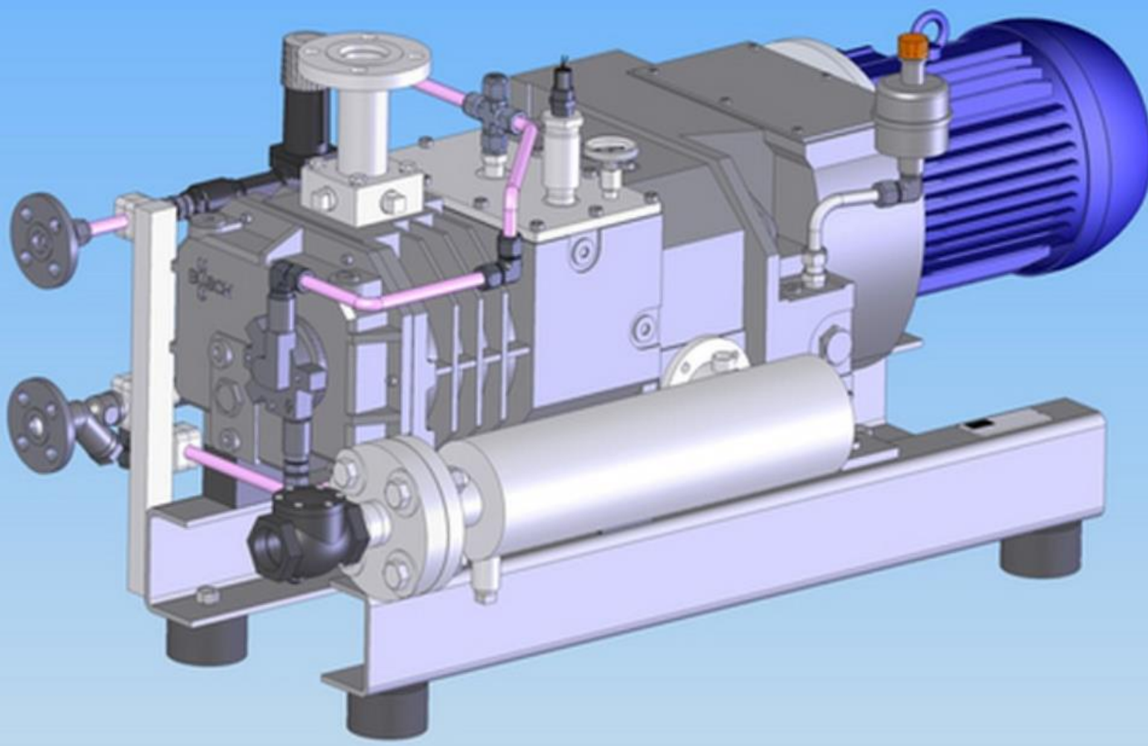

ROTARY VANE VACUUM PUMPS

CONTROL

SPECIALTIES, INC.

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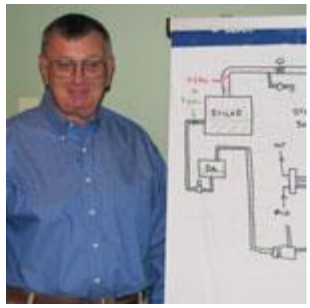
Rotary Vane Vacuum Pumps

BIOGRAPHY OF EDWARD MOSCHETTI

Edward brings over 50 years of knowledge and experience to the manufacturing, medical, university, and commercial arenas. His education background includes a degree in physics from Muhlenberg College. The last 30 years have been devoted to providing solutions to industrial facilities geared around plant utilities and processes. He has spearheaded energy teams in major corporations resulting in the savings of energy dollars as well as building/designing small to medium size boiler facilities.



Preface

A vacuum pump is simply a device that moves air into or out of something else. Sometimes it removes gas from an area, leaving a partial vacuum behind; other times a vacuum pump will remove water from one area to another, as a sump pump does in a basement. Vacuum pumps are used in an industrial setting to produce vacuum tubes and electric lamps, and to process semiconductors. They can also produce a vacuum that can then be used to power a piece of equipment. In aircraft, for example, the gyroscopes located in some of the flight instruments are powered by a vacuum source in case of an electrical failure.

There are as many vacuum pumps as there are uses for them. We will focus this E-Book on Rotary Vane Vacuum pumps. We will also cover general principals on the use of vacuum.

Chapter 1- Moving Air Molecules

A **vacuum pump** is a device that removes gas molecules from a sealed area in order to leave behind a partial vacuum. Compressors, blowers, and vane type pumps are all designed to move air which creates either vacuum or positive pressure. All compressors are vacuum pumps and all vacuum pumps are compressors. Confusing? The air molecules being removed from a space create a vacuum (absence of molecules) and molecules added to a space create pressure (surplus of molecules). Compressors, blowers, and vane type pumps are really molecule movers.

Vacuum pumps are used in a variety of process plants to pump air, water vapor, organic and inorganic solvents and acids. There are many different types of vacuum pumps on the market today that meet special needs in pumping various gases.

ROTARY VANE:

Rotary vane vacuum pumps are oil sealed pumps or dry (no oil) and used for pumping clean, dry, non-reactive gases. These pumps are usually air-cooled, direct-drive 1750 rpm pumps with a small footprint for space savings. Reliability is excellent with regular oil changes or dry vane inspections combined with periodic vane and filter changes which is required to keep maximum up-time. Pricing is very moderate given the vacuum levels they produce.

LIQUID RING:

Liquid ring vacuum pumps are used for moderate to heavy vapor load conditions. A liquid sealant is used with operational vacuum limited to about 30 Torr. Lower vacuum levels are obtainable with the use of oil, glycol or other low vapor pressure fluid. This type of pump is desirable because it can be sealed with a fluid compatible with the process gas/vapor that would harm other type of pumps (i.e.: oil sealed) and is relatively inexpensive. Reliability is high because of its simplicity.

ROTARY PISTON:

Rotary piston vacuum pumps are industrial grade heavy duty pumps made to produce a vacuum in the range of 50-.1 Torr. These pumps are used where contaminants are high and must be handled by the pump. Reliability is moderately high given the abuse these pumps are subjected to. Pricing reflects the performance of these pumps as high vacuum producers while also being able to handle large amounts of contaminants.

DRY VACUUM PUMPS:

Dry vacuum pumps are machines that compress gasses without the aid of a sealing fluid such as oil or water. They are used in extremely corrosive applications where pump failure will occur, or where environmental concerns are present. Vacuum range is from atmosphere to .10 mm Hg. Designs include SCREW, LOBE, and CLAW.

