A Short Course on Vortex Tubes and Application Notes

Contents

History

The vortex tube effects were first observed by Georges Ranque, a French physicist about 1930. He formed a small company to exploit the item but it failed soon. He presented a paper on the vortex tube to a scientific society in France in 1933, but it was met with disbelief and disinterest. Thereafter the vortex tube disappeared for several years, until Rudolph Hilsch studied it and published his findings in the mid-1940s.

Hilsch's paper stirred much interest where Ranque's had not. So much so, in fact, that most readers thought Hilsch had invented the device, and it was popularly called the "Hilsch Tube."

Since then, the vortex tube has become much better known to technical people. There has been a slow but steady increase in research and publication on the subject around the world. Well over 100 serious studies have been published in the world's scientific and engineering journals, scattered so that it is hard to assemble more than a fraction of them. Many popular articles and commentaries have been published. Many engineering schools and industrial and scientific groups are working on the vortex tube.

Today vortex tubes serve in a wide variety of industrial applications, including cooling workers, cooling electrical and electronic equipment, and many process cooling applications.

Air Movement in a Vortex Tube

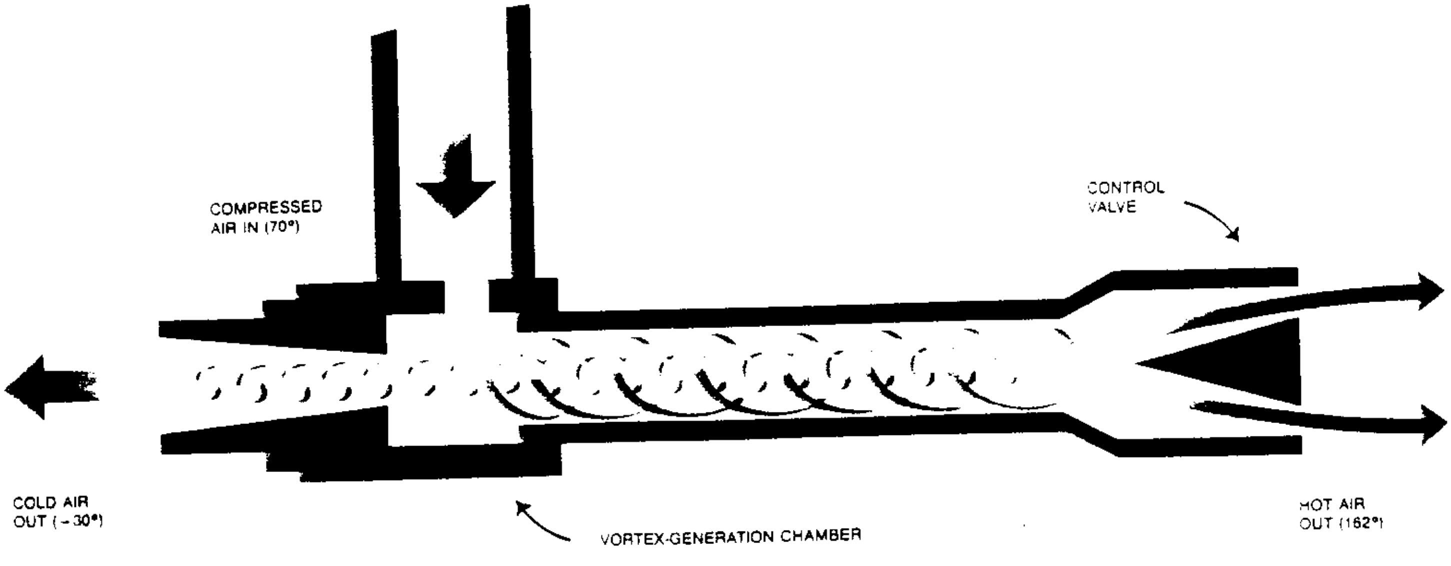
Below is a schematic drawing of a vortex tube showing the internal arrangement and the common names for certain important features.

High pressure air enters the inlet and enters the annular space around the generator. It then enters the nozzles where it loses part of its pressure as it expands and gains sonic or near-sonic velocity. The nozzles are aimed so that the air is injected tangentially at the circumference of the vortex generation chamber. All of the air leaves the vortex generation chamber and goes into the hot tube. It makes this choice (between hot and cold ends) because the opening to the hot tube is always larger than the opening to the cold tube (through the center of the generator). Centrifugal force keeps the air near the wall of the hot tube as it moves toward the valve at the end.

By the time the air reaches the valve it has a pressure somewhat less than the exit pressure at the nozzles, but more than atmospheric (assuming cold outlet is at atmospheric pressure). *It is always true that the pressure just behind the control valve is higher than the cold outlet pressure.*

The position of the valve determines how much air leaves at the hot end. For hot-cold separation, it must allow only part of the air to escape. The remaining air is forced to the center of the hot tube where, still spinning, it moves back toward the cold outlet. It goes all the way through the hot tube, through the center of the vortex generation chamber, to the cold outlet.

Remember the original stream of air in the hot tube did not occupy the center of the tube because of certrifugal force. Therefore it defines an ideal path for the inner stream to follow. This, combined with the above mentioned pressure difference between the valve and the cold outlet, is the reason there are two distinct spinning streams, one inside the other moving in opposite linear directions in the hot tube.



Vortex Tube Performance

As the valve position is changed, the proportions of hot and cold air change, but the total flow remains the same. Thus the amount of air exiting the cold end can be varied over a wide range for a given vortex tube. The amount of this air is known as the "cold fraction."

As you can imagine, one of the secrets of good vortex tube design is to avoid mixing of any of the cold inner stream (the cold fraction) with the warm or hot outer stream. If a tube is operating at a high cold fraction, the passage in the center of the generator must be large enough to handle the cold flow. If not, it will cause some of the cold air to be deflected away and mixed in with the warm air stream, thus wasting refrigeration. At low cold fractions the desired result is usually a small stream of very cold air. An opening too large will invite entrainment of some of the nearby warm air and raise the cold outlet temperature.

