stepped load control device. Inefficient load control device. **Other**: Ends and/or cylinder can be hot, sometimes requiring a shut down.
Timed Valve Closing	**Pulsation Notes**: Devices known to change system's pulsation characteristics. **Flow Control**: Smooth capacity control device. **Load Control**: Smooth load control device. Inefficient load control device. **Other**: Often used in process markets and installed on all stages of compression.

Variable Speed:
Governors, VFDs and other speed control devices.

Relative Advantages	• Common means of capacity control • Lowers compressor valve loss loads • Increases unit's isentropic efficiency • Provides smooth load and capacity changes
Relative Disadvantages	• Torque usually remains same regardless of speed • Decreases fuel efficiency • Often increases emissions • Increases risk of pulsations/vibrations • Poor load control device • Certain ranges of speeds may cause vibration/pulsation issues.
Pre-installation Issues	• Usually not retrofitted to existing equipment. • Engines and Variable Frequency Drive motors (VFDs) provide speed control as a standard feature. Other motors may need to be equipped with torque converters to provide variable speed. • Acoustic studies are especially recommended for systems with variable speed units.
Post-installation Issues	• Most slow speed engines can run from 100% rated speed to about 50% rated speed: most high speed engines can run from 100% down to 75%. • Certain speeds may not be usable due to vibrations and/or pulsation concerns. • Some motors and engines can be altered later to provide more power.
Performance Notes	• Changes to speed have very little effect on interstage pressures. • Inertia-based rod loads and pin reversal issues are directly related to changes in speed.
Maintenance Issues	• Requires minimal maintenance • Reference OEM manual for specific maintenance schedules
Miscellaneous Notes	• Easy to control • Most standard control panels provide for speed control.
Economic Considerations	• Capital: Low (except converting fixed speed motors to variable speed) • Operating: Low • Maintenance: Low • Other: Energy and environmental costs

Suction Throttling:
Suction Pressure Control Valve

Relative Advantages	• Inexpensive device • Often required hardware • Simple control device • Smooth flow control
Relative Disadvantages	• Wastes energy • Can lead to higher BHP/MM
Pre-installation Issues	• Easy to control – most basic control panels support controlling inlet valves.
Post-installation Issues	• Lowering suction pressures too much may create rod load issues, high compression ratios and hence high discharge temperatures. • Changes to ratio can lead to pulsation issues.
Performance Notes	• Always leads to lowering capacity. • Lowering suction may often increase load.
Maintenance Issues	• Easy to maintain.
Miscellaneous Notes	• Most units have to have inlet control valve as part of their startup and shut down procedures.
Economic Considerations	• Capital: Low • Operating: Low • Maintenance: Low • Other: Energy costs to re-compress throttled gas.

Added Fixed Clearance Devices:
Clearance Plugs

Relative Advantages	• Inexpensive device (part of cylinder design)
Relative Disadvantages	• Time and Effort • Shut Down Required • Limited Added Clearance Available
Pre-installation Issues	• Inherent part of cylinder design
Post-installation Issues	• Effort and time of adding and removing devices often means that the unit will not be controlled to operate at maximum ability.
Performance Notes	• Maximum useable volume designed into cylinder.
Maintenance Issues	• No special maintenance is required.
Miscellaneous Notes	• Ideal for applications where operating pressures do not change rapidly, or significantly over short periods of time. • Changes to cylinder clearances do not normally have a significant affect on pulsation loading.
Economic Considerations	• Capital: Low • Operating: Low • Maintenance: Low • Other: Lost revenue during Shut Downs

Added Fixed Clearance Devices:
Valve Spacers

Relative Advantages	• Inexpensive device • Often offered as a standard OEM option
Relative Disadvantages	• Time and Effort • Shut Down Required • Limited Added Clearance Available • Cannot be Automated
Pre-installation Issues	• Not applicable for use in automated applications. • Applications requiring significant clearance volume modification may be limited to cylinder bodies with deep valve pockets.
Post-installation Issues	• Operators should use spacers in consideration of, and in conjunction with, Variable Volume pockets to achieve best performance. • Effort and time of adding and removing devices often means that the unit will not be controlled to operate at maximum ability.
Performance Notes	• Cylinder bodies with shallow valve pockets may result in increased pressure drop through modified valve cage ports required to accept spacers. • On cylinders with VVPs, usually the Crank End is fitted first and/or with more spacers so that cylinder loads are more balanced.
Maintenance Issues	• No special maintenance is required. • Bottom valves with spacers may need drains to prevent oil collection.
Miscellaneous Notes	• Ideal for applications where operating pressures do not change rapidly, or significantly over short periods of time. • Changes to cylinder clearances do not normally have a significant affect on pulsation loading.
Economic Considerations	• Capital: Low • Operating: Low • Maintenance: Low • Other: Lost revenue during Shut Downs