VACUUM BOOSTERS:

Rotary lobe "Roots" vacuum boosters are used to extend the vacuum level and/or the pumping capacity of the vacuum pump by a factor of 2-10. The boosters are gas "accelerators" which increase the flow rate of gas being fed to the vacuum pump, therefore, increasing the capacity of the existing vacuum equipment.

Chapter 2 – Vacuum Charts

Vacuum measurement units can be confusing since many units have evolved over the years. From a simple point of view we can break vacuum usage into five ranges –

	Pressure *(Pa)*
Low vacuum	$1x10^{5}$ to $3x10^{3}$
Medium vacuum	$3x10^{3}$ to $1x10^{-1}$
High vacuum	$1x10^{-1}$ to $1x10^{-7}$
Ultra high vacuum	$1x10^{-7}$ to $1x10^{-10}$
Extremely high vacuum	$1x10^{-10}$
Perfect vacuum	0

http://www.engineeringtoolbox.com/vacuum-converter-d_460.html

Notice the first line in the chart below is atmospheric pressure at sea level and 0% vacuum. The last line on the chart would be deep outer space with 100% vacuum and no air or gas molecules present. It is important to recognize that achieving vacuum levels into the 99-99.5% range is not overly costly. Once your requirements go beyond these levels, costs will escalate quickly so be realistic on vacuum levels you think you might require as opposed to what will actually get the job done. Typically regenerative blowers will move 30 to 60 cfm of air per horsepower. They generate pressures to ~ 7 psig and vacuum to ~ 12" Hg meaning a regenerative blower, if it will meet your requirements, is a much better solution with less operating costs than a rotary vane pump.

Moving molecules can be expensive if you do not consider your end requirements. Assume you need 30 cfm at 5 psig for clearing debris from an area. Using a positive displacement air compressor will require ~ 6 horsepower when a 1 horsepower blower will generate the same air volume. The savings using a blower amounts to 5 horsepower or 3.73 kilowatts of electricity. If you need this air for 400 hours a month, electrical savings would be $1,790 ($.10 per kWh) per year using a blower. Electrical savings would pay for the blower. Further benefits include no friction losses in the compressed air piping and reduced maintenance.

From the Engineering Tool Box website the following chart is useful to compare various vaccum measurements –

% Vacuum	Torr (mm Mercury)	Micron	psia, (lb/in^2 abs)	Inches Mercury Absolute	Inches Mercury Gauge	kPa abs
0.0	760.0	760,000	14.7	29.92	0.00	101.4
1.3	750.0	750,000	14.5	29.5	0.42	99.9
1.9	735.6	735,600	14.2	28.9	1.02	97.7
7.9	700.0	700,000	13.5	27.6	2.32	93.5
21.0	600.0	600,000	11.6	23.6	6.32	79.9
34.0	500.0	500,000	9.7	19.7	10.22	66.7
47.0	400.0	400,000	7.7	15.7	14.22	53.2
50.0	380.0	380,000	7.3	15.0	14.92	50.8
61.0	300.0	300,000	5.8	11.8	18.12	40
74.0	200.0	200,000	3.9	7.85	22.07	26.6
87.0	100.0	100,000	1.93	3.94	25.98	13.3
88.0	90.0	90,000	1.74	3.54	26.38	12
89.5	80.0	80,000	1.55	3.15	26.77	10.7
90.8	70.0	70,000	1.35	2.76	27.16	9.3
92.1	60.0	60,000	1.16	2.36	27.56	8
93.0	51.7	51,700	1.00	2.03	27.89	6.9
93.5	50.0	50,000	0.97	1.97	27.95	6.7
94.8	40.0	40,000	0.77	1.57	28.35	5.3
96.1	30.0	30,000	0.58	1.18	28.74	4
96.6	25.4	25,400	0.49	1.00	28.92	3.4
97.4	20.0	20,000	0.39	0.785	29.14	2.7
98.7	10.0	10,000	0.193	0.394	29.53	1.3
99.0	7.6	7,600	0.147	0.299	29.62	1.0
99.87	1.0	1,000	0.01934	0.03937	29.88	0.13
99.90	0.75	750	0.0145	0.0295	29.89	0.1
99.99	0.10	100	0.00193	0.00394	29.916	0.013
99.999	0.01	10	0.000193	0.000394	29.9196	0.0013
100	0.00	0	0	0	29.92	0

http://www.engineeringtoolbox.com/vacuum-converter-d_460.html

For standard or normal pressure it is common to measure flow in standard cubic feet minute (SCFM). For vacuum, the air or gas is expanded and it is common to use actual cubic feet minute (ACFM). From the Engineering Tool Box website this is a handy reference chart to convert flows from SCFM to ACFM –

