KINNEY®

Rotary Piston Vacuum Pumps

Kinney® Rotary Piston Pumps Selector Guide

About
Kinney and Rotary Piston Vacuum Pumps

Kinney® is the manufacturer of Kinney vacuum pumps. We have enjoyed continuous success in the design, manufacture and application of high vacuum equipment since 1907. During these 100-plus years, we have pioneered and perfected many of the products and designs which are now commonly used in industry.

The basic design of the rotary piston pump, development of the design principle for duplex and triplex balancing, introduction of blower/backing pump packages, and the perfecting of exhaust filters are just some of the contributions we have made to the vacuum industry. Today, the company continues to focus its attention on customers' needs and on finding new ways to meet those needs.

Two basic ingredients enable us to serve you fully – a complete product line, and the experience and know-how necessary to help solve problems. Kinney offers the world's most extensive line of vacuum pumps and mechanical booster pumping systems, in the vacuum range from atmosphere to 0.1 micron,

Our greatest area of service to you lies in our wealth of experience as problem solvers. We welcome the opportunity to serve as an extension of your own organization – to assist you in the selection, sizing and application of vacuum pumps.

This guide was designed as a first step in the selection process. We hope it serves this purpose for you. And if, at any time, you need further assistance, please feel free to contact our representative in your area or consult a member of our knowledgeable staff at our U.S. manufacturing facility located in Springfield, Missouri.

WHY OIL-SEALED ROTARY PISTON VACUUM PUMPS?

The selection of a vacuum pump will frequently include a consideration of those features that make one type of pump more suitable for a given application than other types. Thus, you will find that oil-sealed rotary piston vacuum pumps cover a broad pressure range and provide very high volumetric efficiency throughout most of the pressure range. Power requirements are modest and water consumption is low since it is a valved compressor. The installation of oil-sealed rotary piston vacuum pumps is simple and inexpensive.

From an environmental point of view, the cooling water for water-cooled pumps is not in contact with the process gas and therefore cannot become contaminated. Clear exhaust is economical to achieve and noise can readily be suppressed. Some corrosive gases can be tolerated or handled by means of inexpensive techniques. Many oil-sealed rotary piston pumps are available with inherent balance mechanisms.

ENVIRONMENTAL IMPACT...

Two of the principal concerns of Kinney are the continuous improvement of our products as well as being environmentally conscious.

Responding to these challenges, we have focused our combination of broad technological experience and our extensive product line on the serious environmental hazards that exist in certain industrial vacuum processes. The most common of these problems are air pollution, excessive water consumption, water pollution and excessive energy consumption.

Faced with these problems, a growing number of plants are making the inevitable decision to replace the vacuum pumps they are currently using with more efficient alternatives. Many are turning for solutions to the unique technological skills of Kinney.

Whether the industrial process uses vacuum for evaporation, distillation, crystallization, filtration, drying, deodorization or deaeration, there is a Kinney vacuum pump or system that is both economically feasible and ecologically compatible:

*   Air-cooled systems that use no water

*   Closed loop systems that discharge no pollutants either to the atmosphere or to water sources

*   Unitized systems that operate on demand without excessive energy consumption.

It is this rare combination of technological competence and diverse product line that enables Kinney to make a measurable contribution to our priority of environmental stewardship.

How to use this Guide

For your convenience, this guide has been divided into five sections in such a way that you may either use it as a step-by-step guide to the sizing and selection of pumps, or, by referring to the table of contents, go directly to the subject of your immediate interest.

In *Section I - Pump Selection*, we have included the basic theory and formulae necessary to choose the right pump size and type for many typical applications. Specific applications may present problems not covered in this guide. In such cases, we encourage you to request assistance from our representative in your area, or to draw upon the experience of our Application Engineers at our factory.

You may also find this guide useful as a guide to problem solving on existing installations. The examples of pump selection, for instance, represent considerations which may have been overlooked in an original installation resulting in unsatisfactory performance. A review of these considerations can sometimes reveal a design defect which may easily be remedied.

At the beginning of Sections II and III, you will find complete specification charts for Kinney® compound and single stage pumps, followed by specific information about the capabilities and characteristics of each pump in our line. In selecting a pump, it is necessary to choose a pump of the correct size and pressure capability, but it is also important to look for those features which may be of special importance to your particular application. Section IV covers various booster vacuum pumping systems. As you read through this information, we suggest that you avail yourself of the opportunity to let a Kinney representative assist you in the selection of this type of equipment. Section V provides useful reference material including charts and tables, installation information, and a glossary of terms used in vacuum technology.

Table of Contents

Typical Applications

Kinney oil-sealed vacuum pumps are widely accepted as the standard equipment for applications requiring vacuum over a *wide* pressure range, In research and engineering laboratories, Kinney pumps provide the versatility so essential to technological progress. In production facilities, their ruggedness and compact design permit years of continuous and dependable use. Shown here are a few of the many applications of Kinney vacuum pumps.

AEROSPACE AND AVIATION
Evacuation of environmental chambers and test apparatus. Vacuum coating and brazing. Evacuation of cryogenic equipment and vessels.

AGRICULTURE
Vegetable cooling, produce and berry chilling, grain drying, fumigation, tobacco curing, maple syrup gathering.

AIR CONDITIONING AND REFRIGERATION
Kinney offers high vacuum pumps specifically modified for servicing refrigeration equipment including thorough vacuum drying, degassing and fast leak detection. Of special importance to manufacturers of air conditioning and refrigeration equipment is Kinney's wide range of experience in the custom design and manufacture of vacuum pumping carts for production line evacuation and drying of systems and components.

AIRCRAFT BRAKE PADS
Kinney offers booster/rotary pump vacuum pumping systems specifically designed to handle the process effluents from carbon deposition in CVD or CVI processes during the production of carbon brake pads used by commercial and military aircraft.

AUTOMOTIVE
Vacuum forming and veneering of interiors, decorative and protective coatings, vacuum filling of cooling and hydraulic systems, lamp production, air conditioning system evacuation, vacuum chucking and lifting, carburetor testing, battery drying, component leak testing, mirror coating.

BIOLOGICALS AND DRUGS
Freeze-drying, distillation and filtration of biologicals, drugs, vitamins and blood plasma.

CHEMICAL PROCESSING
Vacuum dehydration, deaeration, purification, distillation and synthesizing. Vacuum evaporation, drying, concentration, deodorizing and filtration.

ELECTRICAL AND ELECTRIC
Evacuation of incandescent bulbs, fluorescent, neon, electron and TV tubes, potting of electronic components, production of transistors and other semi-conductor devices. Vacuum coating, crystal growing and impregnation.

For the electric power industry, Kinney produces complete vacuum systems, both stationary and portable, air cooled and water cooled, for the evacuation, drying and Tilling of large transformers, for cable filling, drying and impregnation, and for power station condenser evacuation.

FOOD PROCESSING
Vacuum sealing of bottles, cans and jars, film packaging of meats, poultry and cold cuts, deaeration of beverages, freeze drying of coffee, fruits, vegetables and other food products, vacuum evisceration.

LABORATORIES
House vacuum systems, chamber evacuation, research and development.

LASERS
Laser cooling and atmosphere control.

METALLURGY
Vacuum degassing, purification, melting, sintering, heat treating, welding, brazing, annealing and impregnation.

NUCLEONICS
Evacuation of nuclear reactors, accelerators, cyclotrons and bubble chambers.

PAPER
Decorative and plastic coating, metallizing.

PETROLEUM AND PETROCHEMICALS
Vacuum distillation and refining, crude yield improvement, oil well evacuation, water deaeration for oil field flooding.

PLASTICS
Vacuum forming, molding and coating of plastic materials.

TEXTILES
Vacuum drying, dying, material handling and solvent extraction.

MISCELLANEOUS
Water desalinization. Evacuation of chambers used in precision balancing of high speed rotary components. Freeze drying of museum specimens. Vacuum coating of reflective architectural glass. Evacuation of shock tubes and wind tunnels. Specimen preparation and replication for electron microscopy. Vacuum coating of optical lenses. Evacuation of ballistic ranges.

Pump Sizing and Selection

A DESCRIPTION OF VACUUM

The term "vacuum" designates any pressure below one standard atmosphere. The degree of vacuum is expressed in many ways and for simplicity's sake, the units cited here are limited to those used in this catalog.

Vacuum in inches of mercury is referred to a 30" barometer (in. Hg, ref.). Directionally, this scale is from the existing atmospheric pressure to absolute zero pressure, or towards a perfect vacuum. When considered in the opposite direction, i.e., from absolute zero pressure it is inches of mercury absolute (in. Hg, abs.). It is normally more convenient to express vacuum in terms of pressure from absolute zero pressure. The commonly accepted terms are torr (essentially equivalent to a millimeter of mercury absolute) and micron of mercury. There are 760 torr to a standard atmosphere and a micron is 1/1000 of a torr. From the above, it can be seen that high vacuum is equivalent to low pressure and conversely high pressure is equivalent to low vacuum.
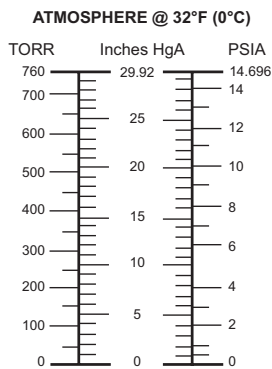
ATMOSPHERE @ 32°F (0°C)

Figure 1. Pressure Equivalents

VACUUM TERMINOLOGY

ATMOSPHERIC PRESSURE (AT SEA LEVEL):

- 29.92 INCHES OF MERCURY ABSOLUTE ((IN. HGA)
- 14.7 POUNDS PER SQUARE INCH ABSOLUTE (PSIA)
- 760 TORR

TORR: Millimeter of mercury absolute

MICRON: 1×10^3 (0.001) torr (Millitorr)

PASCAL: Pa is SI unit of pressure where

$Pa = 1 \frac{Newton}{m^2}$ = 0.0075mm = 7.5 microns

CUBIC FEET PER MINUTE (CFM):

- 28.32 liters/minute
- 0.4719 liters/second
- 1.7 cubic meters/hour

BLANK OFF PRESSURE: Ultimate on lowest pressure attainable with a pump having its inlet closed off (connected only to test gauge)

PARTIAL PRESSURE: The pressure of a designated component of a gaseous mixture

TOTAL PRESSURE: The sum of the partial pressures of a gaseous mixture

GAS BALLAST: Operating technique that limits or prevents condensation of vapors in mechanical vacuum pumps by admitting controlled amounts of air to the compression side of the pumping chamber.

Ultimate pressures and pumping speed curves shown in this catalog are based on the use of hydrocarbon type vacuum pump oils. Pressures are measured by a McLeod (partial pressure) vacuum gauge.
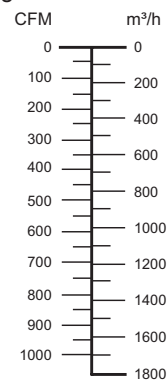

Figure 2. Pumping Speed Equivalents

FACTORS DETERMINING TYPE AND SIZE OF PUMP REQUIRED

The selection of the proper size pump for a given application is straightforward in principle but may not be so obvious in practice. The major factors which should be considered are:

1. **THE OPERATING PRESSURE** required. This determines whether a Kinney single stage pump or a compound pump is required. Generally speaking, the practical lower pressure limit for single stage pumps is 0.100 torr. Below this pressure compound pumps should be considered. When compound pumps are not large enough, mechanical blowers should be considered. (See Kinney Mechanical Booster Catalog.) When the vacuum is below 25" Hg (pressure higher than 125 torr) liquid ring pumps should be considered. (See Kinney Liquid Ring Pump Catalog.)

2. **THE PUMP DOWN TIME** from the initial pressure to the final desired pressure.

3. **VOLUME OF THE SYSTEM** to be evacuated.

4. **THE GAS LOAD** in terms of condensable and permanent type gases that will evolve from the process and are permitted to leak into the chamber. The gas load is meant to include either one of deliberate nature, or one existing as a result of the chamber not being absolutely vacuum tight.

5. **THE VACUUM MANIFOLD** and its effect on reducing pump speed as related to length, diameter, and orifice effect.

Examples of Pump Selection

Assume initially a clean, tight, dry and empty system containing air or some other noncondensable gas at atmospheric pressure. Since it is a well known fact that in practice the pumpdown time for a given system deviates from the basic calculations, it is necessary to use what is called a System Factor.

Figure 3 page 8 shows two sets of system factor curves for the two pump types. Curves labeled FT take into account only the pumpdown time from the basic mathematics without any system allowances. Curves labeled FA incorporate average system factors which are based on extensive Kinney experience. When FA values are used, actual pump-down times for clean, dry, tight systems are obtained. In the examples that follow, the values from the FA curves are used. Vacuum formulae are found on pages 8 & 9.

EXAMPLE 1 — SIZING
What model and size Kinney vacuum pump is required to evacuate a chamber having a volume of 150 cubic feet from one atmosphere to 0.100 torr in a maximum time of 20 minutes?

SOLUTION: From the operating pressure, a Kinney single stage pump is indicated. Figure 3 shows an FA value of 13.6 for the single stage pumps.

$$D = \frac{VF_A}{t} = \frac{150 \times 13.6}{20} = 102 \text{ CFM}$$

From page 16 it can be seen that the KDH-130 pump with a displacement of 134 cfm is the required pump for the job.

EXAMPLE 2 — PUMPDOWN TIME
How long will it take a Kinney Model KTC-112 (displacement 112 cfm) compound vacuum pump to reduce the pressure in a chamber having a volume of 65 cubic feet from one atmosphere to 0.040 torr?

SOLUTION: From Figure 3 the system factor FA for 0.040 torr is equal to 12.8.

Transposing Formula I:

$$t = \frac{VF_A}{D} \text{ .... (Formula II)}$$

Then:

$$t = \frac{65 \times 12.8}{112} = 7.43 \text{ minutes}$$

EXAMPLE 3 — PUMPDOWN TIME WITH SYSTEM FACTORS
If from past experience with systems similar to that under consideration, pumpdown times are longer than average values, system factors of estimated magnitude can be applied to the pumpdown formula.

For example, in the previous problem if we assign the following factors:
1.2 from 760-10 torr
1.3 from 10-1 torr
1.4 from 1-0.1 torr
1.5 from 0.1-0.01 torr

The pumpdown time from Formula VI is:

$$t = \frac{2.3V}{s} \times \log \frac{P_1}{P_2} \times SF$$

and

$$t_1 = \frac{2.3 \times 65}{96} \times \log \frac{760}{10} \times 1.2 = 3.52$$

$$t_2 = \frac{2.3 \times 65}{95} \times \log \frac{10}{1} \times 1.3 = 2.05$$

$$t_3 = \frac{2.3 \times 65}{88} \times \log \frac{1}{0.1} \times 1.4 = 2.38$$

$$t_4 = \frac{2.3 \times 65}{80} \times \log \frac{0.1}{0.04} \times 1.5 = 1.12$$

$$\Sigma t = 3.52 + 2.05 + 2.38 + 1.12$$
$$= 9.07 \text{ min.}$$

EXAMPLE 4 — SIZING FOR PRESSURE RISE
A vacuum chamber has a volume of 1400 cubic feet and is known to have a rate of rise of 50 microns per hour. What pump speed is required to maintain a pressure of 30 microns?