Added Fixed Clearance Devices:
Front Head Spacers

Relative Advantages	• Allows for significant changes to clearance
Relative Disadvantages	• Time and Effort • Shut Down Required • Cannot be Automated • Not usually practical for Crank End
Pre-installation Issues	• Not applicable for use in automated applications.
Post-installation Issues	• Effort and time of adding and removing devices often means that the unit will not be controlled to operate at maximum ability.
Performance Notes	• Spacers must be designed such that they do not interfere significantly with gas flow between valve pockets and cylinder main bore.
Maintenance Issues	• Spacer design may permit lube oil accumulation in clearance volume added between head and cylinder liner or body. Hence, drains must be considered. • Mechanical piston end clearance may vary as clearance volume is changed.
Miscellaneous Notes	• Ideal for applications where operating pressures do not change rapidly, or significantly over short periods of time. • Changes to cylinder clearances do not normally have a significant affect on pulsation loading.
Economic Considerations	• Capital: Moderate • Operating: Low • Maintenance: Low • Other: Costs during Shut Downs

Added Fixed Clearance Devices:
Piston Changes

Relative Advantages	• Provides potential for significant clearance volume changes
Relative Disadvantages	• Not applicable for automated applications • Unit shut down is required • High costs
Pre-installation Issues	• Not applicable for use in automated applications. • Usually requires new piston. • Not ideal for high-pressure compression. • Not ideal for small bore cylinders.
Post-installation Issues	• Effort and time of adding and removing devices often means that the unit will not be controlled to operate at maximum ability.
Performance Notes	• If pipe plugs used to feed volume, then ports feeding internal piston volume must be properly sized for the application.
Maintenance Issues	• Mechanical piston end clearance may vary as clearance volume is changed, depending on nature of design.
Miscellaneous Notes	• Ideal for applications where operating pressures do not change rapidly, or significantly over short periods of time. • Changes to cylinder clearances do not normally have a significant affect on pulsation loading.
Economic Considerations	• Capital: High • Operating: Low • Maintenance: Low • Other: Costs during Shut Downs

Variable Clearance via Adjustable Head End Suction Valves:
Valve-in-Piston (VIP)

Relative Advantages	• Provides wide range of clearance volume adjustment • Provides means for deactivation of head and/or crank ends
Relative Disadvantages	• Valve area to swept volume ratio not ideal for larger bores. • Difficult to add other types of unloading to cylinders. Thus, cylinders and speed must be closely sized to specific applications. • Unique, proprietary (patented) design.
Pre-installation Issues	• Best suited for new applications. Cannot be retrofitted to existing cylinders.
Post-installation Issues	• Normally not automated
Performance Notes	• Provides wide range of performance control for both the head and crank end of cylinders.
Maintenance Issues	• Valve maintenance is complicated as a result of the basic cylinder body design required by this concept.
Miscellaneous Notes	• Wide range of performance control increases the need for acoustic study to minimize risk of gas piping pressure pulsation problems.
Economic Considerations	• Capital: Low • Operating: Low • Maintenance: Medium • Other:

Added Variable Volume Pocket Clearance:
Variable Volume Pockets (Manual Screw Type)