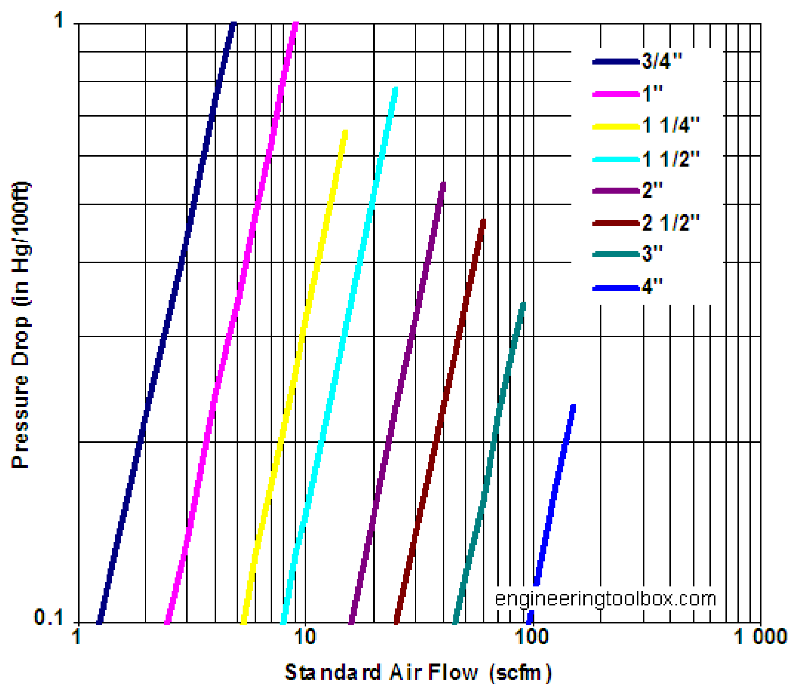
Conversion Factor from *scfm* to *acfm* (or *nl/s* to *al/s*)								
Pressure			Temperature (*^{o}F)*					
in Hg absolute	*in Hg gauge*	*kPa absolute*	0	30	60	90	120	150
29.92	0.00	101.42	0.88	0.94	1.00	1.06	1.12	1.17
28.92	1.00	98.03	0.92	0.97	1.03	1.09	1.15	1.21
27.92	2.00	94.64	0.95	1.01	1.07	1.13	1.20	1.26
26.92	3.00	91.25	0.98	1.05	1.11	1.18	1.24	1.30
25.92	4.00	87.86	1.02	1.09	1.15	1.22	1.29	1.35
24.92	5.00	84.47	1.06	1.13	1.20	1.27	1.34	1.41
23.92	6.00	81.08	1.11	1.18	1.25	1.32	1.40	1.47
22.92	7.00	77.69	1.15	1.23	1.31	1.38	1.46	1.53
21.92	8.00	74.31	1.21	1.29	1.36	1.44	1.52	1.60
20.92	9.00	70.92	1.27	1.35	1.43	1.51	1.60	1.68
19.92	10.00	67.53	1.33	1.42	1.50	1.59	1.68	1.76
18.92	11.00	64.14	1.40	1.49	1.58	1.67	1.76	1.86
17.92	12.00	60.75	1.48	1.57	1.67	1.77	1.86	1.96
16.92	13.00	57.36	1.56	1.67	1.77	1.87	1.97	2.07
15.92	14.00	53.97	1.66	1.77	1.88	1.99	2.10	2.20
14.92	15.00	50.58	1.77	1.89	2.01	2.12	2.24	2.35
13.92	16.00	47.19	1.90	2.03	2.15	2.27	2.40	2.52
12.92	17.00	43.80	2.05	2.18	2.32	2.45	2.58	2.72
11.92	18.00	40.41	2.22	2.37	2.51	2.65	2.80	2.94
10.92	19.00	37.02	2.42	2.58	2.74	2.90	3.06	3.21
9.92	20.00	33.63	2.67	2.84	3.02	3.19	3.36	3.54
8.92	21.00	30.24	2.97	3.16	3.35	3.55	3.74	3.93
7.92	22.00	26.85	3.34	3.56	3.78	4.00	4.21	4.43
6.92	23.00	23.46	3.82	4.07	4.32	4.57	4.82	5.07
5.92	24.00	20.07	4.47	4.76	5.05	5.35	5.64	5.93
4.92	25.00	16.68	5.38	5.73	6.08	6.43	6.78	7.13
3.92	26.00	13.29	6.75	7.19	7.63	8.07	8.51	8.95
2.92	27.00	9.90	9.06	9.66	10.25	10.84	11.43	12.02
1.92	28.00	6.51	13.79	14.68	15.58	16.48	17.38	18.28
0.92	29.00	3.12	28.77	30.65	32.52	34.40	36.27	38.15
0.82	29.10	2.78	32.28	34.38	36.49	38.59	40.70	42.80
0.72	29.20	2.44	36.76	39.16	41.56	43.95	46.35	48.75
0.62	29.30	2.10	42.69	45.47	48.26	51.04	53.83	56.61
0.52	29.40	1.76	50.90	54.22	57.54	60.86	64.18	67.50
0.42	29.50	1.42	63.02	67.13	71.24	75.35	79.46	83.57
0.32	29.60	1.08	82.71	88.11	93.50	98.89	104.29	109.68
0.22	29.70	0.75	120.31	128.15	136.00	143.85	151.69	159.54
0.12	29.80	0.41	220.56	234.95	249.33	263.72	278.10	292.49

http://www.engineeringtoolbox.com/vacuum-flow-measurement-d_836.html

Note that the conversions are both vacuum level and temperature dependent.

Here is a handy chart to help you with sizing vacuum lines –

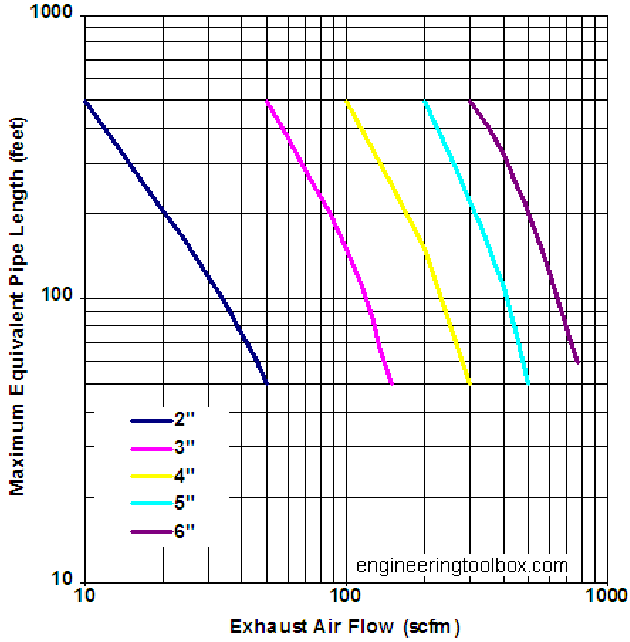
Air Flow - *scfm* - and Pressure Drop - *in Hg/100 ft*