SOLUTION: From Formula IX
Even slightly contaminated, a single stage pump will not blank off at 30 microns. The better choice is a compound type pump. The Kinney KTC-60 is a compound pump and has a speed in excess of 40 cfm at 30 microns.

$$s = \frac{Q}{P} = \frac{V \triangle P}{\triangle t \, P} = \frac{1400 \times 50}{30} = 2333 \text{ CFH} = 38.9 \text{ CFM}$$

EXAMPLE 5 — HANDLING GAS MIXTURES
From a chemical distillation operation, 3.11 pounds per hour of nitrogen and 2.3 pounds per hour of air are liberated. The process conditions require that this be done at a total pressure of 4 torr and with the gas mixture being at 100°F.

Since one pound-mole of any gas at standard conditions (32°F, 0°C, etc. and 14.7 psia, 760 torr, etc.) is equal to its molecular weight and occupies 359 FT³, we can determine the average molecular weight and find the volume removal rate.

SOLUTION: From Formula X

$$MW_{av} = \frac{3.11 + 2.3}{\dfrac{3.11}{28.01} + \dfrac{2.3}{28.97}} = 28.41$$

From Formula XI

$$S = \frac{W}{MW} \times \frac{359}{60} \times \frac{760}{P_2} \times \frac{T_2}{459.4 + 32}$$

$$= \frac{3.11 + 2.3}{28.41} \times \frac{359}{60} \times \frac{760}{4} \times \frac{549.4}{491.4}$$

S = 242 CFM @ 100°F and 4 torr

The Kinney Model KT-300 pump has a speed of approximately 260 CFM at 4 torr, which is ample.

EXAMPLE 6 — EFFECT OF VACUUM MANIFOLDING

While it is a general rule that the vacuum manifold should be the same diameter as the pump inlet and as short as possible, it is necessary that all the factors governing manifold design be understood. Three factors need be considered. The length and diameter of the manifold as well as the orifice effect. Where manifolds are very short the orifice may be the governing consideration.

It has been calculated that a Kinney Model KT-500 vacuum pump will pump down a volume of 1000 cubic feet to 1 torr in adequate time if manifold effects are not considered. The pump is to be located in the pump room. The equivalent length of manifold is 200' and the KT-500 pump inlet size is 6".

From Formula III, $C = 0.52 \times \dfrac{D^4}{L} \times \overline{p}$

NOTE: For all practical purposes, bends are taken at their nominal length and the base pressure is used for P.

$$C = \frac{0.52 \times 6^4 \times 1000}{200}$$

C = 3369 CFM

The net speed from Formula V:

$$S = \frac{S_P \times C}{S_P + C}$$

$$S = \frac{420 \times 3369}{420 + 3369}$$

$$= 373 \text{ CFM}$$

The pumpdown time should be re-calculated using the above figure as the pump speed to determine if it is acceptable. If not, an attempt should be made to reduce the manifold length.

The previous calculation ignored the orifice or entrance effect. This is so because the manifold length was long. When the converse is true, the orifice usually governs. For example, if the manifold length was 10 feet, the conductance would be 67,380 cfm and the net speed would be 417 CFM.

The orifice conductance from Formula VII is:

$$C = 212 \times 6^2 = 7632 \text{ CFM}$$

Now if we look at the net effect, we have, from Formula V:

$$\frac{1}{S} = \frac{1}{S_P} + \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{1}{420} + \frac{1}{67380} + \frac{1}{7632}$$

S = 395 CFM

As can be seen from the previous problem, the orifice effect for the long run of manifold would not influence the net speed. However, for the 10 foot length of manifold, the orifice conductance is lower by a factor of about nine.

HANDLING CONDENSABLE VAPORS

The pumping effectiveness of any oil sealed mechanical vacuum pump is reduced by the presence of condensable vapors.

Kinney vacuum pumps are fitted with a gas ballast device which, within limits, prevents condensation of insoluble vapors in the pump. In addition to gas ballasting, Kinney pumps can handle condensable vapors when used with one or more of the following devices or techniques:

- Air Stripping
- Centrifuges
- Cold Traps
- Combination Pump Units
- Condensers
- Decanting
- High Temperature Operation
- Oil Reclamation Units
- Special Sealants

The Kinney Application Engineering Department will promptly answer inquiries relative to particular condensable vapor problems.
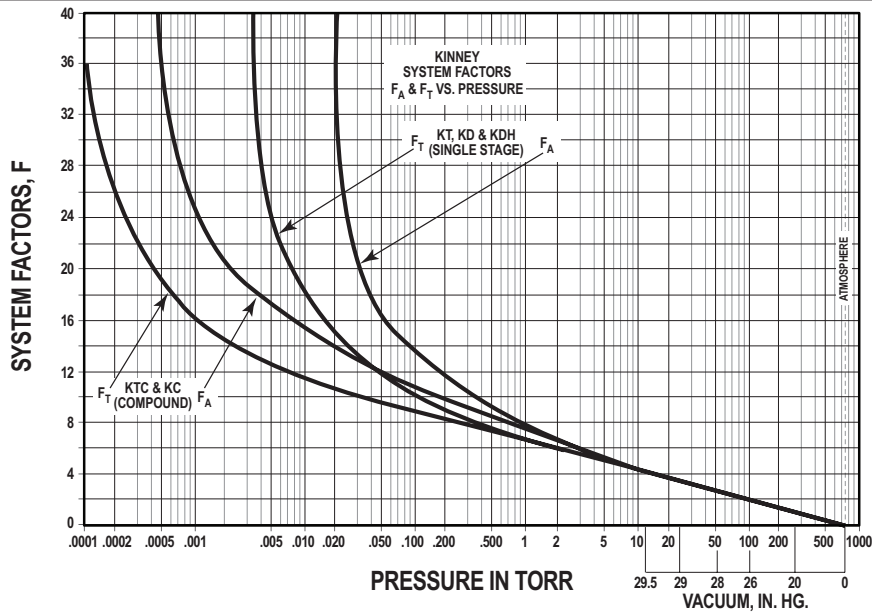
Vacuum Formulae

FIGURE 3 SYSTEM FACTORS

I — REQUIRED PUMP DISPLACEMENT USING FIGURE 3 SYSTEM FACTORS

$$D = \frac{VF_A}{t}$$

D = Pump displacement in cubic feet per minute
V = Volume of system in cubic feet
F_A = Pumpdown factor depending on pressure taken from Figure 3
t = Time in minutes allowed to pump down to the desired absolute pressure in torr (mm HgA)

II — REQUIRED PUMPDOWN TIME USING FIGURE 3 SYSTEM FACTORS

$$t = \frac{VF_A}{D}$$

t = Time in minutes allowed to pump down to the desired absolute pressure in torr (mm HgA)
V = Volume of system in cubic feet
F_A = Pumpdown factor depending on pressure taken from Figure 3
D = Pump displacement in cubic feet per minute

III — RATE OF AIR FLOWING THROUGH A LONG CIRCULAR PIPE

The following rules are for air at 20°C and are accurate to within 10%.

1.) Viscous flow (high pressure) where the average pressure in microns multiplied by the pipe diameter in inches is greater than 200.

$$C = 0.52 \times \frac{D^4}{L} \overline{P}$$

2.) Transition range (intermediate pressure) where the average pressure in microns multiplied by the pipe diameter in inches is greater than 6 and less than 200.

$$C = 0.52 \times \frac{D^4}{L} \overline{P} + 12.2 \times \frac{D^3}{L}$$

3.) Molecular flow (low pressure) where the average pressure in microns multiplied by the pipe diameter in inches is less than 6.

$$C = 0.52 \times \frac{D^4}{L}$$

C = Conductance in CFM
D = Diameter in inches
L = Length in feet
P = Average Pressure = $1/2 (P_1 + P_2)$
P_1 = Initial Pressure in microns
P_2 = Final Pressure in microns

IV — CONDUCTANCE

1. Conductance in series

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$

2. Conductance in parallel

$$C = C_1 + C_2 + C_3 + \cdots$$

C = Total conductance of system in CFM
C_1, C_2, C_3, etc. = Conductance for
    different pipe sizes

V — PUMPING SPEED OF VACUUM SYSTEM

$$\frac{1}{S} = \frac{1}{S_P} + \frac{1}{C} \quad \text{or} \quad S = \frac{S_P \times C}{S_P + C}$$

S = Net pumping speed in CFM
S_P = Speed of pump in CFM
C = Total conductance of system in CFM

VI — TIME FOR PUMPING DOWN OR AVERAGE SPEED REQUIRED

$$t = \frac{2.3V}{S} \log \frac{P_1}{P_2} \quad \text{or} \quad S = \frac{2.3V}{t} \log \frac{P_1}{P_2} = \frac{V}{t} \ln \frac{P_1}{P_2}$$

t   = Time in minutes
V = Volume of system in cubic feet
S = Average pump speed in CFM from P_1 to P_2
P_1 = Initial Pressure (arbitrary units)
P_2 = Final Pressure (arbitrary units)
log = Common Logarithm to Base 10
ln = Natural Logarithm to Base e

VII — RATE OF AIR FLOWING THROUGH A SMALL THIN APERTURE (AIR AT 20° C)

1. Viscous conductance (L is less than aperture size)
   $C = 212D^2$

2. Molecular conductance (L is much greater than aperture size)

   $C = 125D^2$

C = Conductance in CFM
D = Diameter of aperture in inches
L = Mean free path of molecule

VIII — MEAN FREE PATH (AIR AT 20° C)

$$D = \frac{191}{P}$$

L = Mean free path (m.f.p.) in inches
P = Pressure in microns

IX — MASS FLOW

$$Q = S \times P \quad \therefore S = \frac{Q}{P} \text{ and } P = \frac{Q}{S}$$

or

$$Q = C (P_2 - P_1) \quad \therefore C = \frac{Q}{(P_2 - P_1)} \text{ and } (P_2 - P_1) = \frac{Q}{C}$$

S = Pump speed (arbitrary units)
P = Pressure (arbitrary units)
Q = Gas flow (S × P)
C = Total conductance of system or of individual
    components (arbitrary units)
P_2 = Upstream pressure of system or of individual
    components (arbitrary units)
P_1 = Downstream pressure of system or of individual
    components (arbitrary units)

X — AVERAGE MOLECULAR WEIGHT

$$MW_{av} = \frac{W_m}{\dfrac{W_1}{MW_1} + \dfrac{W_2}{MW_2}}$$

W_m = Weight of mix
W = Weight of component
MW = Molecular weight of component

XI — PRESSURE-VOLUME-TEMPERATURE

$$C = \frac{W}{MW} \times \frac{359}{60} \times \frac{760}{P_2} \times \frac{T_2}{459.4 + 32}$$

S = Volume flow in CFM
W = Weight of gas in pounds
    per hour
MW = Molecular weight of gas
P_2 = Final absolute pressure in torr
T_2 = Absolute temperature of gas in
    degrees R

XII — VOLUME-TEMPERATURE RELATIONSHIP

$$\frac{S}{S_1} = \frac{T}{T_1}$$

S = Volume flow in CFM at T
S_1 = Volume flow in CFM at T_1
T = Gas temperature at final conditions
    (degrees absolute)
T_1 = Gas temperature at initial conditions
    (degrees absolute)

Compound Specifications

MODEL NUMBER	UNIT	KC-5	KC-8
Free Air Displacement at Rated RPM, Theoretical	CFM / *m³/h*	5 / *8.5*	8 / *13.6*
Pump Speed	RPM	638	1022
Standard Motor	HP / *kW*	.33 / *.25*	.75 / *.56*
Inlet Connection	ANSI	—	—
Inlet Connection	NPT	1"	1"
Discharge Connection	NPT	3/4"	3/4"
Cooling Water Inlet Connection	NPT	N/A, Air-cooled	N/A, Air-cooled
Cooling Water Outlet Connection	NPT	N/A, Air-cooled	N/A, Air-cooled
Cooling Water Required @ 80°F (26.6°C) (1)	GPM / *L/min*	N/A, Air-cooled	N/A, Air-cooled
Overall Height	In. / *mm*	17.88 / *454*	17.88 / *454*
Overall Width (Facing Drive)	In. / mm	18 / *457*	18 / *457*
Overall Depth	In. / *mm*	12.88 / *327*	12.88 / *327*
Oil Capacity	Quarts / *Liters*	0.8 / *0.76*	0.8 / *0.76*
Weight (Complete Assembly, without Oil)	Lbs / *kg*	115 / *52.3*	120 / *54.6*
Maximum Gas Ballast Flow	%	15%	15%
Typical Blank off Pressure with Full Gas Ballast (3)	Torr / *mbar*	0.020 / *0.027*	0.020 / *0.027*
Ultimate Pressure - McLeod Gauge (3) (with Kinney® AX Vacuum Oil)	microns	0.2	0.2

NOTES:

(1)   Maximum allowable outlet water temperature 110°F (43.3°C)

(2)   Can be furnished for use without water on special request

(3)   Torr = 1 mm Hg Abs.; 1000 microns = 1 Torr

(4)   Model KTC-21 has both threaded and flanged connections. Flange is 1 1/4" with four 5/16-18 tapped holes on a 3 1/2" bolt circle.

KC-15	KTC-21	KTC-60	KTC-112
15 / *25.5*	21 / *36*	60 / *102*	107 / *182*
572	1725	960	1060
1 / *.75*	1.5 / *1.1*	3 / *2.2*	7.5 / *5.6*
—	1 1/4" (4)	3"	3"
2"	2" (4)	—	—
1 1/2"	3/4"	1 1/4" ANSI FLG	2" ANSI FLG
N/A, Air-cooled	N/A, Air-cooled	N/A, Air-cooled	1/4"
N/A, Air-cooled	N/A, Air-cooled	N/A, Air-cooled	1/4"
N/A, Air-cooled	N/A, Air-cooled	N/A, Air-cooled	1.5 (2) / *5.7*
24.31 / *617*	20.25 / *515*	36.5 / *927*	44.25 / *1124*
20.25 / *514*	11.25 / *286*	19.7 / *500*	20.75 / *527*
18.5 / *470*	25.13 / *638*	23.69 / *602*	26 / *660*
3 / *2.84*	2 / *1.90*	8 / *7.6*	16 / *15.1*
210 / *95*	190 / *86*	515 / *234*	880 / *399*
15%	10%	10%	10%
0.020 / *0.027*	0.020 / *0.027*	0.020 / *0.027*	0.020 / *0.027*
0.2	0.2	0.2	0.2

