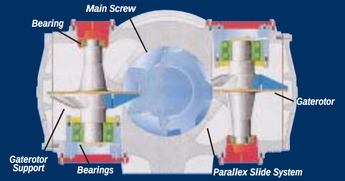
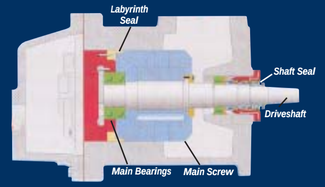
Single Screw Compressors

Design & Operation



The standard Vilter Single Screw Compressor (as shown in this end view drawing) consists of two rotating gaterotor assemblies and a main screw assembly. All bearings are pressure fed with oil.



This side view cross-sectional drawing of a Vilter oil flooded Single Screw illustrates the suction and the discharge ports as well as the various seals and driveshaft.

The Vilter Single Screw compressor is a rotary, positive displacement compressor which incorporates a main screw and two gaterotors. Compression of the gas is accomplished by the engagement of the two gaterotors with the helical grooves in the main screw. The drive shaft imparts rotary motion to the main screw which in turn drives the intermeshed gaterotors.

The compressor is comprised of three fundamental components which rotate and complete the work of the compression process. This typically includes a cylindrical main screw with six helical grooves and two planar gaterotors, each with 11 teeth. The rotational axes of the gaterotors are parallel to each other and mutually perpendicular to the axis of the main screw.

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An employee-owned company

District Sales Offices & Distributors Worldwide

Tradition & Technology

Together. Working For You.