http://www.engineeringtoolbox.com/vacuum-pipe-line-pressure-drop-d_1197.html

Use this chart to aid in sizing exhaust lines from vacuum pumps –

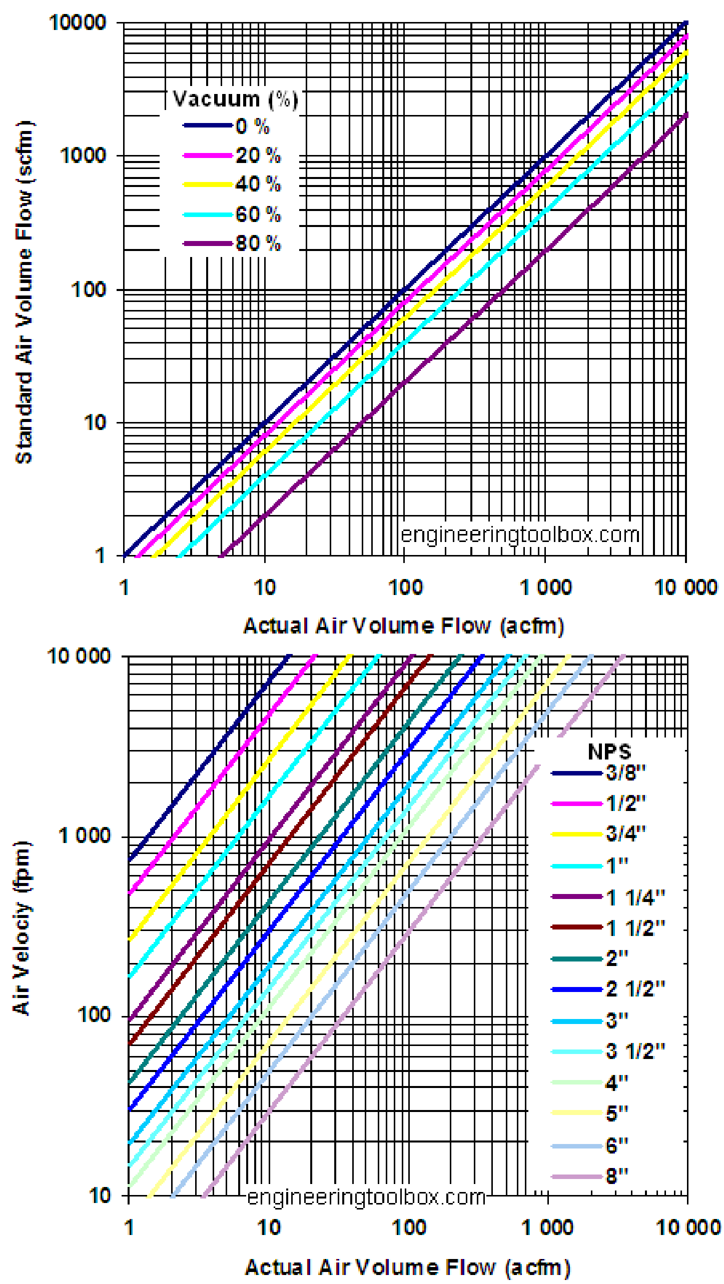
Air flow - *scfm*



http://www.engineeringtoolbox.com/vacuum-pumps-exhaust-piping-d_1198.html

Air velocity in vacuum pipes can be estimated with this chart –

Standard and Actual Air Volume - *cfm*



http://www.engineeringtoolbox.com/vacuum-pipes-air-velocity-d_1195.html

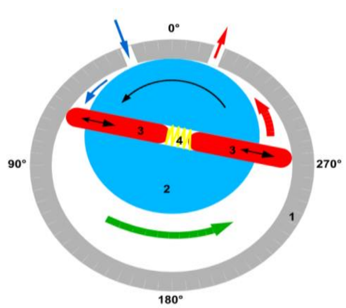
To properly size and select a vacuum pump you need the required vaccum levels as well as the required flow rates. Careful consideration should also be given to the nature of the flow through the vacuum pumps. Issues such as moisture, solids, contaminants, temperatures and duty cycles will point at which type of operating principal and pump is best suited for your application.

Chapter 3-Rotary Vane Vacuum Pumps

In this EBook we will focus on Rotary Vacuum pumps which are the most common type of pump in general use. They work well in a variety of applications and vacuum requirements. Offered in both dry (non-oil lubricated) and lubricated versions, we will explore the advantages and limitations of each. They can be used to generate both vacuum and lower pressure compressed air. Combined pumps are offered which provide both functions in one pump.

Vane type pumps move 15 to 20 cfm of air per horsepower. They generate pressures to 25 psig and vacuum to 29.84" Hg. Compared to many other styles of pumps, the ability to move higher volumes of air per horsepower can provide substantial power savings. One horsepower is equal to .7457 KW.

The simplest vane pump is a circular rotor rotating inside of a larger circular cavity. The centers of these two circles are offset, causing eccentricity. Vanes are allowed to slide into and out of the rotor and seal on all edges, creating vane chambers that do the pumping work. On the intake side of the pump, the vane chambers are increasing in volume. These increasing volume vane chambers are filled with air forced in by the inlet pressure. Inlet pressure is actually the pressure from the system being pumped, often just the atmosphere. On the discharge side of the pump, the vane chambers are decreasing in volume, forcing air out of the pump.



An eccentric rotary vane pump. Note that modern pumps have an area contact between rotor and stator (and not a line contact).
1. pump housing
2. rotor
3. vanes
4. spring

Equipment used to generate vacuum is similar to air compressors. It's even possible to generate compressed air or vacuum with the same machine, depending on how it is installed. Vacuum pumps generally can be considered as compressors in which the discharge, rather than the intake, is at atmospheric pressure. If you will recall, the essence of air compression is the increased number of molecular impacts per second. Conversely, the essence of vacuum generation is the reduction of these impacts. The vacuum in a chamber is created by physically removing air molecules and exhausting them from the system. Removing air from the enclosed system progressively decreases air density within the confined space, thus causing the absolute pressure of the remaining gas to drop. A vacuum is created. Because the absolute maximum pressure difference that can be produced is equal to atmospheric pressure (nominally 29.92 in. Hg at sea level), it is important to know this value at the work site.

The rotary vane design offers significant advantages: compactness, larger flow capacities for a given size, lower cost (about 50 percent less for a given displacement and vacuum level), lower starting and running torques; and quiet, smooth, vibration free, continuous air evacuation without a receiver tank.

Oil-less pumps are almost essential when production processes cannot tolerate any oil vapor carry over into the exhaust air. They also can be justified on the basis of avoiding the cost and time of regularly refilling the oil reservoirs. This is particularly important when the pumps are to be mounted in inaccessible locations.

Oil-lubricated types have distinct advantages if proper maintenance is provided. They can usually provide about 20 percent higher vacuums because the lubricant acts as a sealant between moving parts. They usually last about 50 percent longer than oil-less units in normal service because of their cooler operation. They also are less subject to corrosion from condensed water vapor.

Nothing mechanical is absolutely "maintenance-free." If we restrict the term to lubrication, then an oil-less vacuum pump can best satisfy this need, since periodic oiling is not required.

Rotary vane pumps offer continuous air removal characteristics without the extra cost and space requirements of a receiver tank. Rotary vane pumps have lower noise and vibration levels than reciprocating machines.

The rotary vane design is often selected because of its relative compactness and ease of installation. Typically rotary vane pumps can be set on the floor, or a suitable flat platform, and connections to the vacuum inlet are done using flexible hose, PVC piping, or hard piping if desired. The vacuum pump can, in many cases, be vented to the same space or if desired, vented through PVC pipe or flexible hose to an outside point.

Very short on/off cycles can cause serious problems. When vacuum is controlled by constantly starting and stopping a pump's drive motor, the motor's thermal overload device may be tripped. This will temporarily interrupt the power and result in a pump outage. In some intermittent-duty applications, it may be desirable to install an extra-large receiver tank to permit a longer off time, or a longer cooling period. This naturally will increase the time required for initial pump down. If this is unacceptable, one solution is to increase pump capacity. This will reduce both the time required for initial receiver evacuation and the proportion of its duty cycle that the pump spends running.