Thus for any given vortex tube of a fixed total flow capacity *there is an ideal opening size for every cold fraction.* Practically, a vortex tube user will normally want one of two *modes* of operation. Either *maximum refrigeration* (which occurs at about 70% cold fraction) or *lowest possible cold temperature* (which occurs at about 20% cold fraction). Accordingly Vortec offers H (high cold fraction) bushings designed with the optimum opening for maximum refrigeration and L (low cold fraction) bushings with the optimum smaller opening to create lowest possible cold temperatures.

Each of Vortec's standard tubes can also be fitted with generators for different CFM capacities. Thus we must offer an *H and L bushing for each CFM capacity* in a given tube. So the bushings must be selected *based on two parameters, capacity and mode.* This is why we adopt the simple nomenclature 2-H, 4-L, 8-H, etc.

The 328 tube is made with separate generators and bushings, but it is so rare that anyone would want a tube as large as this to create extremely low temperatures, that we don't show L versions in the price list. All listed 328 series tubes have H style bushings, but L style can be provided on a special order basis.

Temperature Separation Effects In a Vortex Tube

We have already covered the movement of air in the vortex tube. Now we shall attempt to explain why the hot air gets hot and the cold air gets cold.

You'll recall that the air in the hot tube has a complex movement. An outer ring of air is moving toward the hot end and an inner core of air is moving toward the cold end. Both streams of air are rotating in the same direction. More importantly, both streams of air are rotating at the *same angular velocity.* This is because intense turbulence at the boundary between the two streams and throughout both streams locks them into a single mass so far as rotational movement is concerned.

Now the proper term for the inner stream would be a *"forced vortex."* This is distinguished from a *"free vortex"* in that its rotational movement is controlled by some outside influence other than the conservation of angular momentum. In this case the outer hot stream forces the inner (cold) stream to rotate at a constant angular velocity.

In the bathtub whirlpool situation (which most people associate with the word "vortex"), a free vortex is formed. As the water moves inward, its rotational speed increases to conserve angular momentum. Linear velocity of any particle in the vortex is inversely proportional to its radius. Thus, in moving from a radius of one unit to a drain at a radius of ½ unit, a particle doubles its linear (tangential) speed in a free vortex. In a forced vortex with constant angular velocity, the linear speed decreases by half as a particle moves from a radius of 1 unit to a drain at a radius of ½ unit.

So, for the situation above, particles enter the drain with 4 times the linear velocity in a free vortex compared with a forced vortex. Kinetic energy is proportional to the square of linear velocity, so the particles leaving the drain of the forced vortex have 1/16th the kinetic energy of those leaving the drain of the free vortex in this example.

Where does this energy (15/16 of the total available kinetic energy) go? Therein lies the secret of the vortex tube. The energy leaves the inner core as heat and is transmitted to the outer core.

Now you might say the air in the cooling inner stream had to travel through the outer (heating) stream first. Why doesn't it heat the same amount it cools with no net cooling effect? Keep in mind that the rate of flow in the outer stream is always larger than that of the inner stream, since part of the outer stream is being discharged at the hot valve. If the BTUs leaving the inner stream equal the BTUs gained by the outer stream, the temperature drop of the inner stream must be more than the temperature gain of the outer stream because its mass rate of flow is smaller.

If this precept is clear in your mind, a little reflection will allow you to understand why hot end temperatures increase as cold fraction increases, and cold end temperatures decrease as cold fractions decrease.

Effects of Inlet Temperature

It is very easy to predict the temperature drops and rises in a vortex tube for various inlet temperatures. The basic rule to remember is that temperature drops or gains are *proportional to absolute inlet temperature.* Any temperature expressed in degrees Fahrenheit can be converted to absolute (degrees Rankine) by adding 460. That is, 0°F = 460°R or 70°F = 530°R.

Thus, the entire table is based on an inlet temperature of 530°R. If absolute inlet temperature doubles, so does the temperature drop or gain. As an example, suppose you want to find the temperature drop associated with a vortex tube operating at 30% cold fraction and with a 100 psig, 200°F inlet.

1. Table gives 118° drop for 100 psig, 70°F inlet and 30% CF.
2. Ratio of absolute inlet temperature

$$\frac{200 + 460}{70 + 460} = \frac{660}{530} = 1.245$$

3. Drop given in table times ratio is 118 × 1.245 = 147°
4. Cold end temperature is 200° − 147° = <u>53°F</u>

This ratio can be used just as well when the inlet temperature is lower than the 70°F on which the table is based. For example, if inlet temperature were 0°F, ratio would be

$$\frac{0 + 460}{70 + 460} = \frac{460}{530} = .87$$

In this case the temperature drop is reduced.

Exactly the same approach can be used to convert the temperature rises given in the table. They are greater for inlet temperatures higher than 70°F and smaller for inlets below 70°F.

One additional comment on this method should be made. It applies to the pressure range shown on the table only. Whenever pressures considerably higher than the table are involved, the Joule Thompson effect alters the results somewhat. This effect is small at pressures of 140 psig and below, and can be ignored as it is in the method given above. Joule Thompson cooling is the very slight cooling that takes place as gases are throttled.

Using the Performance Table

Two rather important limitations of the performance table in the catalog should be recognized.

First, the table would seem to imply that temperature drops and rises are related to inlet pressure. This is not quite true. They are related in a complex way to the *absolute pressure ratio* between inlet and cold outlet. The table is based upon the assumption that the *cold outlet is at atmospheric pressure*. For any other cold end pressures, the table cannot be used.