VSS Single Screw Compressor

Featuring Vilter's 5/15 warranty

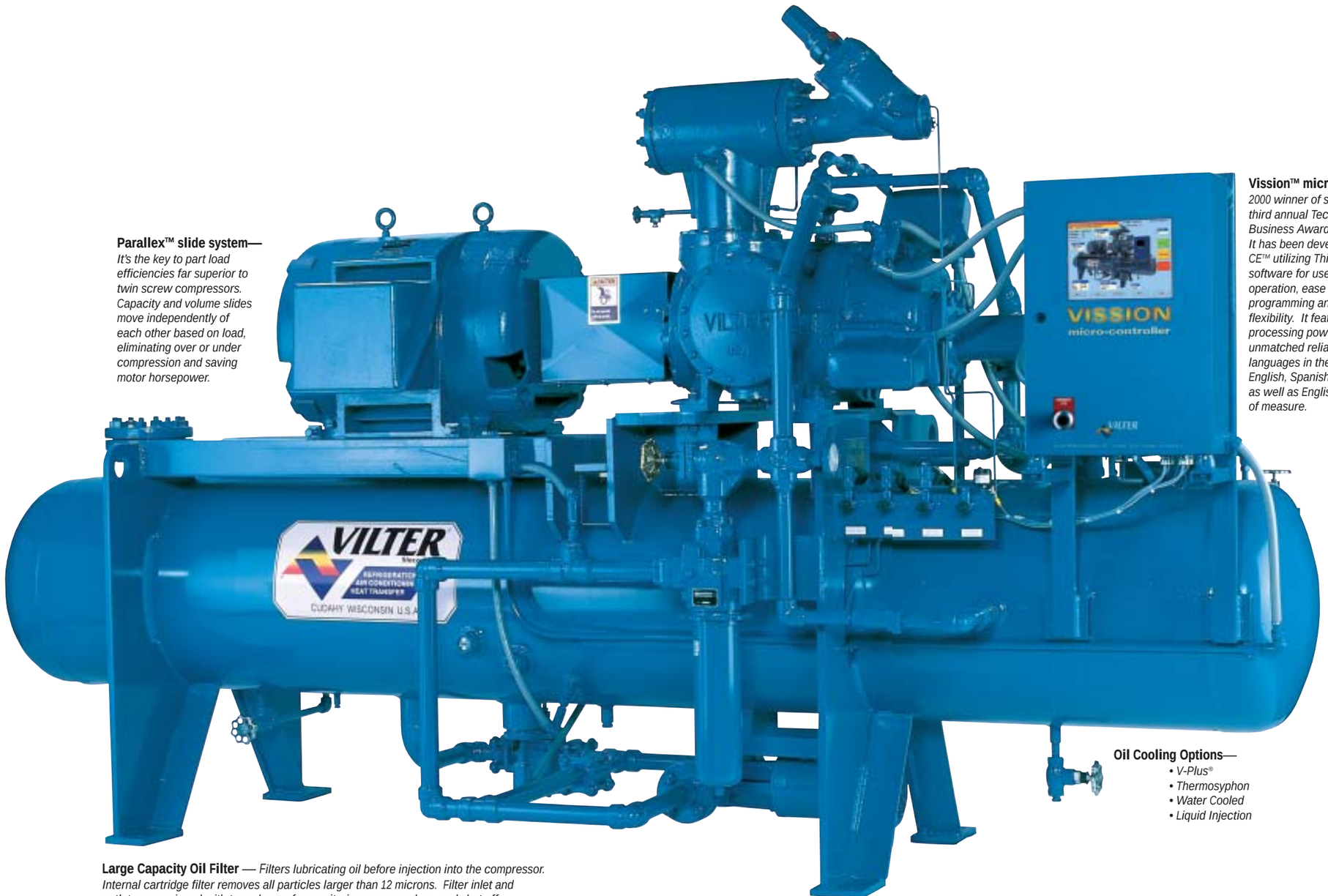
Tradition & Technology

Together. Working For You.

Vilter's VSS line of single screw compressors delivers higher performance than twin screw compressors and have fewer moving parts than reciprocating compressors. The key to Vilter's single screw compressor reliability is its balanced design. This inherent design advantage allows Vilter to offer the 5/15, a five-year warranty on internal components and a fifteen-year warranty on bearings, the industry's longest. The balanced design results in ultra-low bearing loads with significantly decreased vibration and sound levels. The addition of Vilter's exclusive Parallex slide system allows the compressor to run at optimum efficiency.

5/15 WARRANTY™

Parallex™ slide system— *It's the key to part load efficiencies far superior to twin screw compressors. Capacity and volume slides move independently of each other based on load, eliminating over or under compression and saving motor horsepower.*



Vission™ micro-controller— *2000 winner of start magazine's third annual Technology & Business Award competition. It has been developed in Windows CE™ utilizing Think and Do™ software for user-friendly operation, ease of custom programming and maximum flexibility. It features dual processing power providing unmatched reliability. Standard languages in the controller are English, Spanish and French, as well as English or SI units of measure.*

Oil Cooling Options—
- *V-Plus®*
- *Thermosyphon*
- *Water Cooled*
- *Liquid Injection*

Large Capacity Oil Filter — *Filters lubricating oil before injection into the compressor. Internal cartridge filter removes all particles larger than 12 microns. Filter inlet and outlet are equipped with transducers for monitoring pressure drop, and shut off valves for servicing. Available with dual oil filters.*