KC Series
Dimensional Drawing
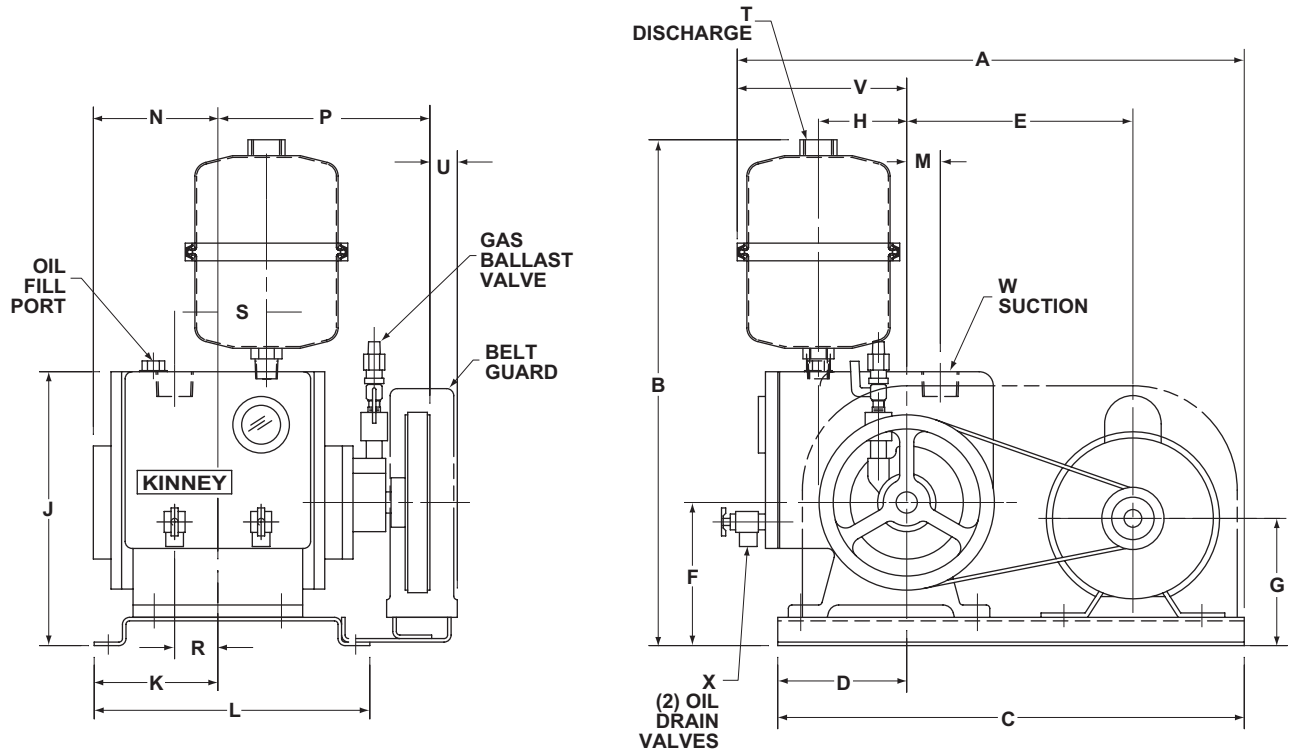
KC SERIES

MODEL		A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T	U	V	W	X
KC-5	in.	17.94	17.88	16.50	4.56	8.00	5.06	4.50	3.13	9.69	4.38	9.75	1.19	4.38	7.50	1.50	1.75	3/4" NPT	1.00 NPT	6.00	1" NPT	1/4" NPT
	mm	456	454	419	116	203	129	114	80	246	111	248	30	111	191	38	44		25	152		
KC-8	in.	17.94	17.88	16.50	4.56	8.00	5.06	4.50	3.13	9.69	4.38	9.75	1.19	4.38	7.50	1.50	1.75	3/4" NPT	1.00 NPT	6.00	1" NPT	1/4" NPT
	mm	456	454	419	116	203	129	114	80	246	111	248	30	111	191	38	44		25	152		
KC-15	in.	20.25	24.31	17.00	4.00	9.00	6.00	5.50	3.75	12.81	8.00	15.75	—	7.25	10.69	3.00	3.50	1 1/2" NPT	0.56	7.31	2" NPT	1/4" NPT
	mm	514	617	432	101	229	152	140	95	325	203	400		184	272	76	89		14	186		

KTC Series
Dimensional Drawings
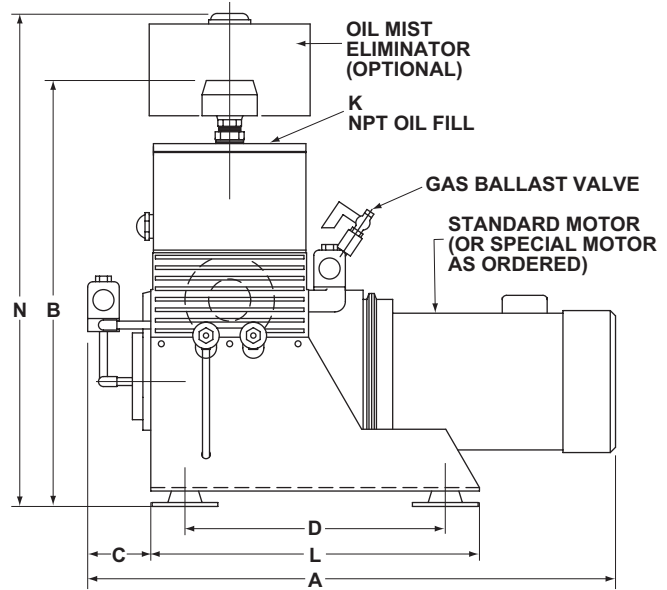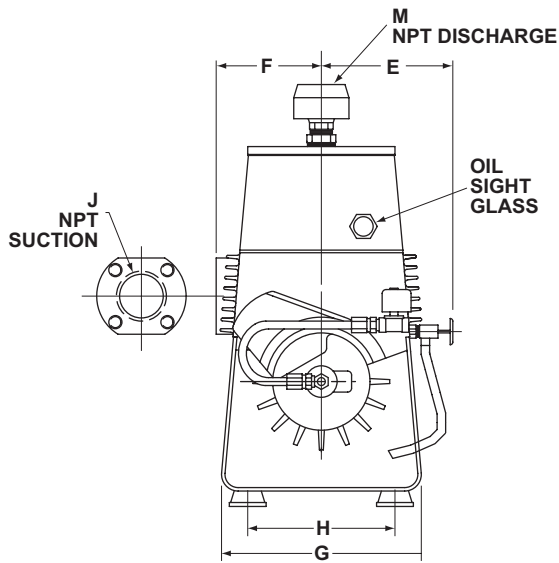
KTC-21

MODEL		A	B	C	D	E	F	G	H	J	K	L	M	N
KTC-21	in.	25.13	20.25	3.00	12.38	6.25	5	9.56	7	2" NPT	3/4" NPT	15.63	3/4" NPT	23.44
	mm	638	515	76	314	159	127	243	175			397		595
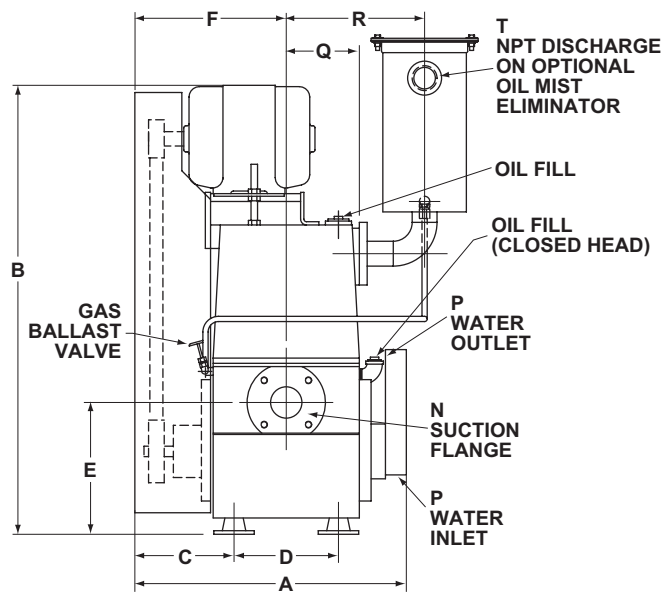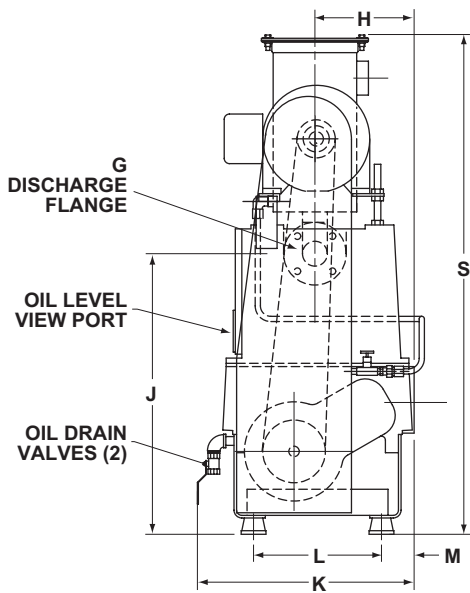
KTC-60/112

MODEL		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T
KTC-60	in.	23.25	36.50	8.75	10	19.63	13.75	1 1/4" ANSI	7.63	21.75	18.75	11.50	2.50	3" ANSI	—	6.18	11.50	38.88	1 1/2" NPT
	mm	591	927	213	254	498	349		194	552	476	292	64			157	292	988	
KTC-112	in.	26	43	9.5	10	12.63	14.50	2" ANSI	9.50	26.88	20.75	12.25	3.13	3" ANSI	1/4" NPT	7.00	13.25	47.88	2" NPT
	mm	660	1092	241	254	321	368		241	695	527	311	79			178	337	1216	

KINNEY®

KC Series

Free Air Displacement: 5, 8 & 15 cfm
Ultimate Pressure: 0.2 microns

FEATURES

- High pumping speed at pressures below 10 microns; much lower than attainable with single stage pumps
- Adjustable gas ballast permits handling of condensable vapors
- Rugged construction and compact design
- No metal-to-metal contact in pumping chamber
- Unequalled durability, even in dirty applications
- Dynamically balanced for functionally vibration-free operation
- Air-cooled
- Caged slide pin outwears other types commonly used

GENERAL DESCRIPTION

Kinney® KC Series compound high vacuum pumps are designed to maintain lower pressures than are attainable with single stage pumps. Two sets of cams and pistons mounted 180° apart on a single shaft operate in series. The two pumping chambers are connected by a channel that serves as an oil supply duct for the high vacuum side of the pump and as a gas duct between the two stages. The high vacuum side is continuously sealed with vacuum-purified oil from its own reservoir, the vacuum conditioning being provided by the roughing (2nd) stage.

In operation, KC pumps are functionally vibrationless, making them well suited for portable installations where high vibration cannot be tolerated. The rotary pistons have no contact with surfaces in the pumping chamber, all clearances being perfectly sealed and lubricated with oil. Because there is no mechanical contact, wear is minimized, permitting Kinney pumps to operate efficiently for years without repairs. Whenever repairs do become necessary, these pumps can be easily serviced in the field without special tools.

All KC pumps are air-cooled and are equipped with controllable gas ballast. The gas ballast feature provides vapor-handling capability and reduces oil changes by preventing condensable vapors from contaminating the oil. They are equipped with oil mist eliminators as standard equipment. This feature, optional on most other makes of pumps, eliminates all visible oil mist in the pump discharge, keeping the work area cleaner, safer, and more pleasant. Each pump operates within the rating of its standard drip-proof motor throughout its entire operating pressure range.

KC pumps will produce an ultimate pressure of 0.2 micron Hg Abs. or less (McLeod Gauge) when using Kinney® AX vacuum oil.
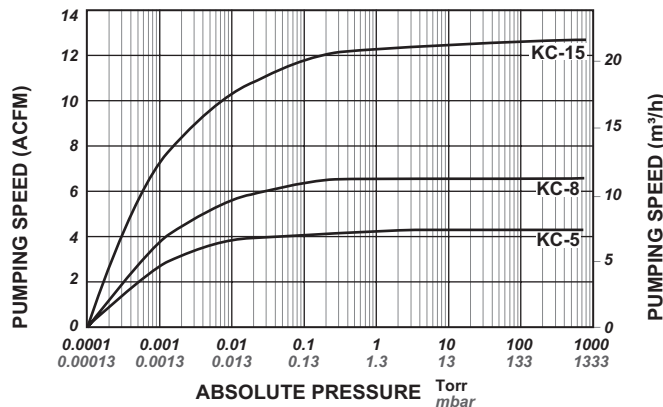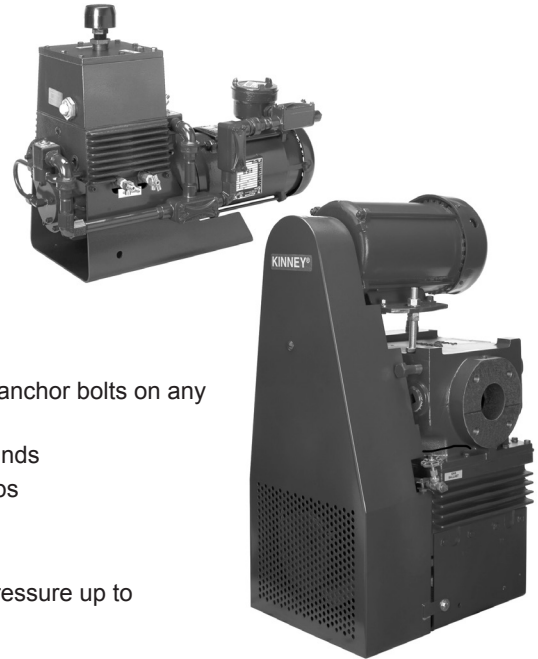
TYPICAL PUMPING SPEED CURVES

KTC Series

Free Air Displacement: 21-107 cfm
Ultimate Pressure: 0.2 microns

FEATURES

- High pumping speed at pressures below 10 microns; much lower than attainable with single stage pumps
- Triplex piston design for quiet, vibration-free operation - will operate without anchor bolts on any structure that will support its weight
- Unique discharge baffle reduces oil loss to rates far below those of other brands
- Produces lower ultimate pressures than are available with single stage pumps
- Adjustable gas ballast permits handling condensable vapors
- Caged slide pin outwears other types commonly used
- The KTC112 offers positive pressure lubrication assuring operation at any pressure up to atmospheric pressure
- No metal-to-metal contact in pumping chamber
- Unequalled durability, even in dirty applications

GENERAL DESCRIPTION

KTC-Series Kinney compound high vacuum pump is designed to maintain lower pressures than are attainable with single stage pumps. This "Triplex" pump has a single shaft with three sets of cams and pistons, one set larger than the other two. In operation, one of the smaller pumping chambers is in series with (backing) the other two which function in parallel. A unique internal balancing technique reduces the magnitude of pump movement (deflection) to 0.002" while simultaneously reducing the dynamic forces transmitted through the flexible mounting pads furnished with each pump to less than 1 pound on the KTC-21, less than 5 pounds on the KTC-60, and less than 10 pounds on the KTC-112. The resultant vibration-free characteristics of this pump make it ideal for portable installations and locations where vibration cannot be tolerated.

KTC-21 and KTC-60 pumps are air-cooled and are equipped with adjustable gas ballast, which provides vapor handling capability and reduces oil changes by preventing condensable vapors from contaminating the oil. KTC-112 pumps are continuously lubricated by forced oil feed at high pressures and by internal pressure differential at low pressures. This permits continuous pump operation at any pressure up to and including atmosphere. They are equipped with adjustable gas ballast. The gas ballast feature provides vapor handling capability and reduces oil changes by preventing condensable vapors from contaminating the oil. Although standard KTC-112 pumps are water-cooled, they can also be furnished as an air-cooled pump.

The advantages of a Kinney Triplex pump are inherent in its design. Caged slide pins far outlast two-piece slide pins or sliding vanes. A special umbrella type discharge baffle reduces oil loss to levels not attainable in other pumps. Solenoid valves protect the pump against oil flooding.

A single gas ballast adjustment assures balanced airflow and simple regulation. The pump operates within the rating of its standard drip-proof motor throughout the entire operating pressure range. KTC Series vacuum pumps will produce an ultimate pressure of 0.2 micron Hg Abs. or less (McLeod Gauge) when using Kinney® AX vacuum oil.

