# Ejectors

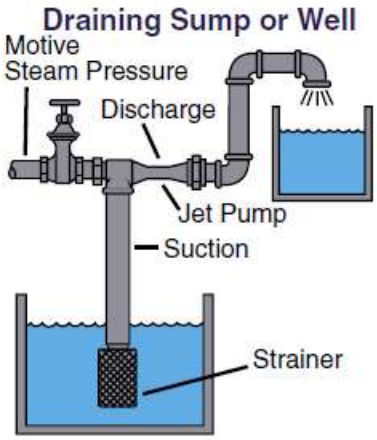
It is important to know the proper nomenclature for internal parts of an ejector before beginning to discuss how an ejector works. An ejector is a static piece of equipment with no moving parts. There are four major components to an ejector, the motive nozzle, motive chest, suction chamber and diffuser.

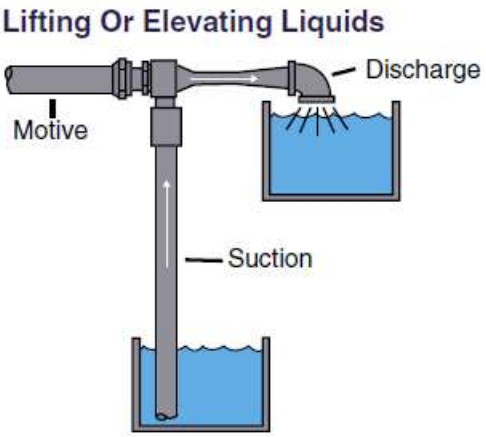
# Steam Jet Ejectors

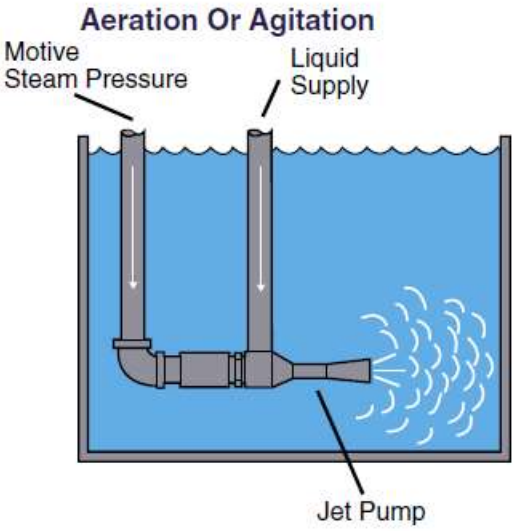
The basic operating principle of an ejector is to convert pressure energy of high pressure motive steam into velocity. High velocity steam emitted from a motive nozzle is then used to work on the suction fluid. This work occurs in the suction chamber and diffuser inlet. The remaining velocity energy is then turned back into pressure across the diffuser. In simple terms, high pressure motive steam is used to increase the pressure of a fluid that is at a pressure well below motive steam pressure.

Thermodynamically, high velocity is achieved through adiabatic expansion of motive steam across the converging/diverging motive nozzle from motive pressure to suction fluid operating pressure. The expansion of the steam across the motive nozzle results in supersonic velocities at the nozzle exit. Typically, velocity exiting a motive nozzle is in the range of Mach 3 to 4, which is 3000 to 4000 ft/sec. In actuality, motive steam expands to a pressure below the suction fluid pressure. This creates the driving force to bring suction fluid into an ejector. High velocity motive steam entrains and mixes with the suction fluid. The resulting mixture is still supersonic. As this mixture passes through the converging, throat, and diverging sections of a diffuser, high velocity is converted back into pressure. The converging section of a diffuser reduces velocity as the crosssectional area is reduced. The diffuser throat is designed to create a normal shock wave. A dramatic increase in pressure occurs as flow across the shock wave goes from supersonic, to sonic at the shock-wave, to subsonic after the shock wave. In a diffuser diverging section, cross-sectional flow area is increased and velocity is further reduced and converted to pressure.