VSS Specifications

Vilter Model Number	CFM	Base Rating (a) Ammonia Tons	Ammonia BHP	R-22 Tons	R-22 BHP	Std. Conn Sizes Suction (b)	Discharge(b)	Unit Dimensions (Approximate) A (b) Length	B (b) Width	C (b) Height	D (c) opt. Dual Oil Filter	E (c) Oil Cooling	F (c) optional Oil Cooler	Approx. Shipping (d) Weight (lbs)
VSS-751	778	303	331	285	327	5	4	12'-7"	3'-7"	8'-0"	4'-4"	1"	16"	5300
VSS-751E		331	350	310	337									
VSS-901	880	342	363	322	360	5	4	12'-7"	3'-7"	8'-0"	4'-4"	1"	16"	5350
VSS-901E		375	384	351	370									
VSS-1051	1070	422	462	398	457	5	5	14'-0"	4'-1"	8'-8"	4'-10"	0	16"	6600
VSS-1051E		462	488	433	470									
VSS-1201	1193	471	500	444	495	6	5	14'-0"	4'-1"	8'-10"	4'-10"	0	16"	6800
VSS-1201E		516	528	483	509									
VSS-1501	1467	591	646	556	639	6	5	14'-2"	5'-8"	9'-10"	5'-8"	0	17"	9200
VSS-1501E		647	683	605	658									
VSS-1801	1717	691	734	651	726	8	5	14'-2"	5'-8"	9'-10"	5'-8"	0	17"	9300
VSS-1801E		757	776	708	747									

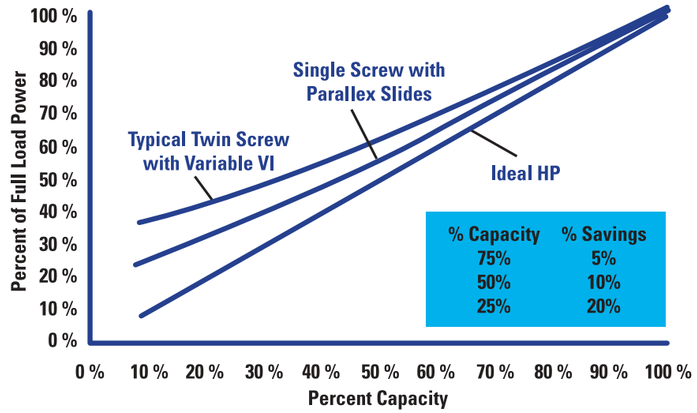
(a) Tons and CFM based on 20°F and 95°F; 10°F liquid subcooling, saturated suction. Ratings for other refrigerants are available - Consult home office.

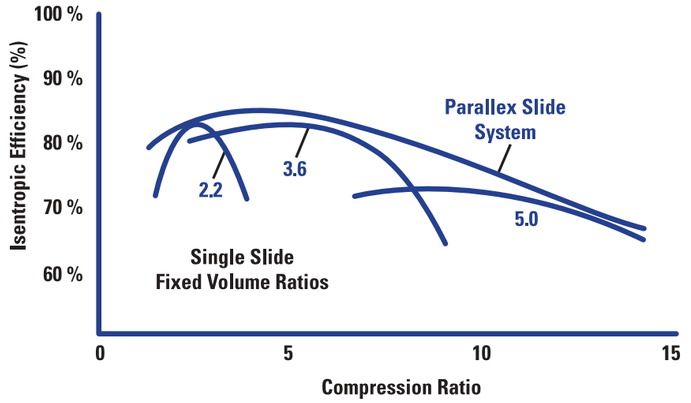
(b) Dimensions shown are approximate and for ammonia high stage units. Other refrigerants and booster units may have different dimensions.