TYPICAL PUMPING SPEED CURVES
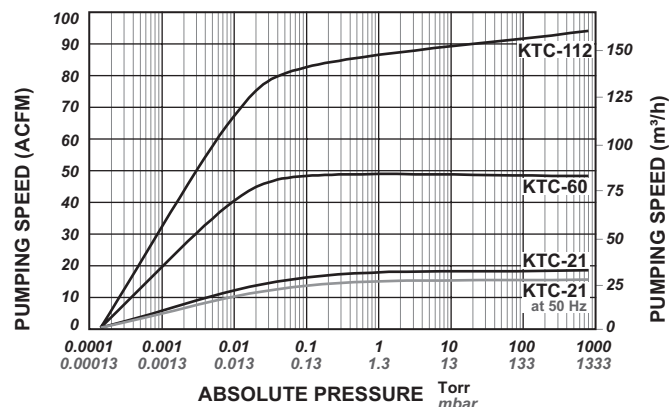
Single Stage Specifications

MODEL NUMBER	UNIT	KD-30	KD-50	KDH-130	KDH-150
Free Air Displacement at Rated RPM, Theoretical	CFM / *m³/h*	33 / *56*	52 / *87*	134 / *228*	165 / *280*
Standard Motor	HP / *kW*	1.5 / *1.11*	2 / *1.5*	5 / *3.7*	7.5 / *5.6*
Inlet Connection	ANSI	—	—	3"	3"
Inlet Connection	NPT	1 1/2"	1 1/2"	—	—
Discharge Connection	ANSI	—	—	—	—
Discharge Connection	NPT	1 1/4"	1 1/4"	2"	2"
Cooling Water Inlet Connection	NPT	Air-Cooled	Air-Cooled	3/4"	3/4"
Cooling Water Outlet Connection	NPT	Air-Cooled	Air-Cooled	3/4"	3/4"
Cooling Water Required @ 60°F (16°C) (1)	GPM / *L/min*	Air-Cooled	Air-Cooled	3/4 / *2.8* (2)	1 / *3.8* (2)
Overall Height	In. / *mm*	29 / *737*	31.5 / *800*	39.25 / *997*	39.25 / *997*
Overall Width (Facing Drive)	In. / *mm*	27.75 / *705*	29.13 / *740*	38.88 / *987*	38.88 / *987*
Overall Depth	In. / *mm*	20.38 / *518*	20.38 / *518*	30.81 / *783*	30.81 / *783*
Oil Capacity	Gallons / *Liters*	1 / *3.8*	3 / *11.4*	6 / *23*	6 / *23*
Weight (Complete Assembly, without Oil)	Lbs / *kg*	200 / *91*	230 / *105*	755 / *331*	840 / *381*
Maximum Gas Ballast Flow	%	8%	6%	6%	5%
Typical Blank off Pressure with Max. Gas Ballast (3)	Torr / *mbar*	1.5 / *2*	1.5 / *2*	1.0 / *1.3*	1.0 / *1.3*
Ultimate Pressure - McLeod Gauge (3)	microns	10	10	10	10

NOTES:

(1) Maximum allowable outlet water temperature 110°F (43.3°C)

(2) Can be furnished for use without water on special request

(3) Torr = 1 mm Hg Abs.; 1000 microns = 1 Torr

KT-150C	KT-300D	KT-500D	KT-850D
144 / *244*	296 / *503*	494 / *839*	778 / *1322*
7.5 / *5.6*	15 / *11*	30 / *22*	40 / *30*
3"	4"	6"	8"
—	—	—	—
2"	3"	4"	5"
—	—	—	—
1/4"	3/8"	3/8"	3/8"
3/8"	1/2"	1/2"	1/2"
1 / *3.8* (2)	1.5 / *5.7*	2.5 / *9.5*	3.5 / *13.2*
43 / *1092*	51.25 / *1302*	63.13 / *1604*	69.5 / *1765*
24 / *610*	27.5 / *699*	33 / *838*	39 / *991*
26 / *660*	34 / *864*	38 / *965*	49 / *1245*
6 / *23*	10 / *38*	15 / *57*	28 / *106*
800 / *364*	1525 / *693*	2700 / *1225*	4400 / *1996*
5%	5%	5%	5%
2.0 / *2.7*	2.0 / *2.7*	2.0 / *2.7*	2.0 / *2.7*
10	10	10	10

KD & KDH Series Dimensional Drawings

KINNEY®
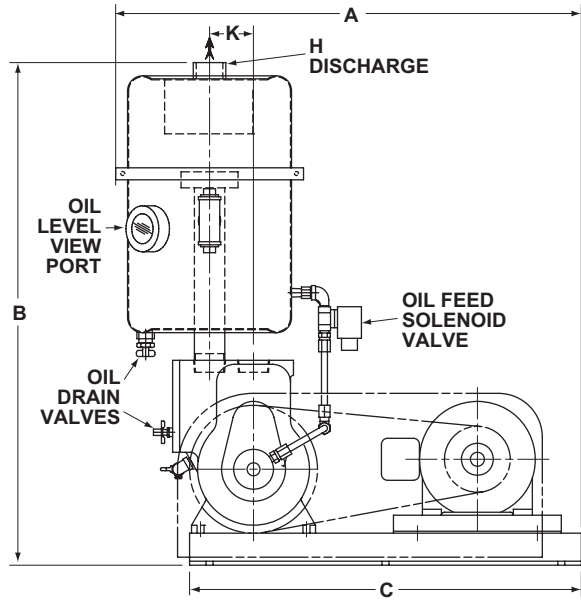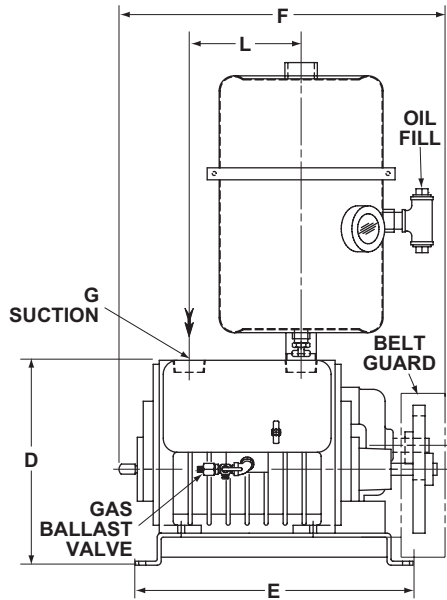
KD SERIES

MODEL		A	B	C	D	E	F	G	H	K	L
KD-30	in.	27.75	29	24.50	12.81	17.38	20	1 1/2" NPT	1 1/4" NPT	2.75	7.00
	mm	705	737	622	325	441	508			70	178
KD-50	in.	29.13	31.50	24.50	12.81	17.38	20	1 1/2" NPT	1 1/4" NPT	2.75	7.00
	mm	740	800	622	325	441	508			70	178
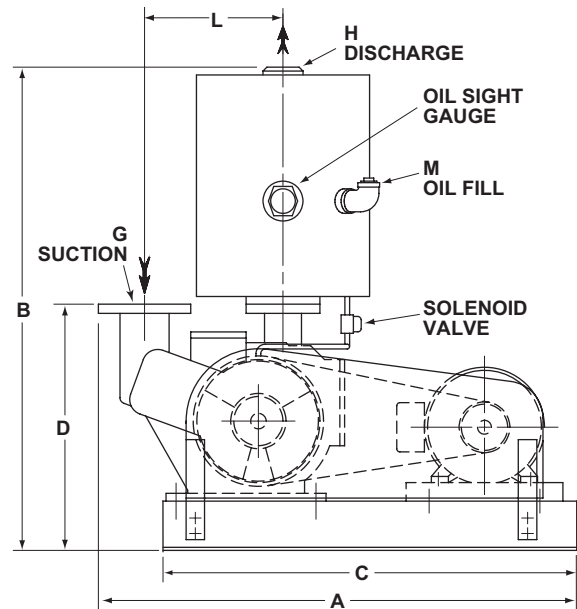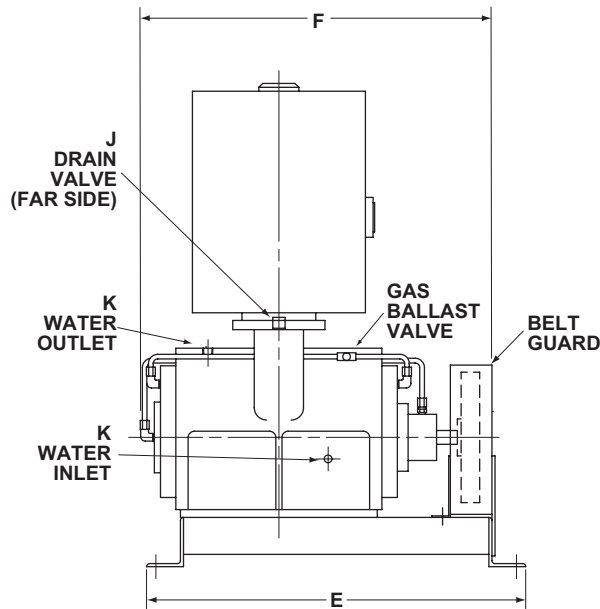
KDH SERIES

MODEL		A	B	C	D	E	F	G	H	J	K	L	M
KDH-130	in.	38.88	39.25	33.63	20	30.81	28.68	3" ANSI	2" NPT	1/2" NPT	3/4" NPT	11.25	1" NPT
	mm	987	997	854	508	783	719					286	
KDH-150	in.	38.88	39.25	33.63	20	30.81	28.68	3" ANSI	2" NPT	1/2" NPT	3/4" NPT	11.25	1" NPT
	mm	987	997	854	508	783	719					286	

KT Series
Dimensional Drawings
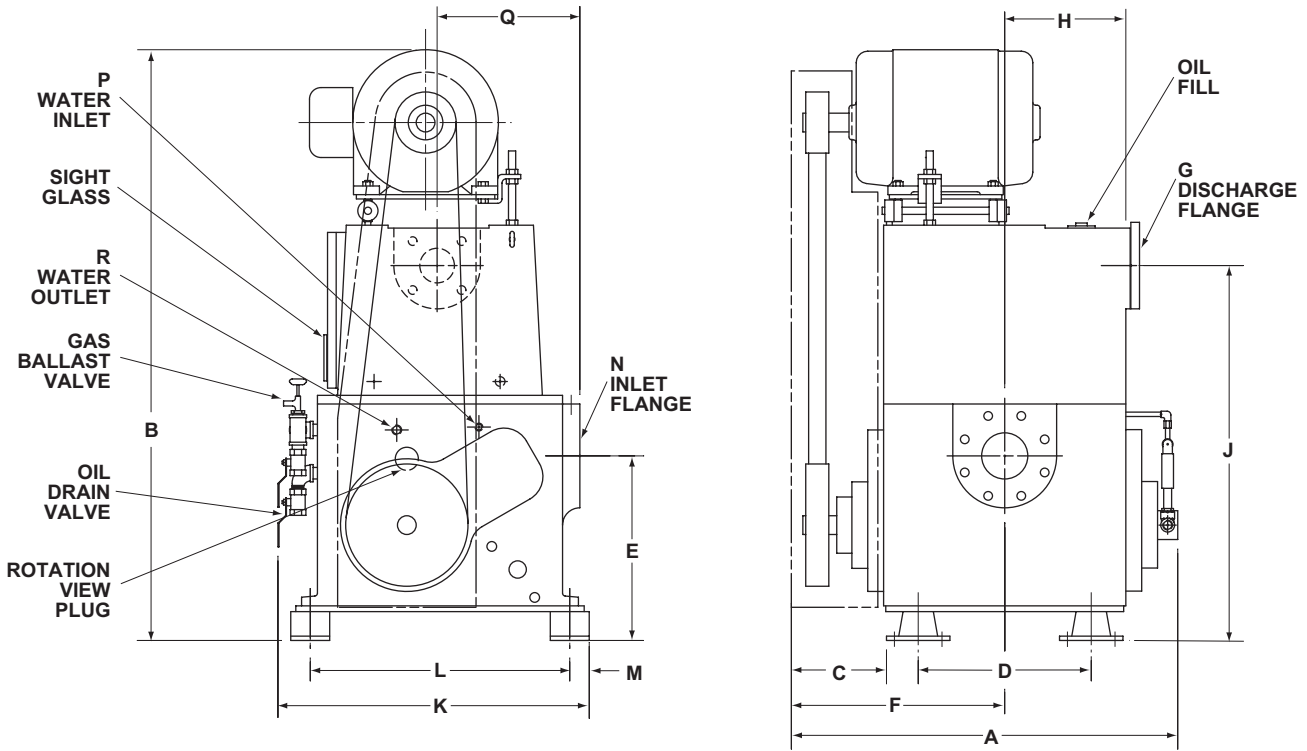
KT SERIES

MODEL		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R
KT-150C	in.	26	43	8.63	11.75	12.63	14.5	2" ANSI	7.25	26.5	22.75	19.13	1.19	3" ANSI	1/4	9.38	3/8
	mm	660	1092	219	298	321	368		184	673	578	486	30			238	
KT-300D	in.	33.5	51.25	11	15	16	18.5	3" ANSI	10.88	32.5	23.19	22.5	1.69	4" ANSI	3/8	12.38	1/2
	mm	851	1302	267	381	406	470		276	826	589	572	43			314	
KT-500D	in.	37.25	63.13	11.75	17	21.5	21.25	4" ANSI	11.75	41	32.32	28	1.31	6" ANSI	3/8	15.38	1/2
	mm	946	1604	298	432	546	540		298	1041	821	711	33			391	
KT-850D	in.	48.5	69.5	13.38	24.75	24.25	25.75	5" ANSI	15.75	46	37.25	33	1.38	8" ANSI	3/8	18.25	1/2
	mm	1232	1765	340	629	616	654		400	1168	946	838	29			464	

KD-30 & KD-50

Free Air Displacement: 33 cfm - 52 cfm
Ultimate Pressure: 10 microns

FEATURES

- Absolute pressures down to the low micron range
- Dual pistons operating in parallel on a single shaft provide trouble-free performance
- Full pumping speed down to 1 Torr
- Integral oil mist eliminator
- Caged slide pin outwears other types commonly used
- Air-cooled
- Dynamically balanced
- High resistance to abrasion and corrosion
- Long-life operation due to no metal-to-metal contact in the pumping chamber
- Adjustable gas ballast permits handling condensable vapors

GENERAL DESCRIPTION

Kinney® KD-30 and KD-50 Kinney single stage high vacuum pumps are of "Duplex" design, having a single shaft with two sets of cams and pistons mounted 180° apart that operate in parallel. The rotary pistons do not touch the walls of the pumping chambers but are sealed by Kinney vacuum oil that acts both as a lubricant and as a sealant. Both models are air-cooled, are very rugged in construction, and are very compact.

Controllable gas ballast, a standard feature, permits the handling of condensable vapors and minimizes oil changes due to vapor contamination of the sealing oil. Model KD-30 pumps are equipped with an efficient oil mist eliminator that effectively filters out oil mist and smog. Each pump operates within the rating of its standard motor throughout the entire operating pressure range.

KD-30 and KD-50 vacuum pumps will produce an ultimate pressure of 10 microns Hg Abs. or less (McLeod Gauge) when using Kinney® AX oil.