The rotary vane pump has its rotor installed directly on the motor shaft, and the rest of the pump is securely anchored to the motor frame. There is no need for baseplate mounting or for a power transmission component. Motor-mounted units are much more compact and lightweight than separate-drive pumps. The end plate on the newer rotary models can be easily removed to expose the vanes for inspection or replacement.

Chapter 4 – Care of Rotary Vane Vacuum Pumps

Rotary vane vacuum pumps can provide long trouble free hours of operation - if properly maintained on a regular basis. Procedures are simple, and since the pumps are usually accessible, regular maintenance is worth the effort.

Vacuum Pump Tips

Tips for Lubricated Pumps-

1. Check oil level daily, if low add oil
2. Use 30 weight non-detergent or proper synthetic blend
3. Change break-in oil at 100 hours of operation
4. Change oil every 500 hours or six months
5. Always change oil filters when changing oil
6. Check filters on a regular basis, clean or replace if dirty
7. Always check for water in the oil on wet applications
8. Change oil mist separators when changing oil
9. Lubricate bearings every 3000 hours or annually
10. Inspect vanes every 3000 hours or annually
11. If you hear abnormal sounds, shut it down immediately
12. Check for easy rotation of the rotor
13. Always bump the motor to confirm rotation is correct
14. If you need less than 25” Hg, consider an oil free pump

Tips for Oil Free Pumps-

1. Check filters on a regular basis, clean or replace when dirty
2. Check width of vanes for wear every 3000 hours
3. Always shut down a hot pump, check circulation
4. Replace all vanes at the same time
5. Lubricate bearings every 3000 hours or annually
6. Check for easy rotation of the rotor

Name plates on vacuum pumps can be confusing to decipher and yet they hold the key for ordering parts or a new pump. Many of the vacuum pumps in common use such as Becker and Rietschle (Werie) are of German origin. Three German words will help in the decoding process:

1. Druck = D = Pressure
2. Vakuum = V = Vacuum
3. Trochen = T = Dry

Pump capacities are measured in cubic meters per hour. With our knowledge of German now expanded to three words, let’s decipher some vacuum pump nameplates.

As an example using Becker, a common pump number is DVT 2.80 or DVT 3.80. The D indicates a pump capable of generating pressure. The V indicates a pump capable of generating vacuum. The T indicates a dry pump. The two or three indicate the generation of the pump with the three series being the most recent version. The 80 is the capacity of the pump in cubic meters per hour.

Rietschle (Werie) pumps require a little extra information to translate.

CL Oil Lubricated, 25-60 cubic meters per hour
DCLF Oil Lubricated, 40-130 cubic meters per hour
TR Dry Running, 10-80 cubic meters per hour
CLFT Dry Running, 60-140 cubic meters per hour

There are several videos on our website, www.control-specialties.com on vacuum pumps. A few are listed below:

Understanding Your Vacuum Pump Nameplate - Video

Length (1:24)
This power point helps explain how to decipher your vacuum pump nameplate to assist in getting the correct replacement parts or pump for you.

http://www.control-specialties.com/t254-understanding-your-vacuum-pump-nameplate.php

Preventative Maintenance on Vacuum Pumps - Video

Length (1:35)
This video powerpoint gives you preventative maintenance tips for both oil-lubricated and oil-free or dry vacuum pumps.

http://www.control-specialties.com/t257-preventative-maintenance-on-vacuum-pumps.php

Proper Vane Placement in a Vacuum Pump - Video

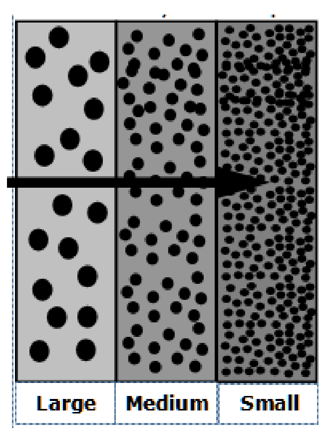
Length (1:13)
This powerpoint helps explain the proper vane placement in your vacuum pump. It includes visual pictures showing the proper way versus the incorrect ways.

http://www.control-specialties.com/t255-proper-vane-placement.php

Filters

Most rotary pumps have a built in inlet filter to protect the pump internals. Internal filters will handle inlet air to the pump with small to modest amounts of very small particles. If the suction connection to the pump is dirty, you should add an auxiliary inlet filter.

Filtering out contaminants should be treated as a progressive process. Think of throwing beach balls, basketballs, baseballs, and tennis balls into a wooded area. The large balls will drop out first and the small balls will penetrate further into the woods before hitting a tree and being knocked down. Filtration of suction air should also be treated in the same manner. By count, the number of smaller particles will outnumber larger particles by a substantial amount. To clean air effectively and not go insane changing filter elements requires a step approach. Take out the beach and basketballs first, then hard and soft baseballs, and finally the golf ball and smaller sized particles. Apply a golf ball filter to beach and basketball sized particles and you will quickly clog the filter leading to a major maintenance headache-frequent filter changes.



Not changing clogged inlet filters will lead to premature failure of the pump since the suction air allows for proper cooling of the pump. As pump temperatures rise, carbon vanes will undergo accelerated wear and oil in lubricate pumps will begin to cook and breakdown, leading to lubrication issues. Pay attention to filters in your pumps to avoid costly down time and repairs.

A costly mistake is to ignore noise coming from your pump since rotary vane pumps tend to be quiet in normal operation compared to other types of vacuum pumps. Since we repair pumps, we often see pumps which have been run as noise and temperature levels have risen above normal levels. This will only increase the damage to the pump and the resulting cost to repair the pump. If your pump noise and temperature levels are above normal levels, shut the pump down immediately.

Vacuum Leaks - A Simple Way to Find Them

Vacuum leaks are both expensive and difficult to find using conventional leak detection methods and equipment.

The easy and inexpensive solution is plastic film wrap, such as Saran Wrap, in our examples below. A leak from a positive pressure system such as compressed air and other compressed gases means you are looking for signs that molecules of the gas are escaping and will leave a detectable footprint. Common methods used are a soap and water solution as well as ultrasonic detection devices. The higher the pressure the easier it will be to detect the leak.

Vacuum is the absence of pressure above atmospheric pressure. At sea level atmospheric pressure is 14.7 pounds per square inch, so the pressure difference at the leak is small which means the detectable noise level will be very low.