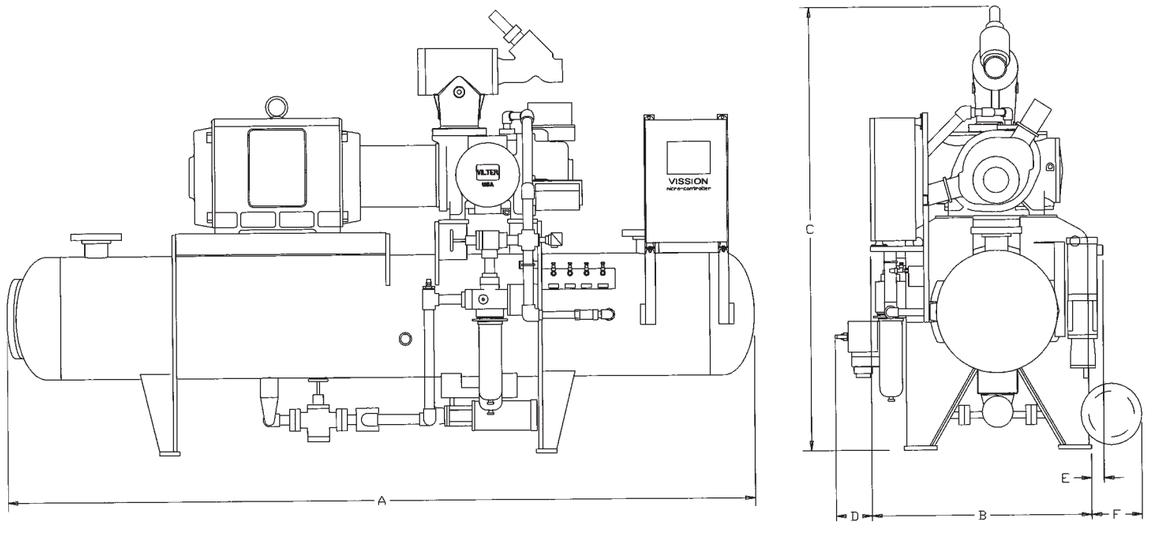
(c) Maximum addition (including safety valve) to width of compressor package.

(d) Without motor; with liquid injection oil cooling. Units with external cooler will weigh approximately 500 pound more.

"E" models above are Econ-o-Mizer® models



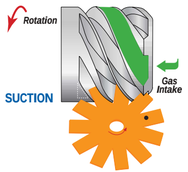




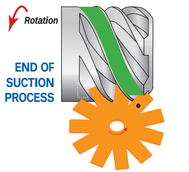
The VSS

The VSM, a more compact model

SUCTION PROCESS

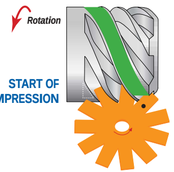


As the groove increases to maximum, the gas flows into the open grooves.

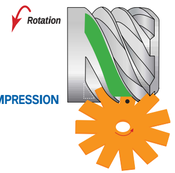


When the groove reaches its maximum length or volume, the groove is closed by the gaterotor and contained within the housing.

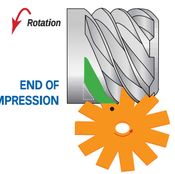
COMPRESSION PROCESS



The gas is trapped in the groove at suction pressure.

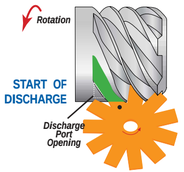


As the groove volume is decreased, the pressure in the groove increases.

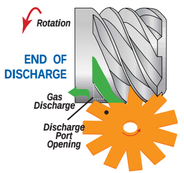


The gas continues to be compressed until it reaches the minimum volume and maximum pressure for the application.

DISCHARGE PROCESS

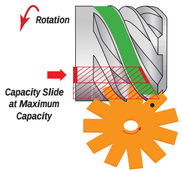


The gas in the groove is at discharge pressure. The main screw aligns with the discharge port in the housing and pushes the gas through the port into the discharge chamber.

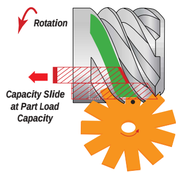


All of the gas that was trapped in the groove is pushed out. The volume of the groove is reduced to zero.

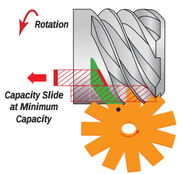
CAPACITY CONTROL



The maximum volume of gas is trapped in the groove.

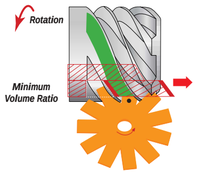


Approximately 50% of the volume of the groove is trapped and allowed to be compressed.

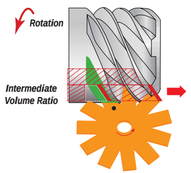


Approximately 20% of the volume of the groove is trapped and allowed to be compressed.