You can appreciate the variation in temperature drops and rises if you consider how quickly the absolute pressure ratio changes with changes in cold end pressure. A 90 psig inlet (105 psia) provides a 7 to 1 ratio when the tube exhausts to atmospheric pressure (0 psig or 15 psia). If inlet pressure remains the same and cold outlet pressure rises to only 15 psig, the ratio drops to 3.5 to 1.

Calculations of temperature rises and drops for pressures other than those shown on the table can be made, but they are beyond the scope of this Short Course. Refer any such problems to Vortec.

The Heat Balance Formula

A very handy formula results from the fact that the energy extracted from the cold air by the vortex tube appears in the hot air.

The formula is:

$$CF \times (t_i - t_c - JT) = (100 - CF) \times (t_h - t_i + JT)$$

where CF = cold fraction, %

t_i = inlet air temperature, °F

t_c = cold air temperature, °F

t_h = hot air temperature, °F

JT = Joule-Thompson temperature correction °F = 4°F at an inlet pressure of 100 psig

By using this formula, cold fraction can be computed from the readings of the three thermometers alone without having to measure any air flow. As an example, suppose $t_i = 100°F$, $t_c = 50°F$, $t_h = 300°F$. Substituting in the formula,

$$CF \times (100 - 50 - 4) = (100 - CF) \times (300 - 100 + 4)$$

Solving for CF, CF = 81.5%

Vortex tubes obey this formula very closely, regardless of their efficiency, provided only that the hot pipe be insulated.

The formula can be rearranged as follows:

$$CF = \frac{t_h - t_i + 4}{t_h - t_c} \times 100$$

This is its handiest form for computing cold fraction.

Humidity Effects

The vortex tube does not separate humidity between the hot and cold air. The absolute humidity of both cold and hot air, in grains/pound, is the same as that of the entering compressed air.

Moisture will condense and/or freeze in the cold air if its dew point is higher than its temperature. The following table shows the amount of moisture that air can hold in the saturated vapor state as a function of air temperature, at standard atmospheric pressure of 14.7 psia:

Temperature, °F	110	100	90	80	70	60	50	
Saturation*	375	295	217	154	111	77	54	
Temperature, °F	40	30	20	10	0	−10	−20	−30
Saturation*	37	24	15	9	5.5	3.2	1.8	1.0

*Saturation Moisture Content Grains/lb. Air

For example, the above table shows that if the moisture content is 14 gr./lb., condensation will begin when the temperature of the cold air falls below 19°F. At 5 gr./lb., condensation will begin at −1°F.

The saturation moisture content of compressed air at 100 psig is given in the following table:

Temperature °F	110	100	90	80	70	60	50	40	30	20
Saturation Moisture Content Grains/lb. Air	48	38	28	20	14	9.9	6.9	4.7	3.1	1.9

By comparing the two tables, it is possible to predict the amount of moisture in the compressed air, and the temperature at which moisture will begin to precipitate or freeze in the cold air. As an example, suppose the compressed air is aftercooled to 80°F following compression, and the precipitated water drained off. Then the second table shows that it will carry 20 grains/lb. of water vapor. When this expands in the vortex tube, the upper table shows that precipitation will begin in the cold air when its temperature falls below 26°F if its pressure is 14.7 psia.

If the compressed air is cooled under pressure by a chiller to 40°F, the second table shows that it will then carry 4.7 grains/lb of water vapor. When expanded in the vortex tube, precipitation will begin when the temperature of the cold air falls below −3°F at 14.7 psia.

If, under unusual conditions, some moisture precipitates in the cold air, the temperature of the cold air will thereby be caused to rise approximately 3/4°F for each grain of moisture that precipitates. This is because some of the sensible refrigeration of the cold air is consumed in producing latent refrigeration of the moisture. This refrigeration is not lost but reappears in the cold air as it warms up in performing its air conditioning duty after leaving the vortex tube, when the precipitated moisture re-evaporates.

The tables show that condensation will not normally occur at moderate cold end temperatures. When temperatures are low enough to cause condensation, it appears as snow. The snow has a sticky quality due to oil vapor and will gradually collect and block cold air passages. Continuous operation at low temperatures can be assured by means of an air dryer or injection of an antifreeze mist into the compressed air feeding a vortex tube.

When selecting dryers give consideration to refrigerative and deliquescent types. While their drying abilities are limited (and need to be considered) they are quite compatible with the vortex tube. Chemical dessicant dryers such as silica-gel and molecular sieve types are exothermic, and tend to heat the compressed air causing refrigeration losses.

Application Notes

The Air Supply

Pressure

Standard vortex tubes made by Vortec Corporation are designed to utilize a normal shop air supply of 80 to 110 psig pressure. Unless pressures run considerably higher than 110 psig, do not use a regulator to reduce the inlet pressure. Pressures higher than 250 psig must not be used. Pressures lower than 80 psig will still produce some cooling. However, both the temperature drops and the flows are reduced due to the lower inlet pressures.

Line Sizes

Up to 25 SCFM, runs of pipe less than 10 feet long may be 1/4" size without excessive pressure drop. Up to 50 feet use 3/8" pipe, and use 1/2" pipe over 50 feet. Rubber hose of suitable pressure rating may be used. Consider 3/8" id hose to be the same as 1/4" pipe, and 1/2" id hose to be the same as 3/8" pipe. Remember that lower transmission pressures will exhibit even greater pressure drops, so care must be taken to avoid large losses in the inlet air piping.

Compressor Size

In most large plants, the size of the compressor is adequate to handle many vortex tubes operating simultaneously. For smaller plants, estimate horsepower required based upon the rated capacity of the tubes. For a 100 psig system, it takes one horsepower to compress four SCFM of air.

Preparing the Air

Moisture

All compressed air systems will have condensed water in the lines unless a dryer is in use. To remove condensed water from the air, a filter-separator *must be used.* Automatic drain types are recommended unless the area is always tended by a responsible employee who can empty the collection bowl periodically. Place the filter-separator as near to the vortex tube as possible.