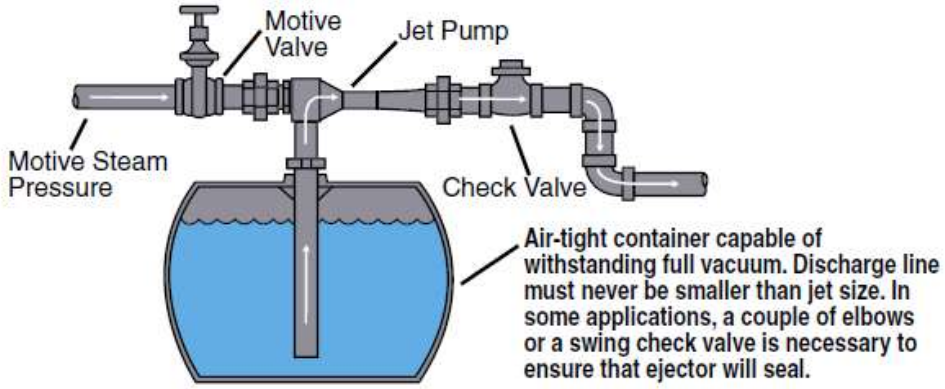
Another method of pumping liquids is to use steam as the motive. This type of jet pump works best in applications where a minimal amount of infusion of the motive media with the liquid to be transported is required. Quiet operating steam motive jet pumps, like liquid motive pumps, are simply designed with no packing glands and no moving parts to wear out. These pumps are attractive to the process industry because of their low initial cost, ease of operation and consistently low maintenance cost.