TYPICAL PUMPING SPEED CURVES
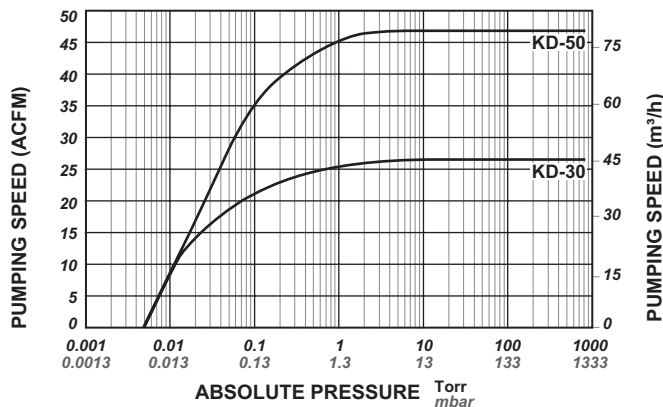
Curves are at 60 Hz unless otherwise noted

Series KDH

Free Air Displacements: 134 - 165 cfm
Ultimate Pressure: 10 microns

FEATURES

- Absolute pressures down to the low micron range
- Full pumping speed down to 1 Torr
- High volumetric efficiency over a wide pressure range
- Dual pistons operating in parallel on a single shaft provide trouble-free performance
- High resistance to abrasion and corrosion
- Quick recovery of operating pressure
- Caged slide pin outwears other types commonly used
- Dynamically balanced for functionally vibration-free operation
- Long-life operation due to no metal-to-metal contact in the pumping chamber
- Adjustable gas ballast permits handling of condensable vapors

GENERAL DESCRIPTION

Kinney® KDH single stage high vacuum pumps are of "Duplex" design, having a single shaft with two sets of cams and pistons mounted 180° apart which operate in parallel. The rotary pistons do not touch the walls of the pumping chambers but are sealed by Kinney vacuum oil which acts both as a lubricant and as a sealant. The pumps are very rugged in construction.

Standard pumps are water-cooled but they can be furnished to operate without water on special request.

Controllable gas ballast, a standard feature, permits the handling of condensable vapors and minimizes oil changes due to vapor contamination of the sealing oil. The pumps are equipped with long wearing sleeve bearings and have a single shaft seal to reduce maintenance and increase reliability. Each model operates within the rating of its standard TEFC motor over the entire operating pressure range.

KDH vacuum pumps will produce an ultimate pressure of 10 microns Hg Abs. or less (McLeod Gauge) when using Kinney® AX oil.
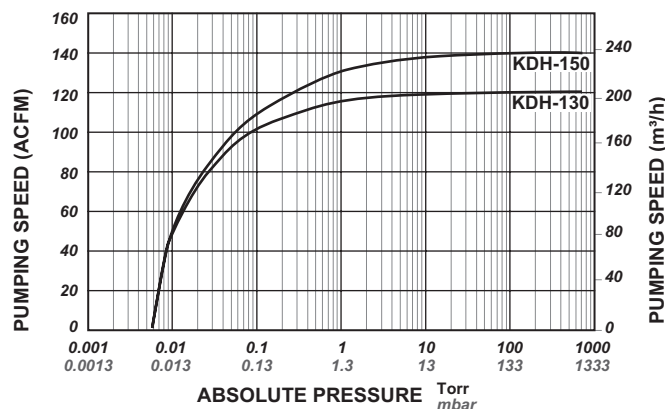
TYPICAL PUMPING SPEED CURVES

Series KT

Free Air Displacement: 144 - 778 cfm
Ultimate Pressure: 10 microns

FEATURES

- Full pumping speed down to 1 Torr
- Can operate continuously (at any pressure) up to 100 Torr
- Ultimate pressure 10 Microns (McLeod Gauge)
- Simple installation, no special foundation or anchor bolts required
- Triplex piston design provides quiet, vibration-free operation
- Adjustable gas ballast permits handling of condensable vapors

- No metal to metal contact in pumping chamber
- Unequaled durability, even in dirty applications
- Unique discharge baffle reduces oil loss to rates far below those of other brands
- Single shaft seal cuts maintenance costs and improves reliability
- Caged slide pin outwears other types commonly used
- Oil flow gauge standard on all models
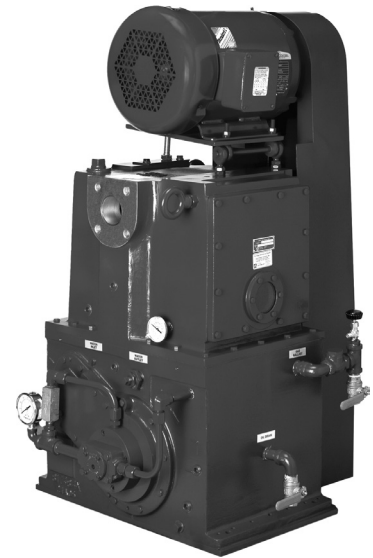
GENERAL DESCRIPTION

Kinney KT® single stage high vacuum pumps are of "Triplex" design having a single shaft with three sets of cams and pistons which operate in parallel in such a way as to reduce vibration to the lowest levels ever found in a pump this size. Our exceptional balancing technique reduces the magnitude of pump movement (deflection) while simultaneously reducing the dynamic forces transmitted through the flexible mounting pads furnished with each pump to the values shown in the table above. As a result of these extremely low vibration characteristics, the installation costs of Triplex pumps are always lower than those of conventional pumps.

KT pumps are continuously lubricated by a built-in oil pump which forces oil to the bearing surfaces at all pressures. This permits continuous pump operation at any pressure up to and

	MAXIMUM PUMP DEFLECTION	TRANSMITTED DYNAMIC FORCE
KT-150	0.0035"	10 Lbs.
KT-300	0.004"	15 Lbs.
KT-500	0.006"	20 Lbs.
KT-850	0.010"	50 Lbs.

including atmosphere. On Model KT pumps, reverse oil flow is controlled by means of a mechanical check valve. Oil feed pump pressure can be used for alarm or fail-safe interlock. Since these pumps are internally balanced, only one shaft seal is required providing a significant advantage over externally balanced pumps which require two shaft seals. Corrosion resistant sleeve bearings are used instead of ball bearings, which are not suitable for general vacuum pump service when they are lubricated by the sealing oil.

The advantages of a Kinney Triplex pump are inherent in its design. Caged slide pins far outlast two-piece slide pins. A special umbrella type discharge baffle reduces oil loss to levels not attainable in other pumps. A single gas ballast adjustment provides vapor-handling capability and reduces oil changes by preventing condensable vapors from contaminating the oil. Each pump operates within the rating of its standard TEFC motor throughout the entire operating pressure range. Series KT pumps will produce an ultimate pressure of 10 microns Hg Abs. or less (McLeod Gauge) when using Kinney® KV100 oil.

TYPICAL PUMPING SPEED CURVES
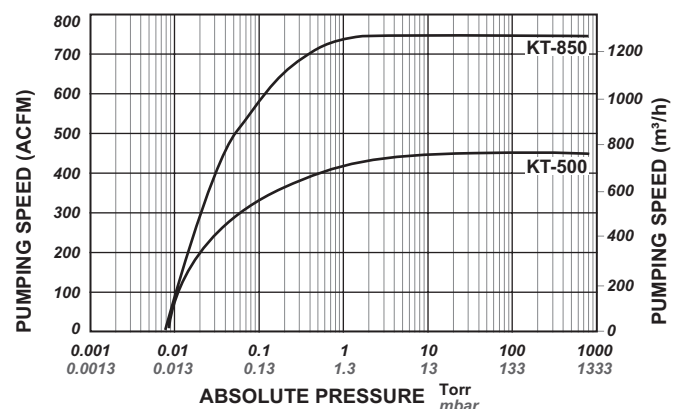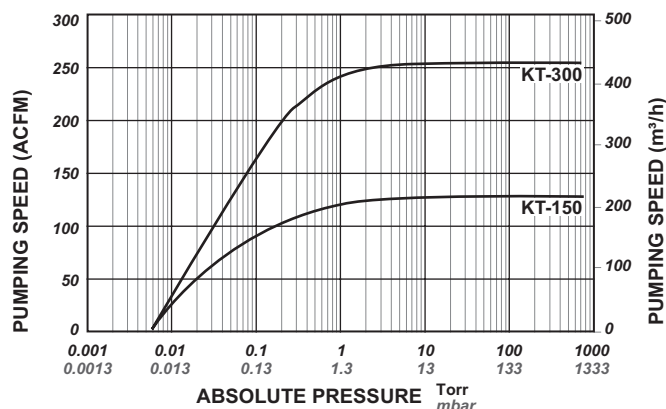
Booster Vacuum Pumping Systems

FEATURES

- Automatic operation
- No sealing oil in booster pump
- Complete, pre-tested packages
- Oil-free systems available

GENERAL DESCRIPTION

Kinney mechanical booster vacuum pumping systems combine positive displacement, lobe-type rotary booster pumps with any of three different types of Kinney backing pumps-oil-sealed rotary piston pumps, liquid ring pumps, or dry pumps. Each system is a compact, complete operating unit delivering superior performance, reliability and volumetric efficiency. Kinney pioneered the combination of blowers with backing pumps and offers the most complete selection of this type of equipment in the vacuum industry.

Kinney pumping systems operate automatically from atmospheric pressure to their blank-off pressure. Each pump is equipped with its own motor and the booster pump is automatically controlled by a self-contained pressure switch. When started, the second stage pump roughs the system to the cut-in pressure of the booster pump, at which point, the booster pump automatically cuts in. When started, the booster pump quickly reaches maximum pumping speed. If the pressure should rise above the set cut-in pressure, the booster automatically stops operation and the second stage pump resumes with its roughing function until the cut-in pressure is once again reached. A temperature switch protects the booster pump in the event of excessive temperature. All oils and greases necessary for system operation are provided.

Booster Systems Backed By Oil-Sealed Pumps
Kinney booster systems backed by oil-sealed pumps have the advantage of operating at maximum efficiency over a wider range of low pressures, while providing high volumetric displacement. Typically, the pumping speed of the vacuum booster is five to ten times that of the backing pump. This combination provides efficient, economical two-stage, compound operation.

The Kinney system is engineered for long, dependable service even under the most demanding conditions. It is simple to maintain and requires no special tools.

Because it is a positive displacement unit, it does not have blocking pressure limitations like those encountered in vapor booster pumps. The Kinney system continues to operate efficiently at pressures well above the stalling pressure for vapor pumps.

Kinney mechanical booster systems backed by oil-sealed rotary pumps are available in sizes from 150 CFM to 11,000 CFM free air displacement in the pressure range from 1×10^{-4} torr to atmosphere.
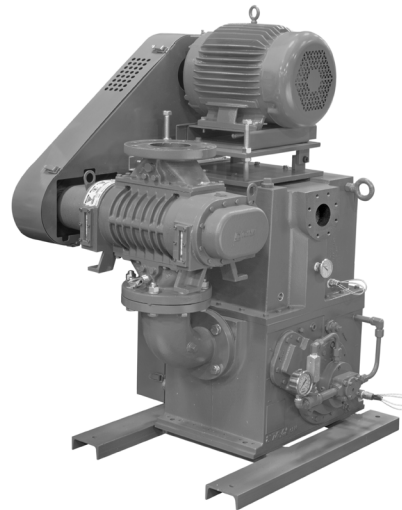
KINNEY® CC (CLOSE-COUPLED) BOOSTER/PISTON SYSTEM

KINNEY® CB (COMPACT) BOOSTER/PISTON SYSTEM

KINNEY® MB/KT BOOSTER/PISTON SYSTEM

Charts & Tables

PRESSURE CONVERSIONS

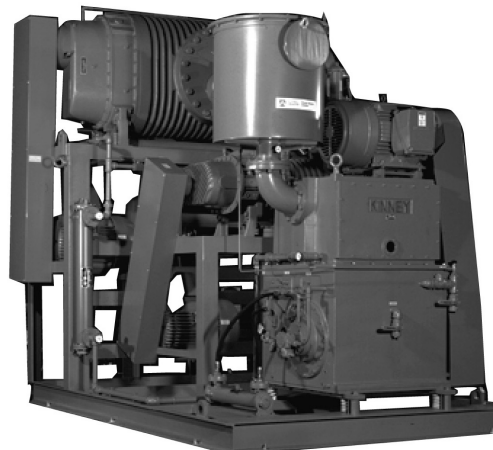| TO OBTAIN → MULTIPLY ↓ BY FACTOR	ATM.	BAR	PSI	kg/cm²	in. Hg (32°F / 0°C)	in. Hg (60°F / 16°C)	In H²0 (39.2°F / 4°C)	In H²0 (60°F / 16°C)	TORR	PASCAL NEWTON/ M²
ATMOSPHERE	1.0	1.01325	14.696	1.0332	29.921	30.005	406.79	407.19	760.00	101,325
BAR	0.98692	1.0	14.504	1.0197	29.510	29.613	401.47	401.87	750.00	100,000
POUNDS PER SQUARE INCH (PSI)	0.06805	0.06895	1.0	0.07031	2.0360	2.0418	27.679	27.708	51.715	6894.8
KILOGRAM PER SQUARE CM (kg/cm²)	0.96784	0.98067	14.223	1.0	28.959	29.041	393.71	394.09	735.56	98,067
INCHES OF MERCURY (in. Hg) (32°F / 0°C)	0.03342	0.03386	0.49116	0.03453	1.0	1.0028	13.596	13.609	25.400	3,386.4
INCHES OF MERCURY (in. Hg) (60°F / 16°C)	0.03333	0.03377	0.48977	0.03443	0.99718	1.0	14.022	13.570	25.329	3,376.9
INCHES OF WATER (in. H²0) (39.2°F / 4°C)	0.00245	0.00241	0.03613	0.00246	0.07355	0.07132	1.0	0.9678	1.8063	249.08
INCHES OF WATER (in. H²0) (60°F / 16°C)	0.00246	0.00249	0.03609	0.00254	0.07348	0.07369	1.0333	1.0	1.8655	248.84
TORR (mm Hg) (32°F / 0°C)	0.00158	0.00133	0.01934	0.00136	0.03937	0.03948	0.5536	0.5358	1.0	133.32
PASCAL (newton/meter²)	98.6×10^{-5}	1.00×10^{-5}	14.5×10^{-5}	10.1×10^{-6}	29.5×10^{-5}	29.6×10^{-5}	4.03×10^{-3}	4.02×10^{-3}	7.50×10^{-3}	1.0

1 torr = 1 mm Hg = 1000 millitorr = 1000 micron (μ) Hg = 1333.2236 dyne/cm²; 1 dyne/cm² (barye) = .1 newton/m² (pascal)

VOLUME CONVERSIONS

TO OBTAIN → MULTIPLY ↓ BY FACTOR	IN.³	FT.³	M³	LITER	GALLON
CUBIC INCH	1.0	5.787×10^{-4}	1.6387×10^{-5}	1.6387×10^{-5}	4.329×10^{-3}
CUBIC FEET	1728	1.0	2.8317×10^{-2}	28.317	7.481
CUBIC METER	6.1023×10^{-4}	35.314	1.0	1000	264.17
LITER	61.02	3.5316×10^{-2}	0.001	1.0	0.26418
GALLON (US LIQUID)	231	13.368×10^{-2}	3.7854×10^{-3}	3.7854	1.0