Dryers

Normally a dryer is not required for vortex tube applications. Occasionally, however, when very low outlet temperatures are produced, icing will cause problems. Also, some applications may require the cold air stream to be completely free of condensed water or ice. A chemical dryer (silica gel, heatless, or other type) can be used in the inlet line to eliminate condensed water or ice in the cold air stream. The dryer should be rated to produce an atmospheric dew point lower than the lowest expected cold outlet temperature.

Dirt

Because of the water in compressed air lines, there is always rust and dirt present. Vortec's filter-separators effectively remove these contaminants by using a 5 micron filter. Replacement filters are available at nominal cost, and it is necessary for the user to determine the frequency of replacement based on the conditions prevailing in his plant.

Oil

Never use vortex tubes downstream of a lubricator. Oil in the air which has been introduced by the compressor lubrication system is usually not a problem for Vortec products, but occasionally older compressors produce very oily air. If the plant air is very oily, use an oil removal filter downstream of the filter-separator. The oil removal filter removes dirt, water, and oil aerosols with an effective filtration of 0.01 micron.

Settings

Maximum Refrigeration. Maximum refrigeration occurs when a vortex tube operates at 60 to 70 percent cold fraction. This is where the product of the mass of cold air and its temperature drop is the greatest. Many applications such as cooling electrical controls, liquid baths, and personal air conditioning use this maximum refrigeration setting. For maximum refrigeration, use H style bushings.

Minimum Temperature. Some applications require the lowest possible cold output temperature. Examples are cooling glass, cooling hot parts, and using cold air to cool machining operations. These air spraying applications usually work better with very cold air, and results seem not to depend upon the refrigeration rate. For these applications, L style bushings and cold fractions in the 20 to 40 percent range are best.

Using the Cold Air

Back Pressure. One of the most common mistakes with vortex tubes is to restrict the cold outlet. This will cause a loss of performance. A small back pressure on the cold outlet to allow the air to move through piping or ducting is acceptable, but back pressure, measured at the tube, should be limited to less than 5 psig. Keep in mind the tube is responsive to the absolute pressure ratio applied and back pressures as low as 15 psig cut this ratio in half. Some pressure is available at the hot end, and it can be used so long as compensating adjustments in the control valve settings are made.

Insulation. As with any thermodynamic device, the proper use of insulation will improve vortex tube system performance. Avoid ducting the cold air through large thermal masses such as heavy piping, drilled holes in large blocks, etc. If possible use plastic tubing or piping. Foam type insulation can also be quite helpful.

Noise Mufflers

General. A common misconception is that a vortex tube emits a scream or whistle due to the sonic speeds inside. Actually such noise is rarely observed, but the sound of escaping air is always present, and in some cases it must be muffled. Ordinarily the cold air will be ducted into an enclosure or through some pipe or tubing. This alone may reduce its noise level to acceptable limits. Hot air escapes in smaller amounts in most applications and may not be objectionable. Nevertheless, jets of escaping air can be quite objectionable if continued over a long period of time near worker. In such situations mufflers are available, and should be used.

Cold Muffling. Mufflers used on the cold air must not be of a stuffed or porous type. Their small openings will quickly block with ice which has condensed and frozen in the cold air stream. Baffle type mufflers and silencers are best for the cold air. Avoid selecting any muffler which will apply high back pressures to the vortex tube.

Hot Muffling. Nearly any air silencer or muffler will work on the hot end. One should avoid selecting a muffler made from plastics or other materials with low resistance to heat since hot end temperatures can easily exceed 200°F.

Maintenance

Since vortex tubes have no moving parts, they are highly reliable, and require little or no maintenance. Prolonged use with dirty or oily air can cause wear or dirt collection in the tube. Occasional disassembly, inspection, and cleaning are the only maintenance activities required.

VORTEX TUBES

Refrigeration from Compressed Air

What Is a Vortex Tube?

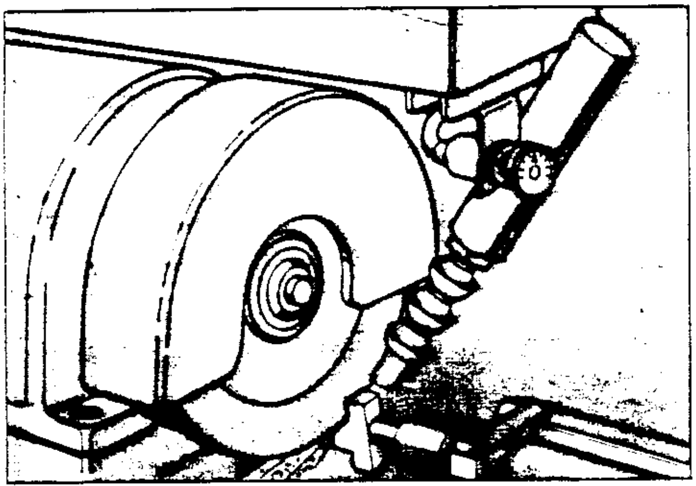
A Vortex tube is an instrument with no moving parts that converts a supply of ordinary compressed air into two airstreams at slightly above atmospheric pressure, one hot and one cold. A Vortex tube can produce up to 6000 BTUH of refrigeration or temperatures down to −40°F, using nothing more than compressed air at 100 psig. A valve in the hot air outlet allows you to infinitely adjust the flows and temperatures over a wide range.