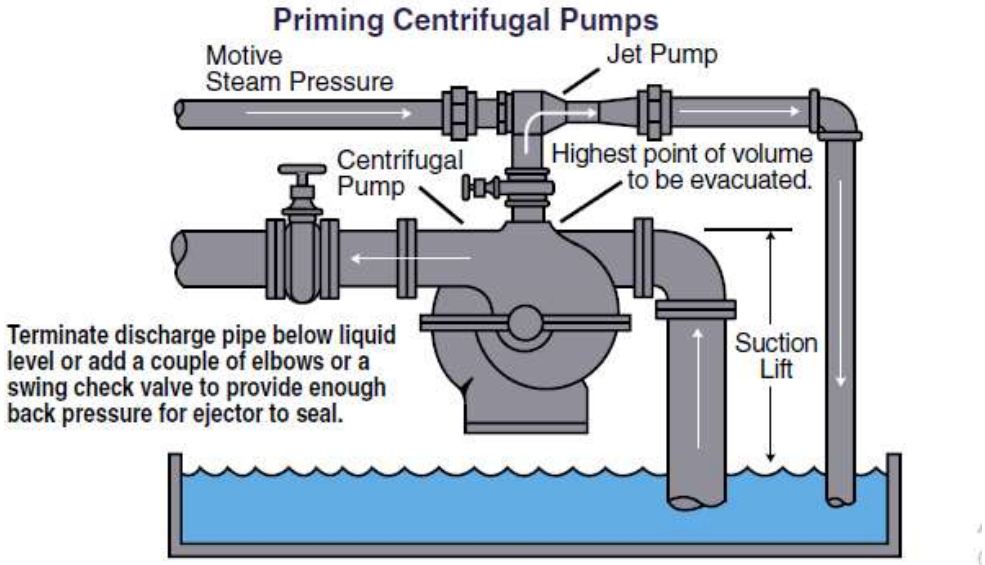


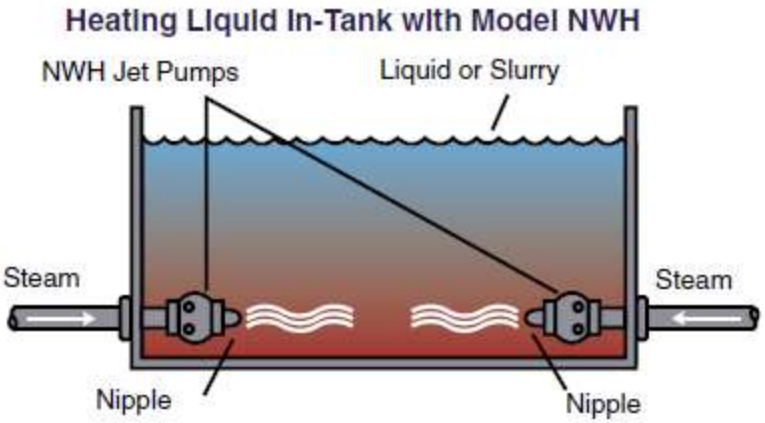



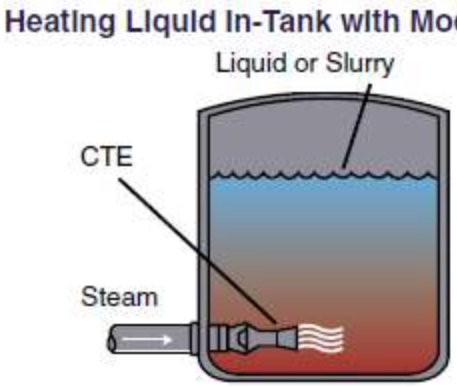

These steam motive jet pumps can be used to drain sumps, drain or fill tanks and elevate or lift liquids. Industries that would benefit from the use of Penberthy G Series jet pumps include: chemical processing, textile manufacturing, food processing, water treatment and petroleum production & refining. Additional uses could be for: distilling & brewing, agricultural processing, pharmaceutical processing, sterilization, HVAC, pulp & paper manufacturing, power generation, mining, plastics production.

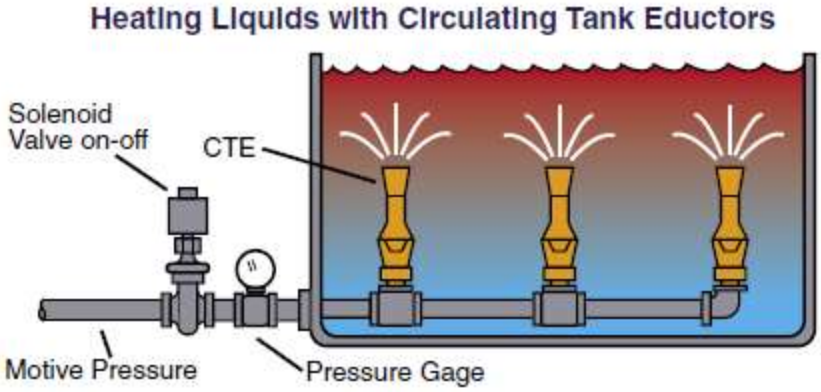



There is a definite benefit to being able to heat a liquid in an open tank. YETCO jet pump in-tank heaters optimize and streamline the operation by completing two jobs at the same time—both heating and circulating the mixture. Installed submerged in the tank, open tank heaters are especially suited for cooking, heating & circulating liquids and they maximize the condensation of steam into operating liquids to provide fluid heating.