To make matters worse, the air molecules are being pulled into the vacuum system so soap and water leak detection solutions will be sucked into the system so the bubble effect, which is a sign of a leak, would be missing.

Film wrap is very thin and tends to cling to most any surface. We can use this to our advantage to find vacuum leaks. Some examples of how you can use film wrap to find leaks-

• For pipe and hose joints wrap a piece of film around the suspect area and the leak source will quickly become apparent as it is sucked to the leak. This could also be an

emergency fix for a failed pipe or hose connection.
• Flexible hoses, which move with equipment, will over time hairline crack resulting in lots of minute leaks which will degrade system performance and increase your power bill. Use sheets of wrap around suspect hose sections to check for integrity.
• Use film wrap to check around valve packing and O-Ring seals.
• For vacuum hold down of raw materials, use film wrap to verify that pieces being worked are in fact making tight contact with the holding fixture.
• Flanged sections of a recently repaired vacuum pump can be checked to make sure gaskets and O-Rings are properly seated.

Hopefully this short list of examples will give you some ideas of how you can adapt film wrap to locate vacuum leaks.

The best part of this leak detector is that it is low cost and in stock at any grocery store.

Chapter 5 – Central Vacuum Systems

Rotary vane vacuum pumps are well suited for individual point of use vacuum applications where the pump is located with the equipment requiring vacuum. If you have multiple uses for vacuum in your facility, or your requirements for vacuum are intermittent, then a central vacuum system might better serve your needs. A wide range of facilities from medical vacuum needs to plants with multiple vacuum pumps are worthy of consideration for a central vacuum system.

A central vacuum, or pressure, system combines multiple pumps with automatic operation to meet your needs while cutting operating costs, noise, maintenance and AC costs. Pumps are turned off and on as required to meet vacuum demand. Systems are offered with up to six pumps.

Central systems are based on the rotary vane vacuum pump which is offered in both lubricated and oil-less versions. For most applications, the oil-less pump is your best bet since there is no oil to ever change or dispose. Oil-less pumps feature carbon vanes, which typically last a number of years, before requiring replacement. Vane replacement is a simple “nut and bolt” job requiring 20 minutes to accomplish.

Central systems are offered in two basic styles – expandable and non-expandable. Tank mounted simplex or duplex systems which are not expandable and built to meet your current requirements. Expandable systems are designed to meet your current requirements, but also provide for future expansion with no piping changes required. Most central systems are controlled by a dedicated PLC which provides for complete automatic operation of the system. A single pressure transmitter monitors system vacuum levels and automatically determines how many pumps need to be in operation to meet the need. The lead and lag pumps automatically alternate on a first on-first off basis. This ensures that all pumps equally share the same duty cycle. The first pump in the system will not run until all other pumps are run which extends the service life of the pumps and extends the maintenance interval.

Expandable systems are modular, with no section wider than the opening of a standard 36'' doorway on most models. Systems can be quickly expanded by adding an expansion module which includes the pump, piping, wiring harness, and accessory items. The system can be expanded while the other pumps are in operation to avoid any down time. Expandable systems are offered in models starting with two pumps and can be expanded to include up to six pumps.

All systems are designed and built to meet the current version of the NFPA 99 Health Care Facilities requirements for medical/surgical systems.

All systems are completely redundant in operation providing for complete fail safe operation. All systems include alarms to indicate a fault in operation and can also be tied to central building management systems for remote monitoring of operations.

Reduce Air Conditioning Loads with a Central Vacuum System

One motor horsepower will generate 2,546 BTU/hr of heat added to your building space. One ton of air conditioning is equal to 12,000 BTU/hr. Using this information, each 4.71 HP of motors operating will consume 4.71 tons of air conditioning to eliminate the heat load.

Many industries use rotary vane pumps and blowers to generate either low pressure air or vacuum for production equipment. Typically vacuum pumps and blowers operate in air conditioned spaces. For the sake of an example, let’s assume that you are operating five, 10 HP vacuum pumps and ten, 5 HP blowers in this air conditioned space. Total motor load in this example works out to 100 HP. When we use our conversion information, the operation of these motors will add an air conditioning load of 21.2 tons.

Operating vacuum pumps and blowers continuously in your building space also adds noise and consumes electricity while they might not be needed to operate when your production machinery is down.

The solution is to consider a central vacuum system, or low pressure (25 psig) compressed air system, located in a remote non air conditioned space. Becker central systems use a PLC based controller, which reads your plant vacuum or air pressure requirements, then automatically turns on or off vane type pumps as needed to meet your load demand. Systems can be expanded to accommodate up to six pumps for maximum flexibility in about one hour by adding the new pump and a simple plug in electrical module. Central systems are offered in sizes up to 150 HP. Individual rotary vane pumps are offered in either oil-less or lubricated construction depending on your vacuum or pressure needs.

The PLC controller provides completely automatic operation of the individual pumps and also rotates the operation sequence of the pumps every 8 hours to provide for even wear of the pumps. Installation is simple and the central systems are designed to be broken down so they can pass through a standard door opening.

Becker Central Vacuum System Testimonial

The following is a testimonial and success story about Walton Press located in Monroe, Georgia. We wish to thank the folks at Walton Press for allowing us to be a part of their plans to update their plant with state-of-the-art equipment. Their goal was to be able to continue to provide the usual outstanding service their customers had grown to expect and still remain competitive in the marketplace well into the future.

They purchased a Becker Central Vacuum System from us. The equipment was shipped to them in a moving van ready for assembly and installation. Up to the time of shipment, they spent valuable time pre-piping the mains and drops to all of the various pieces of vacuum-using equipment. In the installation of the piping Ronnie Butler, Chris Harrison and Donnie Stapp took the time and expense to install vacuum gauges and isolation valves at all critical locations. They wanted to ensure that they would be able to troubleshoot vacuum system losses if necessary, and determine if there were any system leaks and verify the stability of the vacuum. One of the many objectives in purchasing a central system was to get the heat and noise out of the pressroom, so they began construction of a room to house the system which they made into a combination supply and utility room.

Once the equipment arrived, they were ready to begin setting it in place and connecting the system to the piping. They began setting the skid, pumps and receiver tank in place in the morning and were ready to make the switch from single pumps to the system by late afternoon. The whole hook-up process took less than eight hours. Thanks to their preplanning and the fact that the Becker System came to them ready to set in place they continued running the plant. There was no loss time in production.