FLOW CONVERSIONS

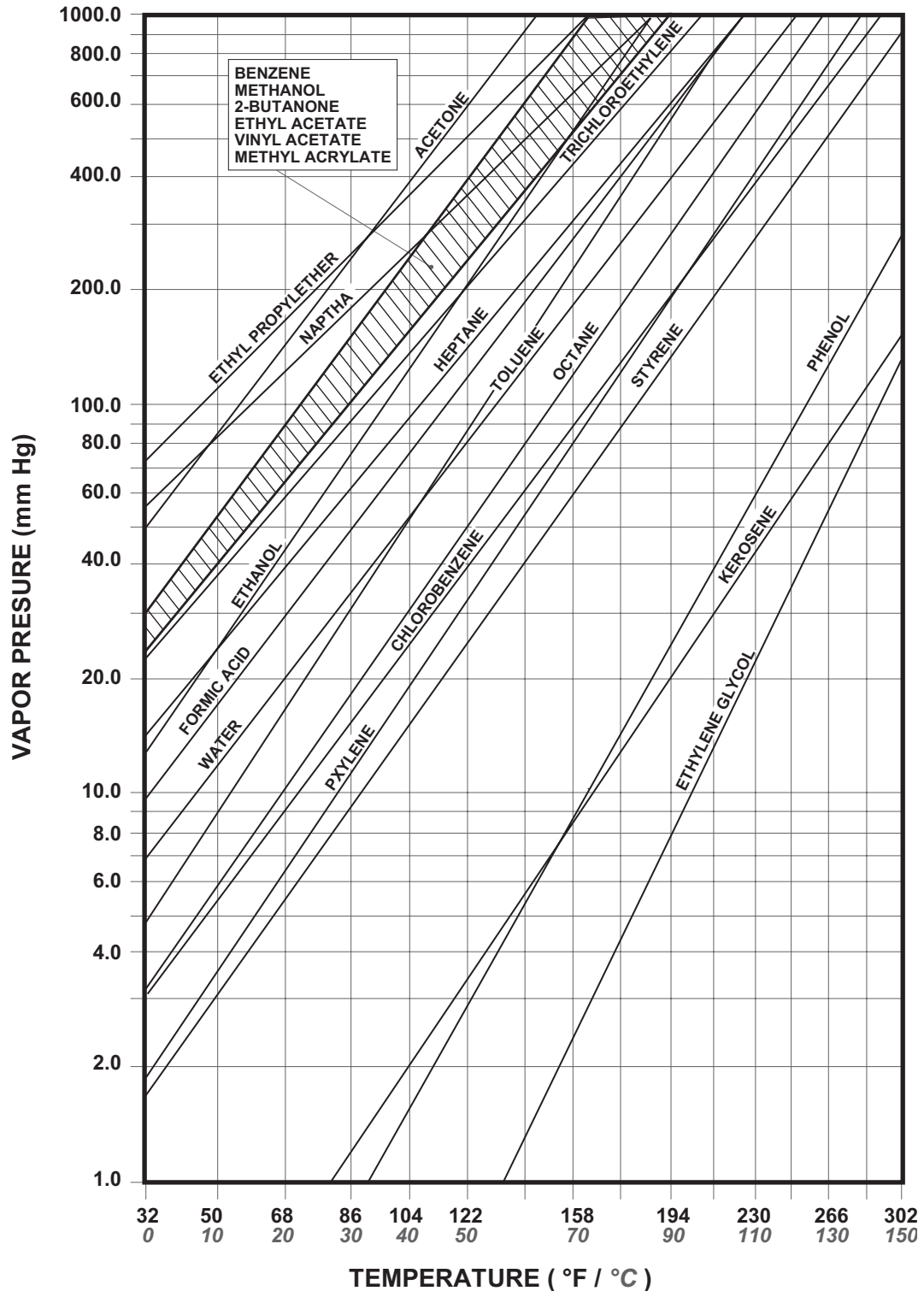| TO OBTAIN → MULTIPLY ↓ BY FACTOR	TORR- CFM	TORR- L/SEC.	TORR- m³/h
TORR - CUBIC FEET PER MINUTE	1.0	0.472	1.699
TORR - LITERS PER SECOND	2.12	1.0	3.60
TORR - CUBIC METERS PER HOUR	0.5886	0.2777	1.0

1 atm-cm³/sec = 1 scc/sec = 760 millitorr-1/sec
1 millitorr-CFM = 1 micron-CFM = .001 torr-CFM
1 millitorr-1/sec = 1 micron-1/sec = .001 torr-1/sec
1 millitorr-m³/h = 1 micron-m³/h = .001 torr-m³/h

PROPERTIES OF SATURATED STEAM

TEMPERATURE, DEGREES CENTIGRADE	TOTAL PRESSURE, (GAUGE PRESSURE PLUS ATMOSPHERIC PRESSURE)		HEAT OF VAPORIZATION		SPECIFIC VOLUME		TEMPERATURE, DEGREES FAHRENHEIT
	TORR	POUNDS PER SQUARE INCH	CALORIES PER KILOGRAM	B.T.U. PER POUND	CUBIC METERS PER KILO	CUBIC FEET PER POUND	
0	4.579	0.0886	595.4	1071.7	206.3	3304	32
2	5.29	0.1023	594.4	1069.9	180	2884	35.6
4	6.097	0.1179	593.3	1068	157.2	2518	39.2
6	7.011	0.1356	592.3	1066.1	137.7	2206	42.8
8	8.042	0.1555	591.2	1064.2	120.9	1937	46.4
10	9.205	0.178	590.2	1062.3	106.3	1703	50
12	10.513	0.2033	589.1	1060.4	93.7	1502	53.6
14	11.98	0.2317	588.1	1058.5	82.9	1327	57.2
16	13.624	0.2635	587	1056.6	73.3	1174	60.8
18	15.46	0.299	585.9	1054.7	65.1	1041	64.4
20	17.51	0.3386	584.9	1052.8	57.8	926	68
22	19.79	0.3827	583.9	1051	51.5	824	71.6
24	22.32	0.4316	582.8	1049.1	45.92	735	75.2
26	25.13	0.486	581.8	1047.2	41.05	657	78.8
28	28.25	0.5463	580.7	1045.2	36.74	589	82.4
30	31.71	0.6132	579.6	1043.3	32.95	528	86
32	35.53	0.6871	578.6	1041.4	29.62	474.7	89.6
34	39.75	0.7687	577.4	1039.4	26.62	426.5	93.2
36	44.4	0.8586	576.4	1037.5	23.98	384.2	96.8
38	49.51	0.9574	575.3	1035.5	21.65	346.8	100.4
40	55.13	1.0661	574.2	1033.5	19.57	313.5	104
42	61.3	1.1854	573.1	1031.5	17.69	283.3	107.6
44	68.05	1.3159	571.9	1029.4	16.01	256.5	111.2
46	75.43	1.4587	570.8	1027.4	14.54	233	114.8
48	83.5	1.6147	569.6	1025.3	13.21	211.7	118.4
50	92.3	1.7849	568.4	1023.2	12.02	192.6	122
52	101.88	1.9701	567.3	1021.2	10.96	175.5	125.6
54	112.3	2.172	566.2	1019.1	10	160.3	129.2
56	123.61	2.39	565,1	1017.1	9.14	146.5	132.8
58	135.89	2.627	563.9	1015.1	8.36	134	136.4
60	149.19	2.885	562.8	1013.1	7.66	122.8	140
62	163.58	3.163	561.7	1011	7.03	112.7	143.6
64	179.13	3.464	560.5	1008.9	6.46	103.5	147.2
66	195.92	3.789	559.3	1006.8	5.94	95.1	150.8
68	214.02	4.139	558.2	1004.7	5.47	87.6	154.4
70	233.53	4.516	556.9	1002.5	5.04	80.7	158
72	254.5	4.921	555.8	1000.4	4.647	74.4	161.6
74	277.1	5.358	554.6	998.3	4.294	68.8	165.2
76	301.3	5.826	553.4	996.2	3.973	63.7	168.8
78	327.2	6.327	552.3	994.1	3.676	58.8	172.4
80	355.1	6.867	551.1	991.9	3.404	54.5	176
82	384.9	7.443	549.9	989.8	3.156	50.6	179.6
84	416.7	8.058	548.7	987.6	2.929	46.92	183.2
86	450.8	8.717	547.4	985.4	2.723	43.62	186.8
88	487.1	9.419	546.2	983.2	2.534	40.59	190.4
90	525.8	10.167	544.9	980.9	2.358	37.77	184
92	567.1	10.966	543.7	978.7	2.197	35.19	197.6
94	611	11.815	542.5	976.5	2.05	32.86	201.2
96	657.7	12.718	541.2	974.2	1.913	30.67	204.8
98	707.3	13.678	539.9	971.9	1.787	28.64	208.4
100	760	14.697	538.7	969.7	1.671	26.78	212
102	815.9	15.778	537.4	967.3	1.564	25.06	215.6
104	875.1	16.923	536.2	965.1	1.465	23.47	219.2
106	937.9	18.137	534.9	962.8	1.374	22.01	222.8
108	1004.3	19.42	533.6	960.5	1.289	20.64	226.4
110	1074.5	20.777	532.3	958.1	1.209	19.37	230

Charts & Tables

BOILING POINTS OF SOLVENTS

BENZENE
METHANOL
2-BUTANONE
ETHYL ACETATE
VINYL ACETATE
METHYL ACRYLATE

Chart axes: VAPOR PRESURE (mm Hg) vs TEMPERATURE (°F / °C)

Labeled curves: ACETONE, TRICHLOROETHYLENE, ETHYL PROPYLETHER, NAPTHA, HEPTANE, TOLUENE, OCTANE, STYRENE, PHENOL, ETHANOL, CHLOROBENZENE, KEROSENE, FORMIC ACID, WATER, PXYLENE, ETHYLENE GLYCOL

PRESSURE AT ATMOSPHERIC ALTITUDES

ALTITUDE FEET	PRESSURE TORR	ALTITUDE FEET	PRESSURE TORR
-1,000	787.87	35,000	179.33
-500	773.83	40,000	141.18
0	760	45,000	111.13
500	746.37	50,000	87.497
1,000	732.93	55,000	68.889
1,500	719.7	60,000	54.236
2,000	706.66	70,000	33.662
2,500	693.81	80,000	21.01
3,000	681.15	90,000	13.208
3,500	668.69	100,000	8.356
4,000	656.4	120,000	3.446
4,500	644.3	140,000	1.508
5,000	632.38	160,000	6.9741×10^{-1}
5,500	620.65	180,000	3.2622×10^{-1}
6,000	609.09	200,000	1.4848×10^{-1}
6,500	597.7	225,000	5.1256×10^{-2}
7,000	586.49	250,000	1.5257×10^{-2}
7,500	575.45	275,000	3.8450×10^{-3}
8,000	564.58	300,000	9.4915×10^{-4}
8,500	553.88	350,000	8.5197×10^{-5}
9,000	543.34	400,000	1.6014×10^{-5}
9,500	532.97	450,000	6.3106×10^{-6}
10,000	522.75	500,000	3.5049×10^{-6}
11,000	502.8	600,000	1.5030×10^{-6}
12,000	483.48	700,000	7.4221×10^{-7}
13,000	464.76	800,000	3.9520×10^{-7}
14,000	446.63	900,000	2.2194×10^{-7}
15,000	429.08	1,000,000	1.3027×10^{-7}
17,500	387.65	1,200,000	4.9576×10^{-8}
20,000	349.53	1,400,000	2.0952×10^{-8}
22,500	314.51	1,600,000	9.5550×10^{-9}
25,000	282.4	1,800,000	4.6198×10^{-9}
27,500	253	2,000,000	2.3292×10^{-9}
30,000	226.13	2,320,000	8.3091×10^{-10}

VAPOR PRESSURE OF ICE*

TEMPERATURE		VAPOR PRESSURE	
DEGREES CELSIUS	DEGREES FAHRENHEIT	mm Hg	MICRONS
0	32	4.579	4579
-2	28.4	3.88	3880
-4	24.8	3.28	3280
-6	21.2	2.765	2765
-8	17.6	2.326	2326
-10	14	1.95	1950
-12	10.4	1.632	1632
-14	6.8	1.361	1361
-16	3.2	1.132	1132
-18	-0.4	0.939	939
-20	-4	0.776	776
-22	-7.6	0.64	640
-24	-11.2	0.526	526
-26	-14.8	0.43	430
-28	-18.4	0.351	351
-30	-22	0.2859	285.9
-32	-25.6	0.2318	231.8
-34	-29.2	0.1873	187.3
-36	-32.8	0.1507	150.7
-40	-40	0.0966	96.6
-44	-47.2	0.0609	60.9
-48	-54.4	0.0378	37.8
-52	-61.6	0.023	23
-56	-68.8	0.0138	13.8
-60	-76	0.00808	8.08
-64	-83.2	0.00464	4.64
-68	-90.4	0.00261	2.61
-72	-97.6	0.00143	1.43
-76	-104.8	0.00077	0.77
-80	-112	0.0004	0.4
-84	-119.2	0.0002	0.2
-88	-126.4	0.0001	0.1
-92	-133.6	0.000048	0.048
-96	-140.8	0.000022	0.022
-98	-144.4	0.000015	0.015

* Pressure of Aqueous Vapor over Ice in mm Hg at Various Temperatures.

How to Install Rotary Vacuum Pumps

Even if a vacuum pump is properly sized to produce the desired operating pressure in the optimum time, and is the correct type of pump to handle both the gas load and any contaminants present, certain basic installation techniques must be followed if the system is to perform up to design. Failure to observe correct procedures can result in unsatisfactory pressure levels, damage to the end product of the system, mechanical difficulties, air pollution and damage to the pump.

While most of the techniques discussed here are well within the knowledge and understanding of vacuum technologists, some installation personnel either may not understand the importance of certain procedures, or may not be familiar with vacuum practices. The illustration on page 35 shows a general installation arrangement in which sound practices have been observed. Some of the components shown are used only in special situations, but most should be present in any good pump installation. At the planning stage, provision should be made to allow ample room for access to the pump and components for maintenance and service. In this regard, it is wise to locate the electrical control point near the pump.

VIBRATION ISOLATION

All vacuum pumps should be vibration isolated. Steps to be taken at the time of installation are dictated by the extent to which the pump itself is balanced. As a guide, the pumps can be separated into three groups: inherently balanced, partially balanced and unbalanced. The table lists the parameters that should be considered and suggests appropriate methods of vibration isolation for each type of pump.

It should be stressed that, when a pump is mounted on vibration isolators, deflections during start and stop can be significantly larger than during steady-state operation. All connections to the pump should be arranged with sufficient flexibility to withstand these deflections.

When elastomer bellows are used, they minimize the propagation of pump noise along the suction and discharge manifolds. Generally, oil sealed mechanical vacuum pumps are quite noisy when operating without any gas load. The noise is of hydraulic origin; it can be efficiently suppressed by admitting a small air flow into the pump. This is most conveniently done by using the gas ballast valve that is usually an integral part of the pump. Further noise isolation is possible with acoustical enclosures.

For large partially balanced pumps (above 150 cfm) and all unbalanced pumps, a rigid base should be constructed as follows:

FOUNDATION

Depending on the pump size, the foundation should be 18 to 36 inches deep, and the length and width dimensions should provide at least 6 inches from any anchor bolt to the nearest edge of the foundation. To simplify leveling of the unit, and to provide for good bond with the final grouting, the top of the foundation should be struck off level but left in a roughened condition.

The concrete on a dry and loose basis should have a mix of 1 part portland cement, 2.5 parts sand and 5 parts stone. The mix should be medium. The foundation should be cured for about three weeks.

ANCHOR BOLTS

Hook type anchor bolts are preferred. The manufacturer's recommendation for length should be followed. The bolts can be centered in metal sleeves twice the diameter and about one-half the length of the bolt set flush with the rough foundation. The sleeves provide for small errors in setting and are filled at the time of grouting. The bolt diameter is determined by the hole in the pump base.