Relative Advantages	• Inexpensive device • Standard OEM device • Smooth performance control • Do not restrict gas flow through valves/passages
Relative Disadvantages	• Require manual assistance to change clearances • Often require shut downs when being adjusted
Pre-installation Issues	• Users can easily retrofit existing cylinders. • VVPs will work equally well on high and low speed compressors.
Post-installation Issues	• Operators need to take care to closely follow performance curves. Adjusting one cylinder's VVP 100% is not always the same as adjusting two VVPs 50% each.
Performance Notes	• Difficulty of operating often leads to very conservative use. • The higher the operating pressure and/or the smaller the cylinder bore the more difficult the use of a VVP. • When permitted, performance can be adjusted during operation if balance pressure lines are properly designed. • Load and Flow can potentially be smoothly controlled. • Very little flow restriction between the pocket and the cylinder allow for minimal losses of efficiency as the pocket is opened.
Maintenance Issues	• Handwheels may become damaged due to vibrations. • Require little maintenance.
Miscellaneous Notes	• Accepted approach for performance control in the gas gathering market segment. • Pipeline compressors typically do not have variable volume pockets. • Process compressors typically do not have variable volume pockets. • VVPs are typically located on the front head.
Economic Considerations	• Capital: Low • Operating: Low • Maintenance: Low • Other: Lower revenues due to conservative use of devices.

Added Variable Volume Pocket Clearance:
Variable Volume Pockets (Hydraulic Assisted)

Relative Advantages	• Smooth performance control • Do not restrict gas flow through valves/passages • Rapid reaction to process changes
Relative Disadvantages	• Initial capital costs are high • When automated, usually requires intelligent control
Pre-installation Issues	• Users can easily retrofit existing cylinders. • Extra hydraulic and/or gas tubing not ideal for sour gas environments. • Maximum working pressure limited (typically less than 2000 psi). • Speed limited (typically less than 1200 RPM, ideally less than 1000 RPM). • Device reaction times are a function of the differential gas forces. • These types of devices are often used in conjunction with fixed volume pockets.
Post-installation Issues	• Reaction times of assisted VVPs and normal fixed volume pockets can differ significantly. Operators and control panels need to determine valid sequences of events to accommodate any performance adjustment delays. • Often designed to operate manually with needle valves, or automatically with solenoids or pneumatic valves.
Performance Notes	• Load and Flow can potentially be smoothly controlled. • Very little flow restriction between the pocket and the cylinder allow for minimal losses of efficiency as the pocket is opened.
Maintenance Issues	• Hydraulic systems require maintenance (oil changes, seal/gasket changes).
Miscellaneous Notes	• Most VVPs are typically located on the front head. • Presently, not many of these devices in actual use.
Economic Considerations	• Capital: High • Operating: Low • Maintenance: Medium • Other: Potential fuel savings by running engines at full load conditions. Higher revenues experienced as device optimizes unit's flow capabilities.

Added Variable Volume Pocket Clearance:
Variable Volume Pockets (Gas Pressure Controlled)

Relative Advantages	• Smooth performance control • Rapid reaction to process changes • May be used on front head, and on valves
Relative Disadvantages	• Often adds noticeable amounts of additional fixed clearance. • Added complexity of controlling balanced gas pressure
Pre-installation Issues	• May be adapted to existing fixed volume pockets. • VVPs will work equally well on high and low speed compressors.
Post-installation Issues	• Complex control system for load and flow predictions, as well as internal pressure predictions required for Rod Load and Pin Reversal calculations.
Performance Notes	• Load and Flow can potentially be smoothly controlled. • When used on front heads, no flow restrictions between the pocket and the cylinder allow for minimal losses of efficiency as the pocket is opened.
Maintenance Issues	• Gas control system • Control valves require similar maintenance as regular valves
Miscellaneous Notes	• Gas-balanced VVPs can be located on valve caps. • Presently, not many of these devices in actual use. • Limited field experiences.
Economic Considerations	• Capital: Medium • Operating: Low • Maintenance: Low to Medium • Other: Potential fuel savings by running engines at full load conditions.

Added Fixed Volume Pocket Clearance:
Front Head Volume Pockets

Relative Advantages	• Do not restrict gas flow through valves/passages • Easy to automate • Economical approach to performance control • Prevalent in the industry from OEMs and third party suppliers • Proven method of performance control • Spacers/fillers can adjust volume for later re-application of compressor
Relative Disadvantages	• Stepped performance approach • Some devices do not have indicators to show current state of device
Pre-installation Issues	• Easy to retrofit existing cylinders. • FVPs work well on high and low speed compressors. • FVPs work well on compressors of various stroke lengths. • Ideal for lower-medium to high compression ratios. • Exotic gases may limit application.
Post-installation Issues	• Manually actuated pockets may be physically difficult to actuate.
Performance Notes	• Unit performance can be adjusted during operation (either manually or automatic). • Since there is very little flow restriction between the pocket and the cylinder, there will be minimal losses of efficiency as the pocket is opened. • Stepped approach to performance control.
Maintenance Issues	• Seals and gaskets are required to be replaced. • Actuation system requires additional maintenance (solenoid, actuation lines, check valves, etc). • Vent line issues. • Maintain required actuation pressure for proper operation. • 1-5 year service for pneumatic systems.
Miscellaneous Notes	• Usually designed and sized for an application's operating ranges. • Standard means of performance control within the pipeline transmission and process market segments.
Economic Considerations	• Capital: Low to Medium • Operating: Low • Maintenance: Low to Medium • Other: Offered as additional item for most new unit sales.