Benefits of Vortex Tubes

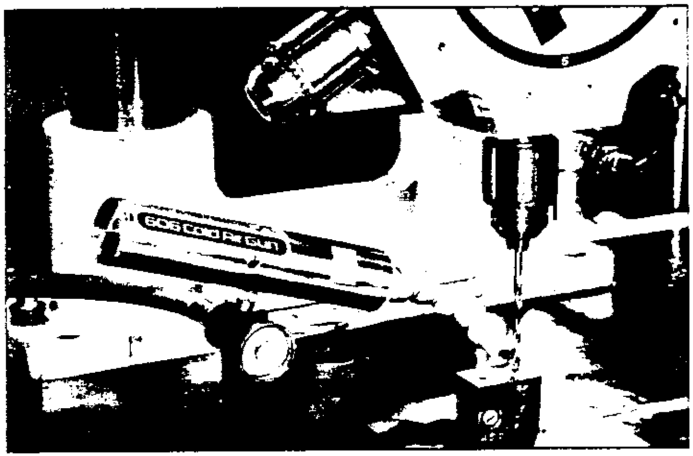
- No moving parts
- Virtually maintenance free
- Low initial cost
- Small size
- Highly reliable
- Easily controlled
- Lightweight
- Portable
- No spark/explosion hazard
- Spot cools without waste
- Instant on/off
- No RF interference

How Is Industry Using Vortec Tubes?

- Cool machining operations
- Set solders, adhesives
- Temperature cycle thermostats, instruments and electronic components
- Dehumidify gas samples
- Cool electronic control cabinets
- Cool workers in protective helmets, hoods and suits
- Test automobile temperature sensors and chokes
- Cool industrial sewing needles
- Chill environmental chambers
- Cool mold tooling
- And many more...see the application cases in section I.



Cold air from a Vortec Model 606 Cold Air Gun eliminates cracks during tool grinding.



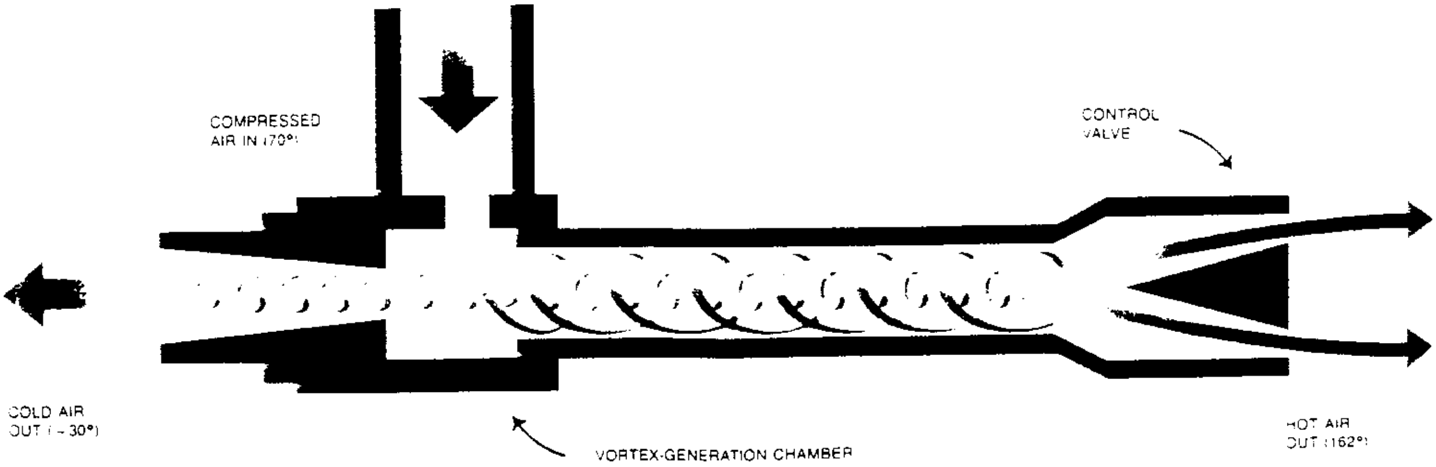
Cold air machining eliminates mists, residues, and other liquid coolant problems.

How Does a Vortex Tube Work?

High pressure air enters a stationary generator and is released with a Vortex motion, spinning along the tube's walls toward the hot air end at sonic speeds up to 1,000,000 rpm. Air near the surface of this spinning vortex becomes hot, and some of it exits through the needle valve in the hot end. The air that does not escape through the hot air needle valve is forced back through the center of the warm air vortex.

Because the air forced back through the sonic-velocity hot airstream moves at a slower speed, a simple heat exchange takes place. The inner, slower-moving column of air gives up heat to the outer, faster-moving column. When the slower, inner column of air exits through the center of the stationary generator and out the cold exhaust, it has attained an extremely low temperature.

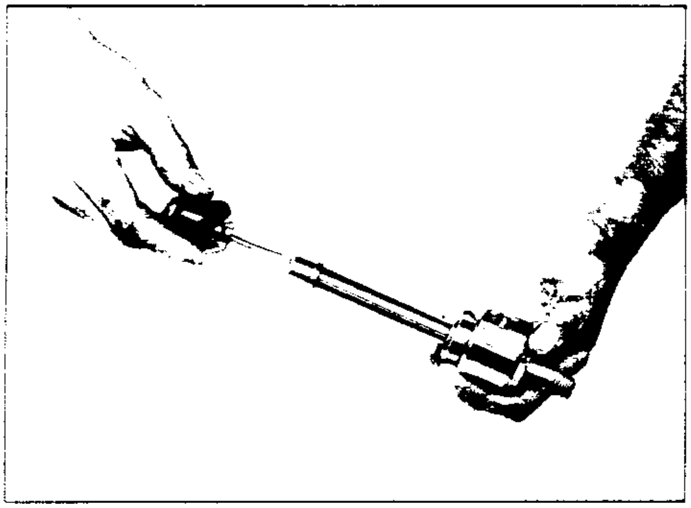
For a more detailed explanation of this process, initially discovered in 1930, read the "Short Course" in section H or call one of our Application Engineers on the Hot Line.