LEVELING

The pump should be set on the rough foundation and leveled by shimming the base.

GROUTING

The concrete foundation should be thoroughly cleaned and wet before grouting begins. Surfaces should be roughened by chipping to remove any glaze or oily spots that would prevent proper bonding. Effective wetting may require up to 12 hours, assuming the foundation has been cured about three weeks. Metal surfaces that will come in contact with the grout should also be thoroughly wetted before grouting begins. The grout must flow into and fill all spaces and cavities before it sets, and must permanently retain its original volume. A mixture of 1 part cement and 1 1/2 parts clean sand will give good results providing the water content by weight doesn't exceed 50 per cent of the weight of the cement. Wait at least 24 hours for the grout to set before tightening the anchor bolts.

INLET CONNECTIONS

Vacuum pump inlet connections should be sized and designed with three objectives in mind to avoid gas flow restrictions; to prevent pump fluids from entering the process chamber; and to protect the pump from the ingestion of particulate matter. Under all normal conditions, the diameter of the inlet manifold should never be less than the pump inlet, and its length should be as short as possible to minimize conductance losses.

Since all oil-sealed mechanical vacuum pumps produce oil splash at the pump inlet unless designed with internal splash baffling, the inlet manifolding must be designed to keep oil from traveling upstream of the pump. With small pumps the problem is not too serious, but it grows with pump size. On pumps with top inlets, it is the length of the horizontal section of manifolding more than the height of the vertical riser that provides the

necessary baffling effect. On such pumps, it is incorrect to run the manifolding vertically with a simple U-turn at the top. The vigorously ejected oil droplets traveling up the center line of the pipe hit the top of the U-turn with some draining back into the pump and some draining into the process system. Figure 1 shows the correct manifold arrangement for either top or side intake pumps. If space limitations prevent manifold baffling, a simple splash baffle as shown in Fig. 2 should be provided.

On all applications, provision must be made to prevent the entrance of solid contaminants into the pump. This is especially true where dust or particulate matter is present in the process. In the case of particles, the simple wet trap shown in Fig. 3 will cause them to impinge on the oil surface and sink to the bottom. The trap should be deep enough to retain the debris until it is mechanically removed during periodic maintenance. When dealing with large dust loads such as might be encountered in vacuum furnaces or certain freeze-dry applications, bag-type inlet filters should be employed. These should be rated for a pressure drop of no more than 10 per cent at pressures above 1 torr, but a pressure drop as high as 50 per cent is acceptable at pressures below 10 millitorr as filter sizes become unreasonably large if small pressure drops are demanded. To meet the requirements of low-pressure drop at low pressures with steady-state operation, another form of wet trap shown in Fig. 4 can be effectively used.
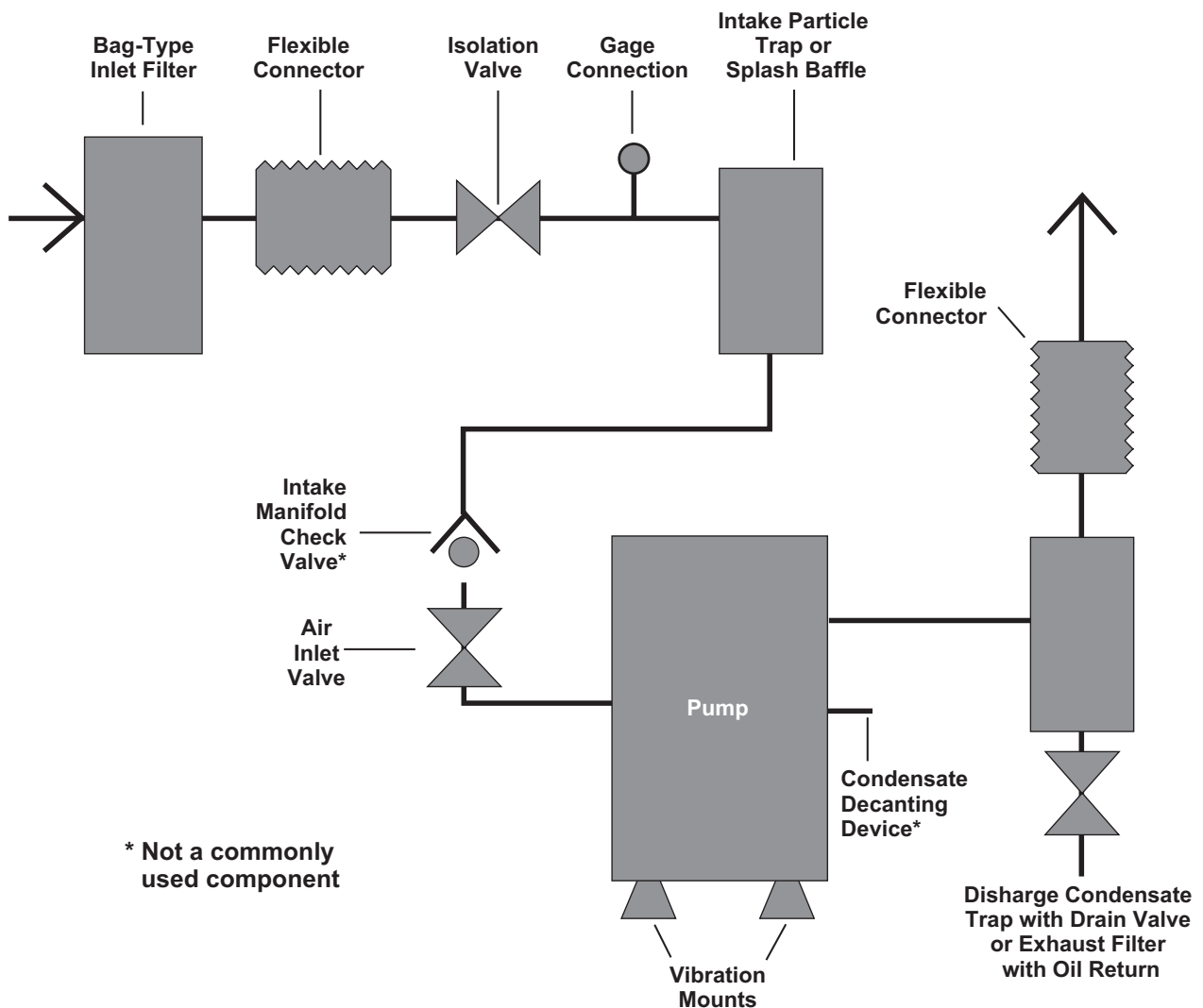
How to Install
Rotary Vacuum Pumps, cont.

KINNEY®

GUIDE TO VIBRATION ISOLATION

|	INHERENTLY BALANCED PUMPS		PARTIALLY BALANCED PUMPS			UNBALANCED PUMPS		
	Small vane pumps up to 50 CFM	Triplex piston pumps all sizes	Medium vane pumps up to 130 CFM	Duplex piston pumps up to 300 CFM	Simplex piston pumps with two flywheels up to 50 CFM	Duplex piston pumps over 300 CFM	Simplex piston pumps all sizes	Large vane pumps over 130 CFM
FREQUENCY OF VIBRATION	Low	High	Low	Low	Low	Very Low	Very Low	Very Low
AMPLITUDE OF VIBRATION	Very Low	Very Low	Low	Low	Low	High	High	High
FOUNDATION REQUIRED	Floor sufficient to support pump weight		Solid floor or heavy frame			Concrete foundation with anchor bolts and grouting		
BASE VIBRATION MOUNTS	Coil springs or air mounts	Elastomer mounts, coil springs, or air mounts	Coil springs or air mounts			Not recommended		
INLET CONNECTOR	Shallow convoluted light gage metal bellows or shallow convoluted elastomer bellows compatible with pump fluid or vacuum hose compatible with pump fluid.							
DISCHARGE CONNECTOR	Flexible connector compatible with pump fluid and gas temperature of 220° F.							
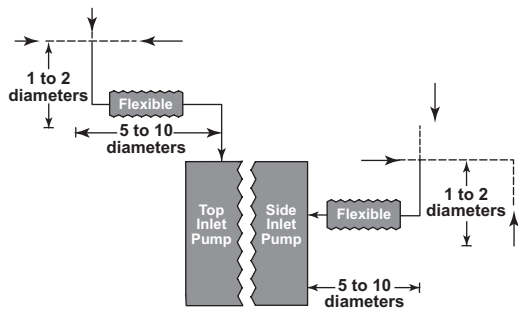
Figure 1. Correct inlet manifold arrangements prevent pump oil from entering the process chamber.
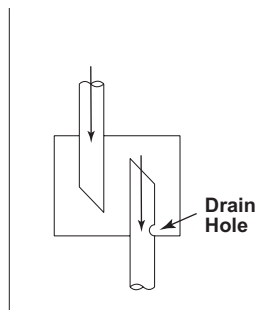

Figure 2. Compact splash baffle for pump inlet can be used with limited space.
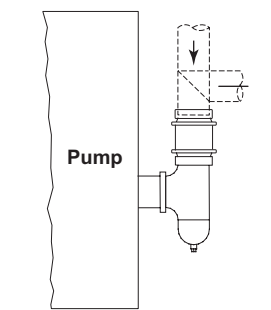

Figure 3. Wet intake particle trap prevents solid contaminants from entering pump.
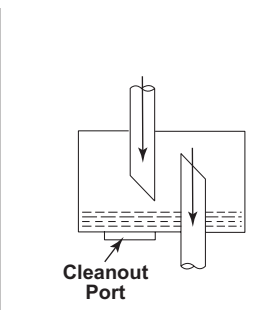

Figure 4. Low impedance particle and liquid trap is used with large capacity pumps.
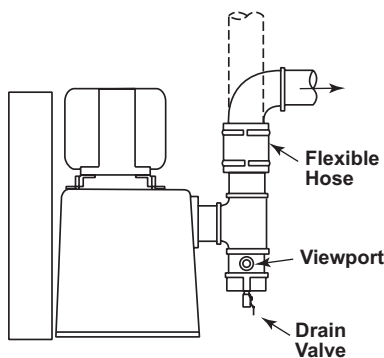

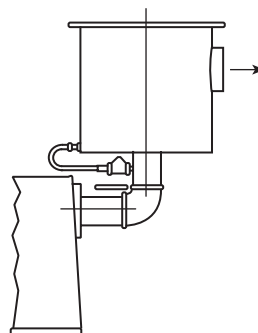**Figure 5.** Properly designed discharge manifold reduces oil loss.

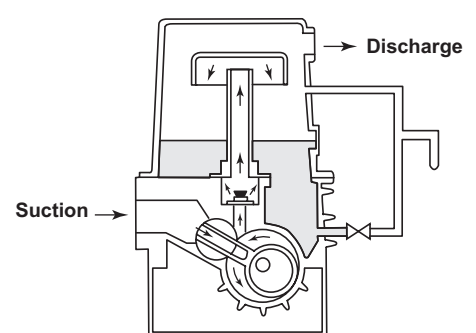**Figure 6.** Typical inline exhaust filter with automatic oil return.

Figure 7. Automatic decanting arrangement removes water from pump oil.

GAGE CONNECTIONS

Pressure measurements are necessary both for process requirements and for trouble-shooting. Gage connections should be located on both sides of the main isolation valve. This permits checking the process pressure and the pump pressure separately. The system pressure will never be quite as low as the ultimate pressure of the pump.

The gage connection should face vertically down for self-draining and be placed in a location protected from the gross splashing of the pump.

DISCHARGE CONNECTIONS

The three principal problems to be overcome in the design of the discharge manifold are oil loss, return of condensate to the pump, and oil mist in the discharge gases. Although an efficient pump separator will limit the oil loss rate to about 0.001 quart per hour for each scfm of gas pumped, not all separators can restrict the oil loss to such a low rate. Some separators that are effective at steady-state operation do not prevent excessive oil loss during sudden pressure excursions due to rapid change in gas load. A properly designed discharge manifold as shown in Fig. 5 can reduce oil loss while at the same time preventing the return of liquid contaminants to the pump. These fluids are produced when vapors expelled with the hot exhaust gases condense on the walls of the exhaust manifold and run down to the pump. The drainable condensate trap shown will collect and store these fluids until drained.

Even the most efficient separator will not remove oil smoke from the pump exhaust. Elimination of oil mist can be accomplished only by use of exhaust filters, either inline or umbrella type. The umbrella type can be located only at the end of the exhaust line and offers a disadvantage in that it has a tendency to drip oil from the outer shell when the element is saturated. Inline filters are generally preferred and can be located where convenient (usually directly at the pump). Figure 6 shows a typical inline exhaust filter installation.

On multi-pump installations it is often more economical to exhaust into one central system. The filtering capacity is based on the total gas load to be handled. On such installations, electrostatic precipitators or fume scrubbers are often useful as they exert no backpressure and are relatively maintenance free. In the case of electrostatic precipitators, provision for the removal of condensate must be made.

ISOLATION AND AIR ADMITTANCE VALVES

Any well designed vacuum system should include an isolation valve and an air admittance valve. When a vacuum pump is stopped, it is a source of leakage. Closing the isolation valve prior to stopping the pump will prevent a pressure rise in the chamber. Isolating the pump from the process chamber permits measuring the pressure in the chamber and/or checking the base pressure of the pump.

The purpose of the air inlet valve is to break the vacuum at the pump inlet just before or at the time the pump is stopped. If this is not done, the pump may flood with oil, making subsequent starting difficult or causing breakage of internal components because of the high hydraulic loads. The air inlet valve should be installed as close as possible to the pump.

The isolation valve should be closed prior to opening of the air admittance valve; venting of the connected vacuum system by means of the air admittance valve may take too long. Start-up of mechanical pumps under full vacuum is undesirable even without oil flooding, as the power requirements are higher than when starting the pump with the inlet at atmospheric pressure.

If the vacuum system must be protected against oil flooding at all cost, added protection can be provided by the use of any of the following devices:

Inlet (float) check valve: allows unrestricted gas flow to the pump inlet but prevents liquid flow into the system.
Discharge check valve: closes after the pump stops. Pump will turn in the reverse direction a few revolutions and the pressure in the separator housing will become the same as that at the pump inlet, and oil flooding will be prevented.
Zero speed switch: connected to actuate the isolation and air admittance valve.

HANDLING CONDENSABLE VAPORS

The most common source of contamination of mechanical vacuum pumps is water. The water can be manually drained from the separator tank, or automatic decanting can be provided by the use of the arrangement shown in Fig. 7. Within specified limits, gas ballast will keep the pump oil clean and/or will clean contaminated oil.

If the vapor is corrosive or cannot be allowed to get to the pump because of pressure consideration, a water-cooled or refrigerated trap at the pump inlet can be incorporated.

Glossary
Of Terms Used in Vacuum Technology
Source: American Vacuum Society

ABSOLUTE MANOMETER
A manometer whose calibration can be calculated from the measurable physical constants of the instrument and which is the same for all ideal gases.

ABSOLUTE PRESSURE
A term used in engineering literature to indicate pressure above the absolute zero value corresponding to empty space or the absolute zero of temperature as distinguished from gage pressure. In vacuum technology pressure always corresponds to absolute pressure not gage pressure, and therefore the term absolute pressure is not required.

ABSORPTION
The process which involves the penetration of a gas or vapor into the bulk of a solid or liquid, usually by some type of diffusion and its subsequent binding or capture; "taking in".

ADSORBATE
The gas removed from the gas phase by adsorption.