When we asked Ronnie the benefits of the system his reply was:

- We replaced 25 pumps and 45 hp with 5 pumps at only 35 hp
- The spare parts and inventory is much simpler to maintain with 5 identical pumps
- We eliminated the heat in the plant
- The Becker dry pumps are much cleaner to operate
- We decreased the noise level in the plant•
- We cut our energy bill
- Our new system runs far superior versus individual pumps
- The system programs an alternating sequence of the pumps so that the pump maintenance has been cut in half plus we have built-in spares
- The vacuum receiver tank saves wear and tear on the pumps

Again we would like to thank Ronnie, Chris and Donnie for allowing us to share their success story with you. We hope that you will give consideration to this system as YOU begin making your plans for the future.

If you are interested in determining if a system has a payback for you, let us know and we can teleconference with you to do a survey of all of your equipment. That then allows us to size a system for your present and future needs. We can also give you an idea of the air conditioning and heating load which is a part of the payback scenario we provide. We certainly hope that you will give this some serious consideration as it has been a WIN-WIN decision for Walton Press.

Chapter 6 – Vacuum System Application Tips

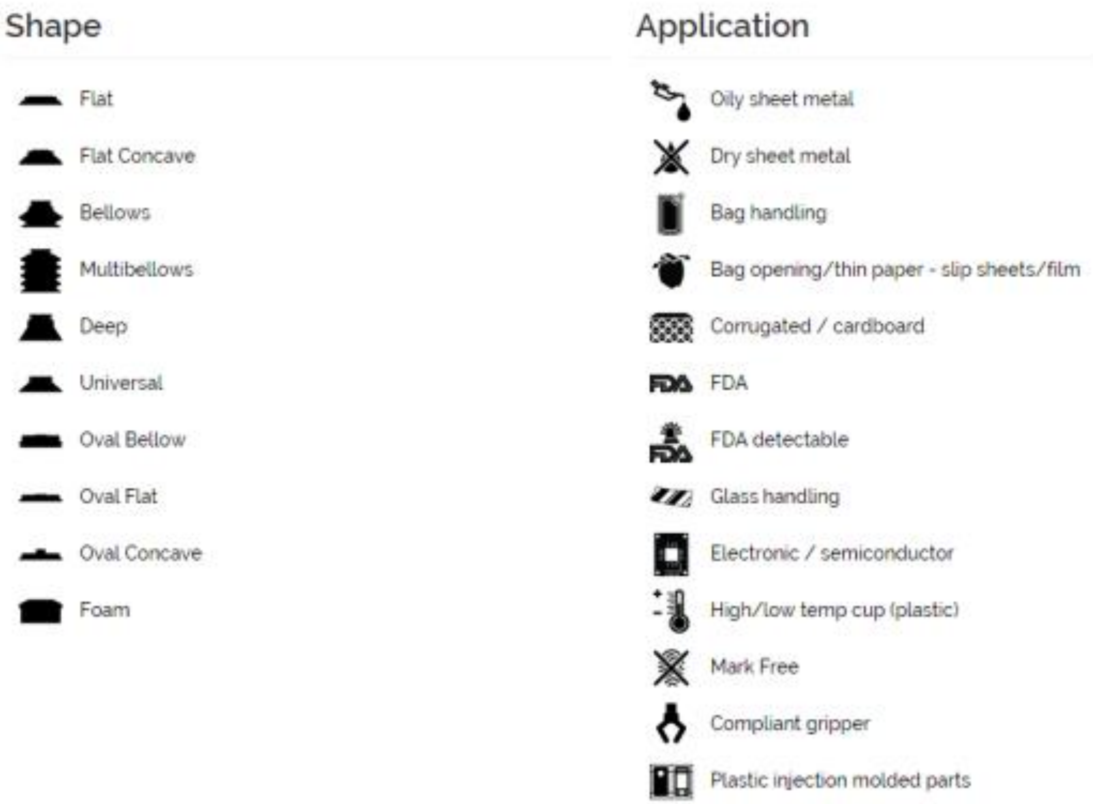
We’ve collected some application tips which might help in your facility to improve your performance and reduce your operating costs.

Vacuum Pick-Up Tips

The term vacuum means a space is devoid of all air or gas. Vacuum is measured in a number of ways such as inches of water, inches of mercury, and other methods to express a value less than 14.7 pounds per square inch, which is atmospheric pressure at sea level. When we speak of a high vacuum, we mean a low absolute pressure. Suction, vacuum, or vacuum cups use the absence of atmospheric pressure to pick up things such as flat sheets, rolls of materials, and removes debris. The rush of atmospheric air causes the item you wish to pick up to move toward the cup and form a seal. The difference between the vacuum level and atmospheric pressure then holds the item.

When picking up a sheet with vacuum, if a small opening is used, then the pickup up force will be small because the pickup force is proportional to the suction cups whole size. If a larger hole is used, then the cup selected for the vacuum pick up force will be larger requiring a larger vacuum pump. If a combination of large and small holes is used, then the large area against the sheet will produce a strong pick up force while the small openings in back of it will restrict the inrush of air between pickups. As an example; if a vacuum level of 1/2” of mercury (Hg) is used, there will be a pick up force of 5 pounds on each square inch of sucker area. If a sucker has an area of 2 square inches, the pickup force will be equal to 10 pounds. The lifting force in pounds per square inch is equal to the pounds where we will have compressed air under 2 pounds gauge pressure or 16.7 pound per square inch absolute pressure.

Using suction cups is a lifting technique with many possibilities. You can, for example, handle board materials or concrete slabs, open bags, pick electronic components, label and hold objects; however, different applications need different requirements as noted on the chart below.



CNC Vacuum Hold Down System Tips

If your CNC vacuum hold down system is not working as well as you require, here are some tips to help restore it-

• Vacuum leaks can rob capacity from your vacuum pumps and reduce the performance for your hold-down requirements. A very effective tool to check for vacuum leaks is plastic film (Saran Wrap as an example). Check for piping and hose leaks by using film wrap around pipe joints, valves and flexible hoses which can hairline crack as they age.

• Vacuum pumps come in two basic versions; oil flooded and dry. Dry vane pumps are more than capable of meeting your vacuum level and flow requirements and are less costly to maintain.

• Most CNC routing involves the generation of debris and fine particles. Portions of that dust mixture will get drawn into your vacuum pumps and if your inlet filters get clogged an overload will result with the dust entering the pump and mixing with the oil. The resulting oil dust mixture will impact the operation of the pump leading to failure.

• Make sure you do regular maintenance of your vacuum pump inlet suction filters. You might even consider a differential pressure gauge, or pressure switch, to warn you of clogged inlet filters. We can provide suggestions if you need help to make a selection.