Vortex Tube Performance

You can vary the volume and temperature of the cold air produced by a Vortex tube by adjusting the valve in the hot air outlet. This controls what is known as the "cold fraction," which is the percent of the input air volume released through the cold outlet. For example, if the total volume of compressed air input is 15 SCFM and the cold fraction is 70%, then 10.5 SCFM exits the cold end and 4.5 SCFM exits the hot end. A *high cold fraction* (more than 50% of the input air released through the cold air end) produces *maximum refrigeration*—the greatest BTU output. This usually occurs at cold fractions of 60%-70%, where the mass of air released at the cold outlet and the temperature drop of the air are optimized to yield maximum efficiency and BTU's. Most applications, such as cooling electrical controls, liquid baths, and personnel, use high cold fractions for maximum refrigeration.

A *low cold fraction* (less than 50% of input air released through the cold end) produces the *lowest temperatures*, but with a reduced flow of air. A low cold fraction, with its extreme low temperature and low flow, is useful in cooling small machining operations, small parts, glass, testing of electronic components, and laboratory experiments.



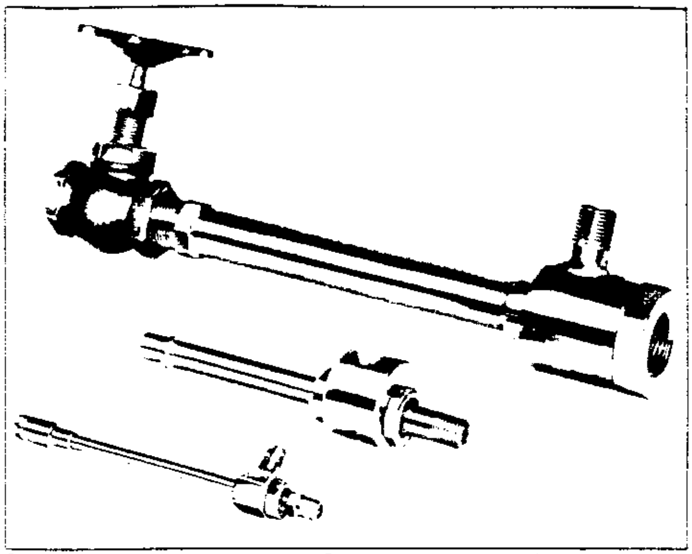
Temperature of cold air from a Vortex Tube is adjusted with a simple valve in the hot-air end.

Standard Models from Vortec

Vortec Corporation was the first company to fully develop and commercialize the Vortex tube.

In more than two decades of work, we have developed three standard tube sizes, each capable of three flow ratings. We accomplish this with three differently-sized, interchangeable generators which provide three CFM ratings for each tube.

The nine different capacities provided by our Vortex tubes cover the entire range of cooling capability which is economically practical with a Vortex tube. This enables you to size a unit for your application without wasteful over-capacity.

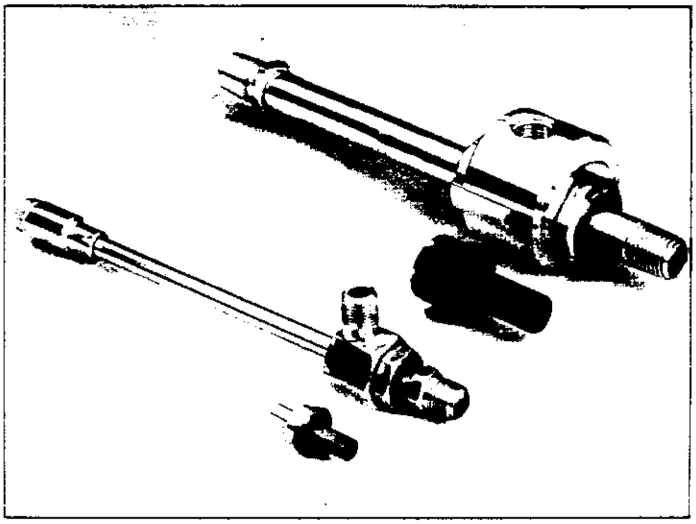


Each of our three standard sizes of Vortex Tubes is capable of three different flow ratings

Optimizing Vortex Tube Efficiency For Your Application

By changing the diameter of the cold air passage in the center of the vortex generator, you can configure your Vortex tube for maximum efficiency as a high-cold-fraction unit or a low-cold-fraction unit. We provide simple bushings to accomplish this in our 106 and 328 tubes. We designate these bushings H and L for high and low cold fractions. Each bushing is sized to match the CFM capacity of its corresponding vortex generator. For example, generators for a 106 tube (designated 2, 4, 8) may be used with bushings 2-H or 2-L, 4-H or 4-L, 8-H or 8-L, depending on the cold fraction you want.

The bushing and generator are separate parts for our 106 and 328 tubes. For the 208 tube, the bushing and generator are manufactured as a single part, with the model numbers again designating CFM rating and high or low fraction efficiency: 11-H, 11-L, 15-H, 15-L, 25-H, 25-L.

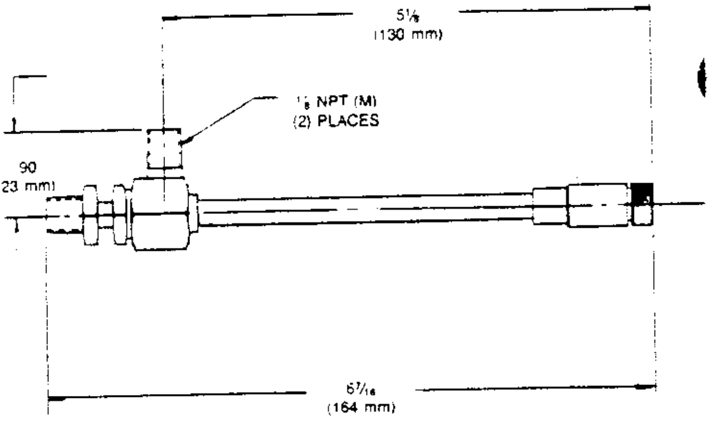


The stationary generators and bushings inside the Vortex Tube control air flow and cold-fraction capabilities.