Added Fixed Volume Pocket Clearance:
Valve Cap Volume Pockets

Relative Advantages	• Easy to automate • Economical approach to performance control • Prevalent in the industry from OEMs and third party suppliers • Proven method of performance control • Spacers/fillers can adjust volume for later re-application of compressor
Relative Disadvantages	• Stepped performance approach • Some devices do not have indicators to show current state of device • May require switching from single deck to double deck valves to maintain appropriate flow areas • Requires special ported valves.
Pre-installation Issues	• Easy to retrofit existing cylinders. • FVPs work well on high and low speed compressors. • FVPs work well on compressors of various stroke lengths • Ideal for lower-medium to high compression ratios. • Exotic gases may limit application.
Post-installation Issues	• Manually actuated pockets may be physically difficult to actuate.
Performance Notes	• Unit performance can be adjusted during operation (either manually or automatic). • Since there is very little flow restriction between the pocket and the cylinder, there will be minimal losses of efficiency as the pocket is opened. • Stepped approach to performance control.
Maintenance Issues	• Seals and gaskets are required to be replaced. • Actuation system may require additional maintenance (solenoid, actuation lines, check valves, etc). • Vent line issues. • Maintain required actuation pressure for proper operation. • 1-5 year service for pneumatic systems.
Miscellaneous Notes	• Usually designed and sized for an application's operating ranges. • Standard means of performance control within the pipeline transmission and process market segments.
Economic Considerations	• Capital: Low to Medium • Operating: Low • Maintenance: Low to Medium • Other: Offered as additional item for most new unit sales.

Added Fixed Volume Pocket Clearance:
Internal Body Volume Pockets

Relative Advantages	• Easy to automate • Economical approach to performance control • Proven method of performance control • Unloading is accomplished independent of the valves and gas passages
Relative Disadvantages	• Stepped performance approach • Some devices do not have indicators to show current state of device
Pre-installation Issues	• Easy to retrofit existing cylinders. • FVPs work well on high and low speed compressors. • FVPs work well on compressors of various stroke lengths • Ideal for lower-medium to high compression ratios.
Post-installation Issues	• Pocket is predetermined and molded into the cylinder body. Use of filler pieces to reduce volume is often not practical.
Performance Notes	• Unit performance can be adjusted during operation (either manually or automatic). • Since there is very little flow restriction between the pocket and the cylinder, there will be minimal losses of efficiency as the pocket is opened. • Stepped approach to performance control.
Maintenance Issues	• Seals and gaskets are required to be replaced. • Actuation system may require additional maintenance (solenoid, actuation lines, check valves, etc). • Vent line issues. • Maintain required actuation pressure for proper operation.
Miscellaneous Notes	• Not common practice for new cylinders.
Economic Considerations	• Capital: Low (inherent part of cylinder design) • Operating: Low • Maintenance: Low • Other: Adds cost to the initial design of the cylinder – designing a cylinder with pockets increases the cost of the pattern and all castings.