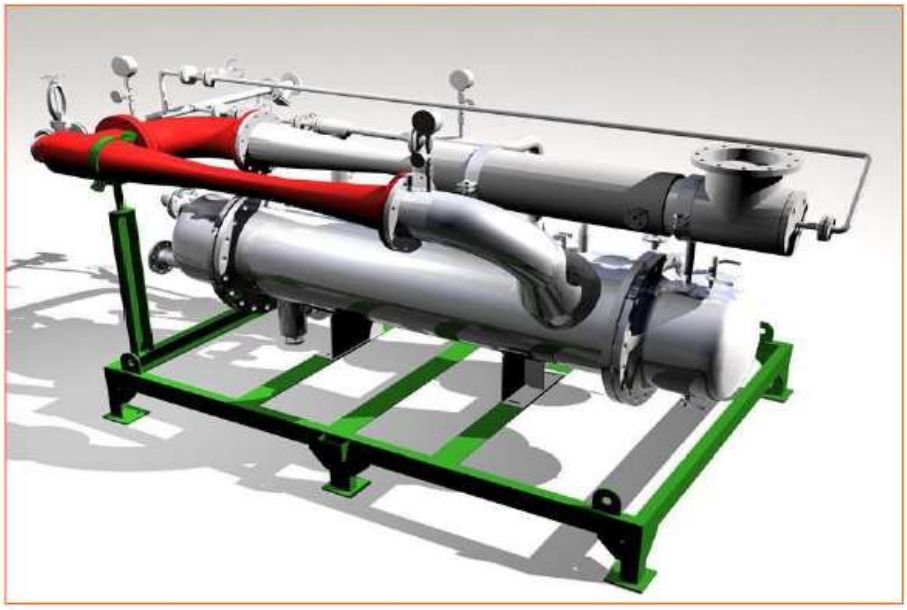




## Multi Stage Steam Ejector

Since the capacity of a single ejector is fixed by its dimensions, a single unit has practical limits on the total compression and throughput it can deliver. For greater compression, two or more ejectors can be arranged in series. For greater throughput capacity of gas or vapor, two or more ejectors can be arranged in parallel.

In a multi-stage system, condensers are typically used between successive ejectors. By condensing the vapors before sending the stream on to the next stage, the vapor load is reduced. This allows smaller ejectors to be used, and reduces steam consumption. Precondensers can be added to reduce the load on the first-stage ejector, and allow for a smaller unit. An aftercondenser can also be added, to condense vapors from the final stage. Adding an aftercondenser will not affect overall system performance, but may ease disposal of vapors.



Ejectors may be installed at any angle. However, to keep condensate and any entrained solids from collecting, low points in the vacuum piping system should be avoided during design and installation.

Provisions should be made to ensure proper drainage of the ejector bodies, since any condensed steam or process vapors may reduce throughput capacity. Drain valves installed at low points can be either manual or automatic, depending on customer requirements, and the drain cycle must relate to the type of process: Batch systems should be drained before each cycle, while continuous processes may be drained during operation if needed.

In most cases, the ejector is an integral part of a steam-jet vacuum system, but it is not intended to provide physical support for the system. Adequate piping support should be provided to minimize external loads on the ejectors, since any misalignment will adversely affect system performance. In fact, care must be exer cised during system design, so that external loads caused by thermal movement and mechanical loading are minimized.

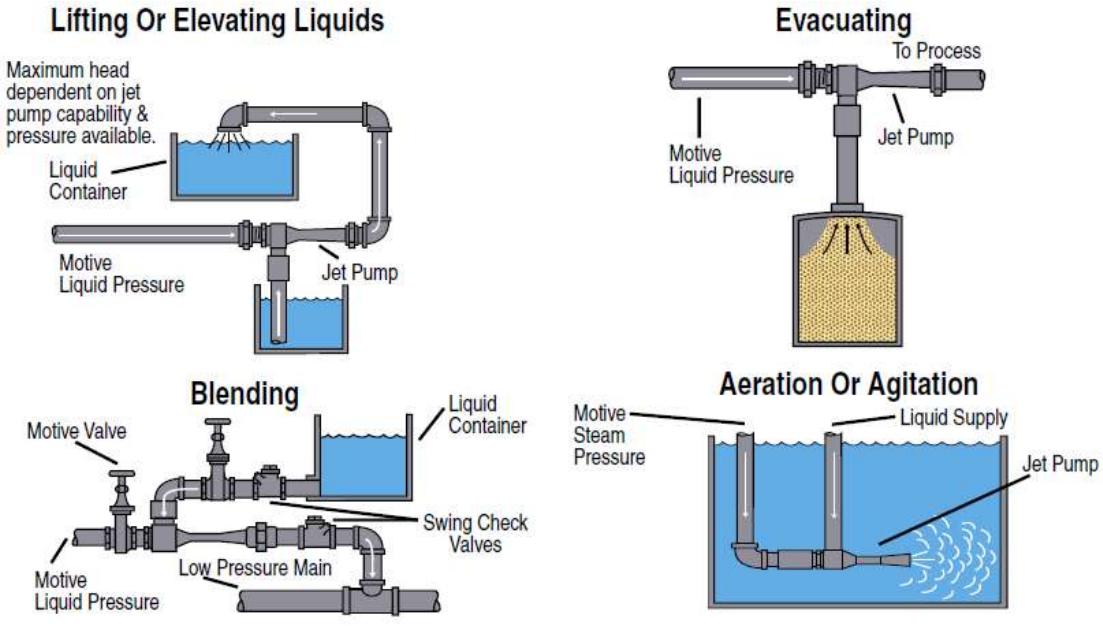
If the ejector or piping is steam jacketed to prevent ice buildup, its orientation will affect the operation and drainage of the jackets. To keep the jackets from filling with condensate, all inlet and outlet piping should be installed so that the jacket can be sufficiently drained.