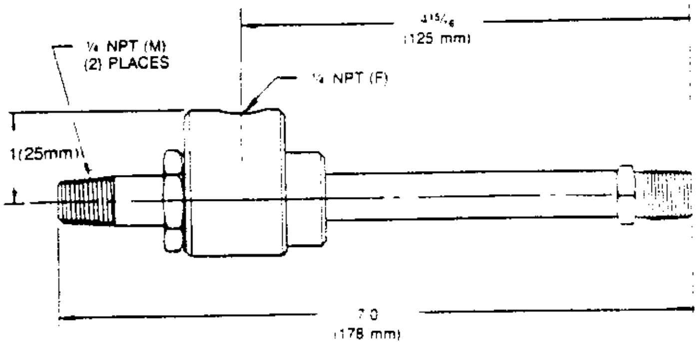
Vortex Tube Capacities

Model Number	Inlet Pressure (PSIG)*	Air Consumption (SCFM)	Capacity (BTU/H)
106-2-H	100	2	100
106-4-H	100	4	200
106-8-H	100	8	400
208-11-H	100	11	600
208-15-H	100	15	900
208-25-H	100	25	1500
328-50-H	100	50	3000
328-75-H	100	75	4500
328-100-H	100	100	6000

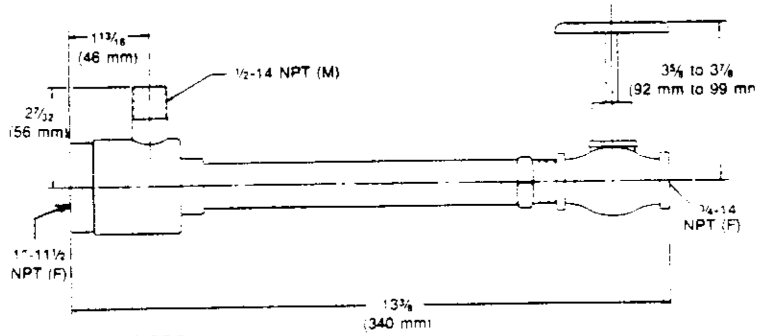
*Inlet temperature: 70°F.



Model 106



Model 208



Model 328

Specifying a Vortex Tube

This table shows the approximate temperature drops and rises you can expect from Vortex tubes adjusted to various cold fractions. The primary determinant in Vortex tube performance, in addition to the cold fraction setting, is inlet pressure.

The table assumes an inlet temperature of 70°F. Keep in mind that the cooling performance of the Vortex tube can be degraded by higher supply air temperatures, by moisture in the supply air which can condense and freeze (easily corrected with an air filter), or by excessive back pressure at either the hot or cold air outlet. A clean Vortex tube, operating with constant inlet pressure and temperature, will maintain temperatures within ±1°F.

Vortex Tube Performance Data

Inlet Pressure PSIG	Cold Fraction, %						
	20	30	40	50	60	70	80
20	**61.5** 14.5	**58.5** 24.5	**55.5** 36.0	**50.5** 49.5	**43.5** 64.0	**36.0** 82.5	**27.5** 107
40	**88.0** 20.5	**85.0** 35.0	**80.0** 51.5	**73.0** 71.0	**62.5** 91.5	**51.5** 117	**38.0** 147
60	**104** 23.5	**100** 40.0	**93.0** 58.5	**84.0** 80.0	**73.0** 104	**59.5** 132	**44.5** 168
80	**115** 25.0	**110** 43.0	**102** 63.0	**92.0** 86.0	**80.0** 113	**65.5** 143	**49.0** 181
100	**123** 26.0	**118** 45.0	**110** 66.5	**99.0** 91.0	**88.0** 119	**70.5** 151	**53.0** 192
120	**129** 26.0	**124** 46.0	**116** 69.0	**104** 94.0	**90.5** 123	**74.0** 156	**55.0** 195
140	**135** 25.5	**129** 46.0	**121** 70.5	**109** 96.0	**94.0** 124	**76.0** 156	**58.5** 193

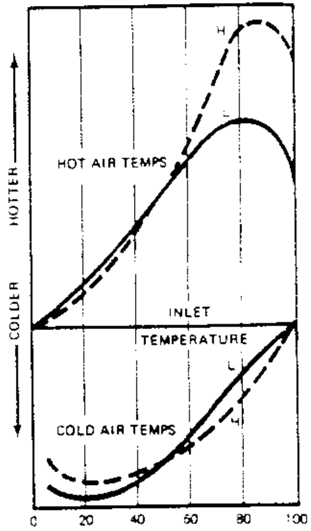
Figures in gray area give temperature drop of cold air, °F
Figures in white area give temperature rise of hot air, °F

Air Flow

The total discharge (hot and cold) in SCFM from a Vortex tube is proportional to absolute inlet pressure. To approximate the total flow for a given inlet pressure, use the following simplified formula:

$$\frac{(\text{inlet psig.} + 15) \times \text{cfm rating of generator}}{115} = \text{approx. total flow}$$

TEMPERATURE VERSUS COLD FRACTION FOR A TYPICAL VORTEX TUBE



Air Conditioning Power

To approximate the cooling and heating power in BTUH, use the following simplified formulas:

CF = Cold Fraction
CFM_t = Total Air Flow
CFM_c = Cold Air Flow = CFM_t (CF)
CFM_h = Hot Air Flow = CFM_t (100-CF)

t_i = Inlet Temperature
t_c = Cold Air Outlet Temperature
t_h = Hot Air Outlet Temperature