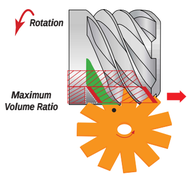
VOLUME RATIO CONTROLS



The discharge port opens early in the cycle allowing only a small reduction in volume and a small increase in pressure.

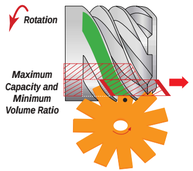


The discharge port opens later in the cycle allowing a significant reduction in volume and a significant increase in pressure.

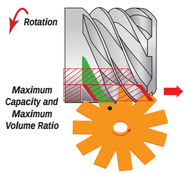


The slide and resulting discharge port location are in the maximum position resulting in the maximum reduction in volume and a maximum increase in discharge pressure.

CAPACITY & VOLUME RATIO CONTROLS



The capacity slide is set to compress the maximum (100%) of the swept volume while the volume slide is set to allow a minimal increase in discharge pressure.



The capacity slide is set to compress the maximum (100%) of the swept volume while the volume slide is set to allow a maximum increase in discharge pressure.

Theory

The compression cycle begins after suction gas fills the top and bottom grooves of the main screw at the suction end of the casing. Since the screw compressor has two gaterotors, the compression process occurs simultaneously on opposite sides of the screw; the top and bottom. As the main screw rotates, it in turn drives the gaterotors. The engagement of the gaterotor with a screw groove traps the suction gas and begins the compression process. As the screw rotates, the engagement of the gate rotor continues, thus reducing the initial volume of the groove and increasing the pressure in the groove. Once again this occurs simultaneously on opposite sides of the screw.

Finally, as the main screw rotates toward the completion of the compression cycle, the groove aligns with a port in the housing at the discharge end of the casing. The gas and any liquid in the groove are radially discharged through the port into the discharge plenum. Since there are six grooves in the main screw, the compression process simultaneously occurs six times in two locations per revolution of the screw. Operation at 3600 RPM results in 21,600 simultaneous compression strokes at the top and bottom grooves per minute and a relatively smooth flow of discharge gas.

Balanced Loading

One advantage of the Single Screw compressor is the fact that there are no net radial or axial forces exerted on the mains screw or drive shaft components due to the work of compression. Since the compression process occurs symmetrically and simultaneously on opposite sides of the screw, the forces due to compression are canceled out. The only vertical loads exerted on the main screw bearings are due to gravity. Since the discharge end of the screw is vented to suction, the suction gas pressure is exerted on both ends of the screw resulting in balanced axial loads.

The Single Screw has an inherent design advantage of reduced loading during the compression process. This is due to the fact that the gaterotor tooth area decreases as the gas pressure in the groove approaches discharge pressure. When the gaterotor first engages with the main screw the compression process begins. As rotation continues, the gate rotor tooth area exposed to the gas pressure increases. The resultant force creates the axial loads on the gate rotor assembly. Approximately half way through the stroke, or when the radial axis of the gaterotor is perpendicular to the rotational axis of the main screw, the maximum area of the gate rotor is exposed to the gas pressure. As the compression cycle continues, the pressure within the groove increases but the area of the gate rotor exposed to the discharge pressure continues to decrease. The lower loads transmitted to the components and bearings result in higher reliability. At the end of the stroke, the area of the gate rotor has been reduced to zero as it disengages from the main screw.

Another design feature of the Single Screw compressor that enhances reliability is the loads on the gate rotor assemblies are well defined and isolated from the main screw. Since the gaterotor assemblies are independent and do not interfere with the rest of the main screw body, bearings can be sized for maximum reliability.

Sealing During Compression

Sealing is accomplished by the combination of precision running clearances and an injected liquid (coolant/lubricant) which is allowed to leak through and thus seal the clearances during the compression process. In the Single Screw compressor, this liquid must also have adequate viscosity to lubricate the bearings. The liquid is swept into the groove during the suction process and also injected into the compression groove during the compression process to maximize sealing of the running clearances.