ADSORBENT
The material which takes up the gas by adsorption.

ADSORPTION
The process by which gas or vapor is bonded on a solid or liquid surface; "sticking".

AIR-INLET VALVE
A valve used for letting atmospheric air into a vacuum system. Also called a vacuum breaker.

ATMOSPHERIC PRESSURE
The pressure of the atmosphere at a specified place and time.

BOOSTER PUMP
A vapor pump or a specially designed mechanical pump used between a vapor pump and a fore pump to increase the maximum gas throughput which can be handled. The limiting or breaking forepressure of the booster at this maximum throughput must be appreciably greater than that of the vapor pump which it backs.

CENTRIFUGAL PUMP
A pump without a discharge valve which moves the gas from the axis to the circumference by the propelling action of a rapidly rotating member provided with ducts, blades, or vanes.

CHEMISORPTION
The binding of gas on the surface or in the interior of a solid (or liquid) by chemical action.

COLD TRAP
A vessel designed to hold a refrigerant, or cooled by coils in which a refrigerant circulates, inserted into a vacuum system so as to condense on its inner surface vapors present in the system.

COMPOUND MECHANICAL PUMP
A mechanical pump having two or more stages in series.

CONDENSATION RATE
The number of molecules which condense on a surface per square centimeter per second.

CONDUCTANCE (MEASURED VALUE)
The ratio of throughput, under steady-state conservative conditions, to the pressure differential between two specified cross sections inside a pumping system.

DESORPTION
The process of removing physically sorbed gas.

DISPLACEMENT
The geometric volume swept out per unit time by the working mechanism of mechanical pumps at normal frequency.

DRY PUMP
A rotary mechanical vacuum pump than can pump gas and discharge to atmosphere without any liquid required within the pumping chamber. It relies upon close internal clearances to reduce gas slippage such as a rotary screw, lobe, claw, or scroll pump.

DUPLEX MECHANICAL PUMP
A mechanical pump having two single stage units in parallel operated by the same drive.

FORE PUMP
The pump which produces the necessary fore vacuum for a pump which is incapable of discharging gases at atmospheric pressure. Sometimes called the backing pump.

FREE AIR DISPLACEMENT
The volume of air passed per unit time through a mechanical pump when the pressure on the intake and exhaust sides is equal to atmospheric pressure. Also called free air capacity.

FREEZE DRYING
Evaporation to dryness in vacuum for preservation or storage of a labile solution, maintained frozen throughout the process. Sometimes known as lyophilization or sublimation from the frozen state. Frequently hyphenated to freeze-drying.

GAS BALLAST

The venting of the compression chamber of a mechanical pump to the atmosphere to prevent condensation of condensable vapors within the pump. Also called vented exhaust.

GAS BALLAST PUMP

A mechanical pump (usually of the rotary type) equipped with an inlet and valve through which a suitable quantity of atmospheric air or "dry" gas can be admitted into the compression chamber so as to prevent condensation of vapors within the chamber by maintaining the partial pressure of the vapors below the saturation value. Sometimes called a vented-exhaust mechanical pump.

HIGH VACUUM

The term high vacuum has frequently been defined as a pressure less than some upper limit, such as 1mm Hg or 1μ Hg.

HOLDING PUMP

A fore pump used to hold a vapor pump at efficient operating conditions while a roughing pump reduces the system pressure to a point at which the valve between the vapor pump and the system can be opened without stopping the flow of vapor from the nozzles.

IDEAL GAS

A gas which obeys Boyle's law and has zero heat of free expansion (or also obeys Charles' law). Also known as a perfect gas.

IMPEDANCE

The apparent resistance in an alternating current circuit, made up of two components, reactance and true or ohmic resistance; the reciprocal of conductance.

IMPLOSION

The rapid inward collapsing of the walls of a vacuum system or device as the result of failure of the walls to sustain the atmospheric pressure. Usually followed by an outward scattering of the pieces with possible danger to nearby equipment and personnel.

INLEAKAGE RATE

The combined leak rate (in pressure-volume units per unit time) from all existing leaks in a specified evacuated vessel. Sometimes expressed in terms of the rate of rise of pressure in the isolated vessel.

INLET PRESSURE

In connection with performance data on pumps, when not otherwise specified, inlet pressure refers to the "total static pressure" measured in a standard testing chamber by a vacuum gauge located near the inlet port.

LEAK

In vacuum technology a hole, or porosity, in the wall of an enclosure capable of passing gas from one side of the wall to the other under action of a pressure or concentration differential existing across the wall.

LEAK DETECTOR

A device for detecting and locating leaks, and indicating the magnitude thereof.

LEAK RATE

The quantity of gas in pressure-volume units at room temperature flowing into the system or through the pump from an external source in unit time. Recommended unit is Torr • liter per second at 20°C. (Also expressed in micron-liters per second, or micron cubic feet per minute, or cc-atmos/sec at 25°C).

LIQUID RING PUMP

A positive displacement vacuum pump, which utilizes a sealant liquid to perform like a liquid piston, filling and emptying the volumes between the vanes of a rotary impeller to create suction and compression of gas. Low pressure performance is normally limited by the vapor pressure of the sealant liquid used for sealing and heat transfer and/or gas slippage from discharge to suction.

LIQUID-SEALED MECHANICAL PUMP

A mechanical pump in which a liquid (usually oil) is used to seal the gap between parts which move with respect to one another and to reduce the free space ("harmful space") in the compression chamber at the end of the compression cycle. The liquid also usually serves to lubricate and reduce wear.

LOW VACUUM

The term low vacuum applies to the condition in a gas-filled space at pressures less than 760 Torr and greater than some lower limit.

MANOMETER

An instrument for measuring pressure of gases and vapors whether above or below atmospheric pressure.

MCLEOD GAUGE

A liquid level vacuum gauge in which a known volume of the gas, at the pressure to be measured, is compressed by the movement of a liquid column to a much smaller known volume, at which the resulting higher pressure is measured. Particular designs are named after the inventors or various trade names.

MEAN FREE PATH (OF ANY PARTICLE)

The average distance a gas molecule travels without colliding with another molecule or surface.

Glossary
Of Terms Used in Vacuum Technology
Source: American Vacuum Society

MECHANICAL PUMP
A device with moving parts such as rotating vanes, a piston, or eccentric rotary members used for pumping gas or vapor.

MICRON OF MERCURY
A unit of pressure equal to 1/1000th of one millimeter of mercury pressure. Abbreviated as µ of Hg or µ Hg.

MILLIMETER OF MERCURY
A unit of pressure corresponding to a column of mercury exactly one millimeter high at 0°C under standard acceleration of gravity of 980.665 cm/sec2.

MILLITORR
A proposed new unit of pressure equal to 10-3 Torr.

MOLECULAR FLOW
The movement of a gas through a channel under conditions such that the man free path is much greater than the dimension of a transverse section of the channel. The molecules collide mainly with the surfaces rather than with each other.

NET SPEED
(Measured value) - The throughput divided by the pressure at a specified point in the system at a distance from the inlet port of the pump. Also called simply the speed of flow at the specified point.

NON-CONDENSABLE GAS
A gas whose temperature is above its critical temperature, so that it cannot be liquefied by increase of pressure alone.

OCCLUSION
The trapping of undissolved gas in a solid during solidification.

OIL SEPARATOR
An oil reservoir with baffles to reduce the loss of oil by droplets in the exhaust.

OUTGASSING
The evolution (setting-free, releasing) of gas from a liquid or solid under vacuum.

PARTIAL PRESSURE
The pressure of a designated component of a gaseous mixture. The sum of the partial pressures of all the component species in a mixture is equal to the total pressure.

PROBE GAS
A tracer gas which issues from a more-or-less fine orifice so as to impinge on a restricted test area.

PUMP-DOWN FACTOR
The product of the time to pump down to a given pressure and the displacement (for a service factor of one) divided by the volume of the system. F = t D/V

PUMP FLUID
The operating fluid used in vapor pumps or in liquid sealed mechanical pumps. Sometimes called working medium, working fluid, or pump oil.

RATE OF RISE
The time rate of pressure increase at a given time in a vacuum system which is suddenly isolated from the pump by a valve. The volume and temperature of the system are held constant during the rate of rise measurement.

RECIPROCATING PUMP
A pump which moves the gas by means of a system of reciprocating pistons and valves.

ROOTS BLOWER PUMP
A rotary blower pump having a pair of two-lobe inter-engaging impellers of special design.

ROTARY BLOWER PUMP
A pump without a discharge valve which moves the gas by the propelling action of one or more rapidly rotating members provided with lobes, blades, or vanes. Sometimes called a mechanical booster pump when used in series with a mechanical fore pump. Rotary blowers are sometimes classified as either axial flow or cross flow types depending on the direction of flow of gas.

ROTARY PISTON PUMP
A liquid-sealed mechanical pump employing a rotor, stator and sliding vanes.

ROTARY SCREW PUMP
A rotary mechanical vacuum pump that normally utilizes twin intermeshing helical rotors or screws, that may have constant or variable pitch, to move gas along from the low pressure suction end to the atmospheric discharge end without requiring any liquid within the pumping chamber.

ROTATING PLUNGER PUMP
A liquid-sealed mechanical pump having a cylindrical plunger (or piston) which is moved by an eccentric rotor in a sliding rotary motion with a liquid seal against the walls of a cylindrical stator and which divides the stator into two compartments by means of an attached vane or blade which slides through a slot in a cylindrical bearing in the stator wall.

ROUGHING LINE

A line running from a mechanical pump to a vacuum chamber through which preliminary pumping is conducted in the rough vacuum range.

ROUGHING PUMP

The pump used to reduce the system pressure to the point at which a vapor pump (or other pump requiring a fore vacuum) can take hold and operate efficiently. The roughing pump may then also be used as the fore pump for the vapor pump, or the roughing pump may be shut off and a smaller pump used as fore pump when the gas load is relatively small.

ROUGHING TIME

The time required to pump a given system from atmospheric pressure to the take-hold pressure for the vapor pump (or other high-vacuum pump) or to a pressure at which valves to the vapor pump can be opened without stopping the flow of vapor from the nozzles.

SERVICE FACTOR

An empirical factor equal to or greater than one which is specified by the engineer for given pressure ranges and which is multiplied by the displacement as calculated from formulas for a service factor of one to obtain the equivalent pump displacement required by a mechanical pump to meet unusual demands due to outgassing and other service conditions in average industrial systems. Also called system factor or system allowance factor.

SORBATE

Gas taken up by a sorbent.

SORBENT

The material which takes up gas by sorption.

SORPTION

A generic term used to describe the uptake of a gas or vapor by a solid without distinction as to whether the process occurs by adsorption and/or absorption.

SPEED

The speed of a pump for a given gas is the ratio of the throughput of that gas to the partial pressure of that gas at a specified point near the mouth (or inlet port) of a pump.

THROTTLING

Reducing the net pumping speed of a pumping system by partially closing a valve or installing a section of pipe line with low conductance.

THROUGHPUT

The quantity of gas in pressure-volume units at a specified temperature flowing per unit time across a specified open cross section of a pump or pipe line. The specified temperature may be the actual temperature of the gas or a standard reference temperature. It is recommended that throughput be referred to standard room temperature. The recommended unit of throughput is the Torr • liter per second at 20°C. Other units of throughput in common use are micron liters per second at 25° C and micron cubic feet per minute at 68°F.

TIME OF EVACUATION

The time required to pump a given system from atmospheric pressure to a specified pressure. Also known as pumpdown time or time of exhaust.

TORR

A unit of pressure; 1/760th of a standard atmosphere.

TRACER GAS

A gas which, passing through a leak, can then be detected by a specific leak detector and thus disclose the presence of a leak. Also called search gas.

ULTIMATE PRESSURE

The limiting pressure approached in the vacuum system after sufficient pumping time to establish that further reductions in pressure will be negligible. Sometimes called the ultimate vacuum. The terms blank-off pressure or base pressure are also sometimes used in referring to a pump under test.

VACUUM

In vacuum technology the term vacuum refers to a given space filled with gas at pressures below atmospheric pressure.

VACUUM CONCENTRATION

The removal of liquid in vacuum to concentrate a solution; normally used for heat sensitive materials.

VACUUM COOLING

A process for lowering the temperature of a material by subjecting it to vacuum conditions to cause vaporization of a liquid.

VACUUM DRYING

The removal by evaporation of liquid, or sorbed molecules of a liquid, from a substance in vacuum. When the liquid is water, the process is sometimes called vacuum dehydration.

VACUUM ETCHING

A process for etching a surface by causing gas ions to bombard the surface in a vacuum. Also called cathodic etching.

Glossary

Of Terms Used in Vacuum Technology
Source: American Vacuum Society

VACUUM FORMING

A process to form or shape sheets utilizing the differential between atmospheric pressure on the external surface and a reduced pressure between the sheet and a mold.

VACUUM FUMIGATION

A process of vacuum impregnation using a toxic vapor as the impregnating material to reduce or eliminate infestation.

VACUUM GAUGE

An instrument for measuring gas pressure below atmospheric pressure.

VACUUM IMPREGNATION

A process for filling voids or interstices with a fluid by first subjecting the article to a vacuum, then flooding with the desired fluid, and breaking the vacuum.

VACUUM MANIFOLD

An enclosure with several ports so that a number of vacuum devices may be attached to it at one time for evacuation and processing.

VACUUM POTTING

A process for filling voids or interstices with a solid material by first evacuating and then flooding with a liquid which later becomes a solid. Also called vacuum encapsulation.

VACUUM POWDER INSULATION

Use of*a powder-filled and evacuated space for reduction of conductive, convective and radiant heat transfer.

VACUUM PUFFING

A process for increasing the volume of material by subjecting it, while in a plastic state, to a vacuum to cause the evolution of volatiles or the expansion of gas bubbles trapped in the material.

VACUUM SYSTEM

A chamber, or chambers, having walls capable of withstanding atmospheric pressure having an opening through which the gas can be removed through a pipe or manifold to a pumping system. The pumping system may or may not be considered as part of the vacuum system. A complete vacuum system contains all necessary pumps, gauges, valves, work-holding fixtures, and other components necessary to carry out some particular process; such a system is referred to in England as a vacuum plant.

VACUUM THERMAL INSULATION

Use of evacuated space for reduction of conductive and convective heat transfer.

VAPOR

The gaseous phase of a substance that is normally a solid or a liquid at room temperature and atmospheric pressure.

VAPOR PRESSURE

Usually means saturated vapor pressure; a fixed value at a particular temperature for all substances.

VIRTUAL LEAK

a. The evolution of vapor from a cold trap on which the vapor had previously condensed at higher pressures or lower trap temperatures.
b. The semblance of a leak in a vacuum system caused by slow release of sorbed or occluded gas. The term is sometimes used to include volatilization or disintegration of a material unstable under vacuum.

VISCOUS FLOW

The flow of gas through a duct under conditions such that the mean free path is very small in comparison with the smallest dimension of a transverse section of the duct. This flow may be either laminar or turbulent.

Pumping Accessories & Technical Data

PUMPING ACCESSORIES

VACUUM GAUGES
McLeod Gauge
Portable Thermocouple Gauge -1 station
Thermocouple Gauges -1 through 3 station
Dual Range Thermocouple Gauges
Discharge Gauge
Dial Gauges

VACUUM VALVES
Right Angle Valves, manual & pneumatic
Three-way Ball Valves
Globe Valves
Flexible Connectors
Straight and Right Angle Connectors, flange, weld and threaded ends.
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