• Supply line sizes to the table must be at least the same as the suction inlet connection of the vacuum pump. If your pumps are located away from the CNC machine, then allowances should be made to possibly larger line sizes. Same holds true on line sizing, if you have a large number of fittings between the pump suction connections and the table hose connections. If you have more than one table zone, then make sure that the master line size from the pump suction to the table connection is at least double the individual zone connections. As an example, if you have two vacuum zones of 2” on the table, then make the master feed line at least 4” (double the two 2” connections).

• Check your hoses for kinks and flat spots which restrict flow and rob vacuum levels from the table. Reinforced hoses are suggested as added insurance against wear as the table moves.

• Check for table leaks at each location for the CNC part you are shaping. When in doubt, do a film wrap test to ensure that you are not getting leakage around the edges. If you doubt that air can be pulled through plywood or particle board, then do a film test by laying a piece of Saran Wrap over a section of the plywood or particle board. If you blank off a section of the table or a complete zone do not use plywood, particle board or similar porous materials. Your best blank materials will be plastic sheets that will prevent air from being sucked through the porous sheets. MDF board also works, but make sure you paint or seal the edges with tape.

• Vacuum gauges are one of your best tools to verify the system is tight. Locate a gauge on the suction side of the pump, at the suction side of the inlet canister filter, and on each zone of your CNC machine. Mark the gauges to show normal good readings so you can do a quick check if you suspect any changes in machine operation.

Maintaining your CNC vacuum system will reduce scrap costs, allow you to operate at maximum production rate and reduce your power bill. If you need help with your CNC vacuum system; contact us with details to allow us to offer you suggestions to solve your problem.

Save Water in Your Vacuum System

Liquid Ring vacuum pumps are a good choice when handling high vapor loads, liquid slugs, and other wet processes requiring vacuum. Liquid ring pumps can operate continuously at vacuum levels as low as 30 torr.

Liquid ring pumps use a rotating ring of liquid as a sealant. The liquid ring is created by the centrifugal force generated by the rotation of the impeller. This rotating ring of sealant liquid provides the means to generate vacuum in your equipment. The typical sealing liquid in many applications is water.

Liquid ring pumps are provided in size ranges from 5 to 50 horsepower. Seal water can either be once through, partially recovered, or fully recovered. Pumps of this type are most efficient when using seal water at 60°F. Higher water temperatures will affect pump capacity. A liquid ring pump using 85°F seal water will lose about 18% of its capacity as compared to operating it with 60°F seal water.

Seal water flow rates on a once through basis will range from 5 to 25 gpm. As an example, a typical 10 horsepower pump will use 7 gpm of seal water which then goes to waste. Based on 24 hours per day and 30 days per month, this works out to 302,400 gallons of water per month. Using a water cost of $5.00 per 1,000 gallons, water cost would be $1,512 per month.

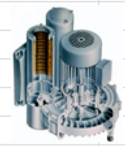
Depending on your application specifics, either add a water sealant recovery system or consider another style of pump.

Rotary vane pumps come in two styles, oil free and lubricated. Pumps are available in sizes up to 25 hp with dry pumps capable of 25" Hg and oil sealed pumps to 29.6" Hg. In either case, no sealing water is required. Vane style pumps are best suited for clean, dry vacuum applications. Knock out pots and other separation devices can be added to the pump system to handle limited quantities of water vapor and other materials.

Cost Comparison of Air Compressors and Vacuum Pumps

Compressed Air Cost Evaluation Analysis

Compressed air is an expensive utility and improper use will substantially increase your monthly electric bill. This analysis sheet will permit to you compare the costs of generating compressed air using high pressure air compressors, rotary vane air compressors, high speed centrifugal blowers, and regenerative blowers.

	Air Compressor	**Rotary Vane Compressor**	**Regenerative Blower**	**High Speed Blower**
				
Cost of Electricity (KWH)	$0.10	$0.10	$0.10	$0.10
CFM per Horsepower	4.3	6.5	25	20
Air Pressure (psig)	100	22	4.2	3.5
Cost per 1,000 cubic Ft of Air	**$0.388**	**$0.256**	**$0.067**	**$0.083**

Operational Cost Comparison

Air Volume Required (CFM)	430	430	430	430
Horsepower Required	100.0	66.2	17.2	21.5
Cost of Electricity	$0.10	$0.10	$0.10	$0.10
Cost per Hour	$7.46	$4.93	$1.28	$1.60
Hours per Month of Operation	720	720	720	720
Cost per Month	$5,369.04	$3,551.83	$923.47	$1,154.34

Chapter 7 – Frequently Asked Questions

1 – What would be better for my application, an oil-lubricated pump or a dry carbon vane pump? This depends on your application. Information on the different types of pumps can be found in Chapter 1 of this E-Book

2 – What is the difference between SCFM and ACFM? How does it relate to my pump selection process? SCFM (standard cubic feet per minute) is used to measure normal pressure. For vacuum applications, the air is expanded so it should be measured in ACFM (actual cubic feet per minute). This is explained more at the end of Chapter 2 in this E-Book.

3 – How do I find a vacuum leak? A simple and effective method is achieved by using plastic film wrap. We explain this in Chapter 4 of this E-book, sub-category “Vacuum Leaks”.

4 – How is vacuum measured? Torr, HG, etc. There are various ways to measure with all being equal – you can read more of this in Chapter 2 Vacuum Charts.

5 – What type of oil should I use in my oil flooded pump? It is recommended to use 30 weight non-detergent or synthetic oil. More tips on these pumps is found in Chapter 4, Care of Rotary Vanes Vacuum Pumps, sub-category Tips for Lubricated Pumps.

6 – OSHA says my pumps are too loud. How can I reduce the noise? There are pump enclosures available for most pumps. We can also help evaluate if you have the proper pump for your application. Central Vacuum systems can cut down on noise and heat in your facility. Read Chapter 5, Central Vacuum Systems for more information.

7 – How often should I change the vanes in my vacuum pump? You should check your vanes for wear every 3000 hours or annually. More tips can be found in Chapter 4, Care of Rotary Vanes Vacuum Pumps.

8 – What is the procedure for changing vanes? There are videos on our website, www.control-specialties.com, which gives you step by step instructions on changing vanes.

Chapter 8 – Conclusion

In conclusion, there are a lot of options to choose from when it comes to vacuum applications.

We hope our E-book has given you some ideas to improve your productivity while reducing your electricity and air conditioning costs.

Maybe you need dry, lubricated, or liquid ring pumps.

Maybe you need vacuum, pressure, or combination pumps.

Maybe you need a single pump or a central vacuum system.

Maybe you don't know, so if you need further assistance in determining the direction to go with your vacuum requirements, give us a shout via e-mail at info@control-specialties.com and we will be happy to help!