Due to the rotation of the screw, centrifugal force impels the injected liquid to the circumferential clearance volume between the screw and the housing. This minimizes the leakage described as cascading. Cascading is defined as the leakage from the high pressure groove past the land separating the grooves into the trailing low pressure groove. Another inherent attribute of the Single Screw design is that there is more surface area on the lands near the discharge end of the groove than near the middle of the groove. This attribute also minimizes leakage from the highest pressure region of the groove. Another area where the leakage is minimized is between the high pressure end of the groove to the volume behind the screw which is at suction pressure. This potential leak path is sealed by means of a non-contacting hydrodynamic seal known as a viscoseal, windback seal, or labyrinth seal.

Shaft Seal System

A shaft seal system prevents any of the process gas from leaking around the drive shaft of the main screw to the environment. The oil flooded Single Screw compressor has two seal types; the standard single mechanical face seal or a triple mechanical face seal with purge capabilities depending on the process requirements. The stationary carbon face of the seal rides on a hydrodynamic film of oil on the rotating mating ring which is fixed on the shaft. The optional triple seal allows various options including a purge and vent to be connected to the housing thus adding a secondary safety buffer during operation. The incorporation of this seal is shown in the cross-section of the oil flooded gas end.

Design

Each rotating assembly within the gas end has two sets of bearings. A typical oil flooded Single Screw compressor consists of two rotating gaterotor assemblies and a main screw assembly, each having one pair of angular contact bearings to maintain axial position of the assembly and a cylindrical roller bearing to support the opposite end. All of the bearings are pressure fed with oil. The oil, upon draining from the bearings, is drawn into the suction of the main screw and is discharged with the process gas and injected oil. Since the main screw has no loads except for gravity, the bearings are considered over designed since they are determined by the required shaft diameter for the applied horsepower. The Single Screw design does not restrict the bearing sizes for the gaterotor supports. As a result, the bearings are optimized for maximum reliability.

Slide Design

The dual slide design on the Vilter Single Screw compressor offer the highest level of flexibility and performance optimization for screw compressors. This design actually has two slides per compression side of the gas end. The two slides are commonly referred to as the capacity slide and the volume slide. The capacity slide moves from positions of 20% to 100% of flow to allow the compressor to match the system flow requirements. Although lower flow rates are possible, they are not recommended since this reduces the amount of oil flowing through the gas end and may result in overheating. The volume slide allows the discharge port to be positioned in the optimum location depending on the capacity slide location, the properties of the gas and the injectant.

A unique feature of the dual slide design is that it allows the compressor to start completely unloaded. This is unlike any other screw compressor. When both slides are in the open position an unrestricted flow path through the compressor is created.. If for any reason the gas end is completely full of oil, the position of the slides on startup will allow the oil to be swept out of the gas end thus preventing the possibility of hydraulic lock. The slides also allow the operation at extremely low ratios down to 1.2. However, the recommended operating points for optimum design efficiency occurs at pressure ratios of 2.0 and greater. Due to their design, Single Screw compressors are able to operate more efficiently and reliably with higher suction pressures and lower ratios than other types of screw compressors.

Since the capacity and volume slides operate in parallel (not in series like other types of screw compressors), an important feature of the Singe Screw compressor is the ability to operate with optimum efficiency even at part load conditions. Other types of screw compressors have dual slides which operate in series. This results in one of the slides blocking off some of the porting behind the other slide creating a restriction and performance penalty at part load conditions.

Conclusion

The Vilter single screw compressor with the 5/15-year warranty and Parallex™ slide system makes it the most efficient and reliable compressor in the world. It's superior to any other single screw and most certainly every twin screw.

Thousands of single screws are in operation worldwide for gas compression, air conditioning, refrigeration, and petrochemical industries.