Timed Valve Closing:
HydroCOM

Relative Advantages	• Online monitoring • Stepless capacity control • Balances load across stages, if applied • Balances temperatures across stages, if applied
Relative Disadvantages	• Requires a high level of automation for proper control. • Installation restricts gas passages and valve areas. • Utilizes a finger type device for depressing the valve plates. • Separate hydraulic oil system used for actuation of device. • Compressor efficiency reduced due to the back flow of the gases when the valve is held open.
Pre-installation Issues	• Primarily used on slow speed, process-type compressors. • Need to have a unit control panel. • Retrofits are complex.
Post-installation Issues	• Limited to less than 2320 psi. • Limited to less than 1200 RPM. • Used only on plate type valves (ensure Peek or MT material is used). • Maximum suction valve temperature of 250 deg. F. • Suitable for corrosive environments. • Suitable for non-lube applications.
Performance Notes	• Adjust performance to allow for the reduction in valve flow area (higher resistance factor during normal operation.) • May be required to be installed on all suction valves. • Review the entire operating range to ensure rod reversal and rod loads are within the acceptable OEM specifications. • Dynamic changes in internal pressures may make prediction of rod loads and pin reversals more difficult.
Maintenance Issues	• Seal housing contains dynamic and static seals that require attention. • Hydraulic system requires maintenance: dual supply and return filters; float, pressure, and temperature switches; hydraulic oil lines, pumps, and heater/cooler; and oil maintenance program. • Wear of valve sealing elements due to the finger type device. • OEM provides an overhaul schedule for each component. • Need to remove the device to service the suction valves.
Miscellaneous Notes	• Not suited for harsh environment, such as gas gathering.
Economic Considerations	• Capital: High • Operating: Medium • Maintenance: Medium • Other: Losses associated with back-flow of suction gas.

Timed Valve Closing:
Infinite Step Unloader

Relative Advantages	• Online monitoring • Stepless capacity control • Balances load across stages, if applied • Balances temperatures across stages, if applied
Relative Disadvantages	• Requires a high level of automation for proper control. • Installation restricts gas passages and valve areas. • Utilizes a finger type device for depressing the valve plates. • Separate hydraulic oil system used for actuation of device. • Compressor efficiency reduced due to the back flow of the gases when the valve is held open.
Pre-installation Issues	• Need to have a unit control panel. • Retrofits are complex.
Post-installation Issues	• Limited to less than 1200 RPM. • Used only on plate type valves (ensure Peek or MT material is used). • Suitable for corrosive environments. • Suitable for non-lube applications. • Not published, but likely there is a limit on the suction pressure.
Performance Notes	• Adjust performance to allow for the reduction in valve flow area (higher resistance factor during normal operation.) • May be required to be installed on all suction valves. • Review the entire operating range to ensure rod reversal and rod loads are within the acceptable OEM specifications. • Dynamic changes in internal pressures may make prediction of rod loads and pin reversals more difficult.
Maintenance Issues	• Hydraulic system requires maintenance: dual supply and return filters; float, pressure, and temperature switches; hydraulic oil lines, pumps, and heater/cooler; and oil maintenance program. • Wear of valve sealing elements due to the finger type device. • OEM provides an overhaul schedule for each component. • Need to remove the device to service the suction valve.
Miscellaneous Notes	• Not suited for harsh environment, such as gas gathering. • Hydraulic pressure and timing are used to dampen the force exerted on the valve elements due to the fingers.
Economic Considerations	• Capital: High • Operating: Medium • Maintenance: Medium • Other: Losses associated with back-flow of suction gas.

End Deactivation:
Internal Cylinder Body Ports

Relative Advantages	• Easy to automate • Can be used on either end of cylinder • Unloading accomplished independent of valves and gas passages
Relative Disadvantages	• Cannot be retrofitted • Adds fixed clearance in most cases • Limited practicality on short stroke compressors • Stepped unloading
Pre-installation Issues	• Port is built into cylinder by OEM • Requires control and vent systems, if pneumatic
Post-installation Issues	• Performance is only controlled within limits of the device •
Performance Notes	• Unit performance can be adjusted during operation
Maintenance Issues	• 1-5 year service intervals on actuators • Gaskets, seals and electrical devices • Vent lines must be kept clear
Miscellaneous Notes	• Tends to be used only on long stroke cylinders with space for porting.
Economic Considerations	• Capital: Low (inherent part of cylinder design) • Operating: Low • Maintenance: Low • Other:

End Deactivation:
Valve Seal Element Opening – Finger Type Devices

Relative Advantages	• Easy to automate • May be used to deactivate either end • May be retrofitted to most compressor cylinders • Large unloading step
Relative Disadvantages	• Stepped unloading • Mechanical complexity may limit reliability • Increased valve pocket losses during normal operation • Use limited by suction pressure (e.g. high pressure cylinder with small valves)
Pre-installation Issues	• Requires control and vent systems • May not be required on all suction valves • Limited use on cylinders with small valves
Post-installation Issues	• Unit performance can be adjusted during operation • Prolonged use of multiple devices may cause overheating
Performance Notes	• Fingers create additional valve losses during normal operation • Consider effect on interstage pressure when activated
Maintenance Issues	• Finger mechanism requires precision rebuilding • Limited valve seat re-machining possible • 1-5 year service intervals on actuators • Gaskets, seals and electrical devices • Vent lines must be kept clear
Miscellaneous Notes	• Breakage of fingers may cause consequential cylinder and/or piston damage.
Economic Considerations	• Capital: Medium • Operating: Medium • Maintenance: Medium • Other:

End Deactivation:
Valve Seal Element Opening via Rotary Poppet Devices

Relative Advantages	• Easy to automate • May be used to deactivate either end • Efficient • Large unloading step
Relative Disadvantages	• Stepped unloading • May add significant fixed clearance
Pre-installation Issues	• Requires control and vent systems
Post-installation Issues	• Unit performance can be adjusted during operation
Performance Notes	• Consider effect on interstage pressure when activated
Maintenance Issues	• Limited valve seat re-machining possible • 1-5 year service intervals on actuators • Gaskets, seals and electrical devices • Vent lines must be kept clear
Miscellaneous Notes	•
Economic Considerations	• Capital: Medium • Operating: Low • Maintenance: Low • Other:

End Deactivation:
Valve Assembly Lifter

Relative Advantages	• Efficient method of end deactivation • May be used to deactivate either end • May be retrofitted to most compressor cylinders • Large unloading step
Relative Disadvantages	• Usually requires valve redesign for lifting • Mechanical complexity may limit reliability • Stepped unloading
Pre-installation Issues	• Requires control and vent systems
Post-installation Issues	• Unit performance can be adjusted during operation
Performance Notes	• Consider effect on interstage pressure when activated
Maintenance Issues	• 1-5 year service intervals on actuators • Gaskets, seals and electrical devices • Vent lines must be kept clear x
Miscellaneous Notes	• Sealing issues around valve during normal use need to be monitored
Economic Considerations	• Capital: Medium • Operating: Low • Maintenance: Low to Medium • Other:

End Deactivation:
Valve Plug-type Bypass

Relative Advantages	• Can be used to deactivate either end of cylinder • Large unloading step • May be retrofitted to most cylinders
Relative Disadvantages	• Requires a reduction of valve flow area • Stepped unloading • If new valves are required to keep same flow areas, then resulting designs will often increase unit's fixed clearances.
Pre-installation Issues	• Adds a small amount of fixed clearance to cylinder • Reduced flow area of the valve increases valve losses • Requires control and vent systems
Post-installation Issues	• Unit performance can be adjusted during operation
Performance Notes	• Consider effect on interstage pressure when activated
Maintenance Issues	• 1-5 year service intervals on actuators • Gaskets, seals and electrical devices • Vent lines must be kept clear
Miscellaneous Notes	•
Economic Considerations	• Capital: Medium • Operating: Medium • Maintenance: Low • Other:

End Deactivation:
Front Head End Plug-type Bypass

Relative Advantages	• Efficient means of deactivating head end • Large unloading step • Does not compromise valve area or performance • May be retrofitted to most cylinders • Easily automated
Relative Disadvantages	• Application limited to head end • Requires external piping connection to suction header or valve cap • Stepped unloading
Pre-installation Issues	• Requires external piping • Adds a small amount of fixed clearance to head end of cylinder • Requires control and vent systems
Post-installation Issues	• Unit performance can be adjusted during operation
Performance Notes	• Efficient; low parasitic loss when activated • Small added fixed clearance when deactivated
Maintenance Issues	• Internal actuator requires disassembly for servicing • 1-5 year service intervals on actuators • Gaskets, seals and electrical devices • Vent lines must be kept clear
Miscellaneous Notes	• May include a fixed volume pocket in its design.
Economic Considerations	• Capital: Medium • Operating: Low • Maintenance: Low • Other:

Unit/Stage Bypass:
External Piping Bypass

Relative Advantages	• Simple operation • Can reduce downstream flow from 0% to 100% • Reliable • Effective for unloading compressor for start-up • Required hardware for most installations
Relative Disadvantages	• Very inefficient – does not unload the compressor in normal operating range! • Large pressure drops across throttle valve may cause freeze-up, liquid formation or hydrate formation • Requires gas cooling (of bypass gas) to prevent overheating the compressor
Pre-installation Issues	• Proper control valve and line sizing • Coded piping or vessel connections • Requires control system
Post-installation Issues	• Control valve freeze up • High energy cost when in use • Unit performance can be adjusted during operation • Prolonged use will cause overheating unless recycled gas is cooled
Performance Notes	• Least efficient method of capacity control
Maintenance Issues	• Minimal
Miscellaneous Notes	• Standard method of capacity found in most simple control panels.
Economic Considerations	• Capital: Medium • Operating: Very high • Maintenance: Low • Other:

DEVICE RATING SUMMARY *(Table 1 of 3)*

DEVICE	INSTALLED COST	EFFICIENCY	ADAPTABILITY	SIMPLICITY	AUTOMATABLE
Variable Speed Control	●●●●●	●●●●●	●○○○○	●●●●●	●●●●●
Unit / Stage Bypass	●●●○○	●○○○○	●●●○○	●●●●●	●●●●●
Throttling of Operating Conditions	●●●●○	●●○○○	●●●●○	●●●●●	●●●●●
End Deactivation (Internal Body Ports)	●●●●●	●●○○○	●○○○○	●●●●○	●●●●●
End Deactivation (Finger Type Valve Unloaders)	●●●○○	●●○○○	●●●○○	●●●●○	●●●●●
End Deactivation (Plug Type Valve Unloaders)	●●●○○	●●○○○	●●●○○	●●●●○	●●●●●
End Deactivation (Radial Poppet Unloaders)	●●●○○	●●○○○	●●●○○	●●●●○	●●●●●
End Deactivation (Valve Assembly Lifter)	●●●○○	●●○○○	●●●○○	●●●○○	●●○○○

In general, more black circles ● are better. If grey circles ● are shown, treat as white ○ on existing units, and as black ● on new units.

DEVICE RATING SUMMARY *(Table 2 of 3)*

DEVICE	INSTALLED COST	EFFICIENCY	ADAPTABILITY	SIMPLICITY	AUTOMATABLE
End Deactivation (Front Head Plug Type Bypass)	●●●○○	●●○○○	●●●○○	●●●●○	●●●●●
Displacement Changes	●●●○○	●●●○○	●●●○○	●○○○○	○○○○○
Added Fixed Clearance (Clearance Plugs and Bottles)	●●●●●	●●●○○	●●●●●	●●○○○	○○○○○
Added Fixed Clearance (Valve Spacers)	●●●●●	●●●○○	●●●●●	●●○○○	○○○○○
Added Fixed Clearance (Piston Modifications)	●●●●○	●●●○○	●●●●○	●○○○○	○○○○○
Added Fixed Clearance (Front Head Spacers)	●●●●●	●●●○○	●●●●○	●●○○○	○○○○○
Adjustable Head End Suction Valve	●○○○○	●●●○○	●○○○○	●●○○○	●●○○○
Added Variable Volume Clearance (Manual Screw Type)	●●●●○	●●●○○	●○○○○	●●○○○	○○○○○

In general, more black circles ● are better. If grey circles ● are shown, treat as white ○ on existing units, and as black ● on new units.

DEVICE RATING SUMMARY *(Table 3 of 3)*

DEVICE	INSTALLED COST	EFFICIENCY	ADAPTABILITY	SIMPLICITY	AUTOMATABLE
Added Variable Volume Clearance (Hydraulic Assisted)	●●○○○	●●●○○	●●○○○	●●●●○	●●●●○
Added Variable Volume Clearance (Gas Pressure Controlled)	●●●○○	●●●○○	●●○○○	●●●○○	●●●●○
Added Fixed Volume Clearance Devices (Front Head Volume Pockets)	●●●○○	●●●○○	●●●○○	●●●●○	●●●●●
Added Fixed Volume Clearance Devices (Valve Cap Volume Pockets)	●●●○○	●●●○○	●●●○○	●●●●○	●●●●●
Added Fixed Volume Clearance Devices (Internal Body Volume Pockets)	●●●●●	●●●○○	●●●●●	●●●●○	●●●●●
Timed Valve Closing	●○○○○	●●○○○	●●○○○	●●●●●	●●●●○

In general, more black circles ● are better. If grey circles ● are shown, treat as white ○ on existing units, and as black ● on new units.