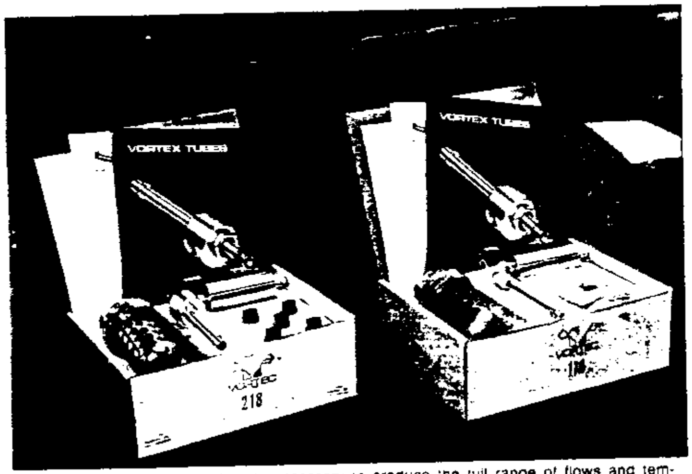
For Cooling:
$BTU/hr = 1.0746\ (CFM_c)\ (t_i - t_c)$
For Heating:
$BTU/hr = 1.0746\ (CFM_h)\ (t_h - t_i)$

Getting Started

The technical and practical questions you may have about designing a Vortex tube into a product or process can be handled by our Vortecnology Application Engineers. They not only know our products inside-out, but they've also helped thousands of customers use those products in a variety of industries and applications. Their experience is a technical resource that's available to you for the asking. And it's *FREE.*

Experimental Kits

If you want to "learn on your own," or if you need to periodically test Vortex tubes in your products or systems, we have available two experimental kits containing the generators and bushings needed to produce the full range of flows and temperatures with the two most commonly used tubes: the 106 and 208. The kits also contain a 5-micron filter, a cold-end muffler, and a booklet on the operation and application of Vortex tubes. The kits are handy design tools to have whenever you are contemplating the use of a Vortex tube in your product or system.



Experimental kits contain all parts necessary to produce the full range of flows and temperatures from the 106 and 208 Vortex Tubes.

Specifications

	116 EXPERIMENTAL OUTFIT	218 EXPERIMENTAL OUTFIT
Vortex Tube	106	208
Refrigeration	up to 400 BTU/hr.	up to 1500 BTU/hr.
Flow Rates (SCFM)	2, 4, 8	11, 15, 25
Temperature	to −40°F	to −40°F

Accessories

We stock a full line of accessories that have proven the most-useful and most-asked-for by Vortex tube purchasers and system designers:

- Bushing/generator kits
- Cold end mufflers
- Hot end mufflers
- Thermostats
- Solenoid valves
- Air lines
- Pressure regulators
- Filter/separators
- and more

PRICE #106 $88 —
#208 $239 —

APPLIED VORTEX TUBE PRODUCTS

Standard System Packages

We've learned from working with our customers that a number of Vortex tube applications are almost universal, so we've packaged several systems with the tubes and accessories designed for specific uses. Four of those systems are described in this section: Cold Air Gun, Circuit Tester, Choke Tester, and Thread Guard. Two others—Vortex Control Cooling Systems and Mancooling—have grown into complete product lines. They are described fully in the sections devoted to those applications.

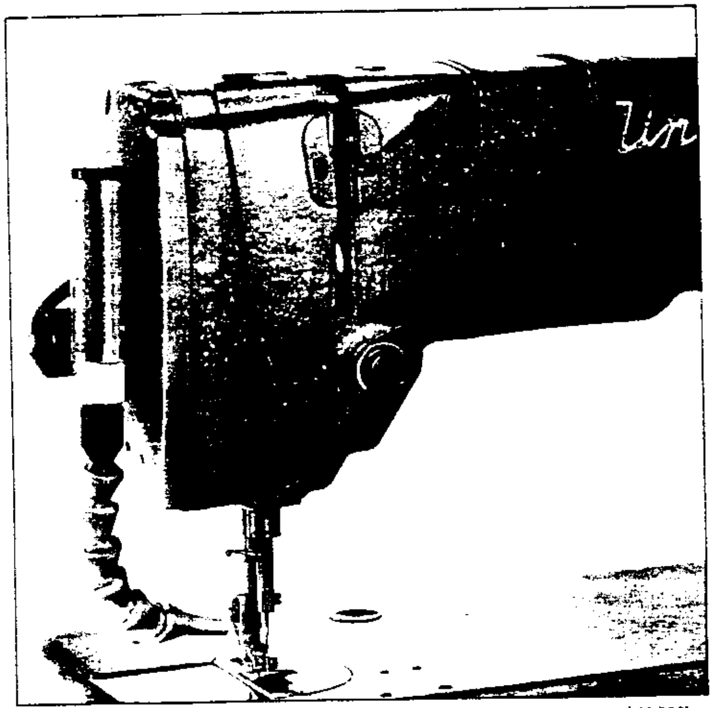
Thread Guard

Add the model 424 Thread Guard to any sewing machine and watch production soar, even in continuous operations for waistbands and belt loops, and with tough materials such as denim and belting.

The continuous stream of 10°F air from the Thread Guard virtually eliminates thread burning and breakage, as well as heat-related needle breakage. It's especially effective with synthetic threads.

Ready to Use

- Uses just 4 SCFM of shop air at 80-100 psig.
- Easily and quickly mounted.
- Adapts to any machine.
- Includes mounting hardware, five-micron filter, shut-off valve, pressure regulator/gauge, cold air tube and complete instructions.


Thread Guard cools sewing operations. It stops thread burning and breakage as well as heat-related needle breakage.

VORTEC
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