## Liquid Jet Ejectors

Liquid jet pumps with liquid motives use a converging nozzle, since liquids usually cannot be compressed. Jet pumps not only pump liquids, they can also heat, mix, and blend either in-line or in a tank. Jet pumps can evacuate gases, create a vacuum, boost suction pressures, mix granular solids with liquids and move granular solids with compressed air. In fact, you will be surprised at what a jet pump can do to solve your problem.

One of the most common applications for a liquid jet pump is to pump liquids using a liquid motive. In the process industry, this is perhaps one of the most recognized uses for a jet pump. Like all jet pumps, liquid motive jet pumps are simple in design with no moving parts to wear out, they require no lubrication, are virtually maintenance-free and are easy to install without special structures or foundations. All YETCO jet pumps are self-priming and are available in a variety of materials to suit the specific characteristics of the liquids involved in the process.

Some industries in which these models are particularly well-suited include chemical processing, textile manufacturing, petroleum production & refining, power generation, mining, nuclear power generation, waste water treatment & processing, construction, distilling and potable water processing.

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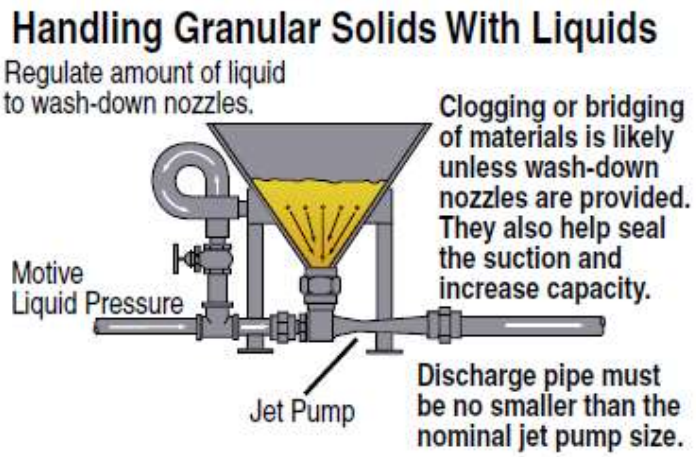



To determine the correct jet pump for a specific application, certain operating information is necessary. Simply make note of the individual specification data that is required under each of the functions listed below: MOTIVE, SUCTION and DISCHARGE. By completing our appication form with the required information, identifying the correct jet pump will be easy. Then simply contact your YETCO representative who will be able to select the optimum jet pump based on the data.

MOTIVE:

• Liquid

- Pressure (Available)
- Flow Rate (Available volume)
- Specific Gravity/Viscosity
- Temperature/Vapor Pressure

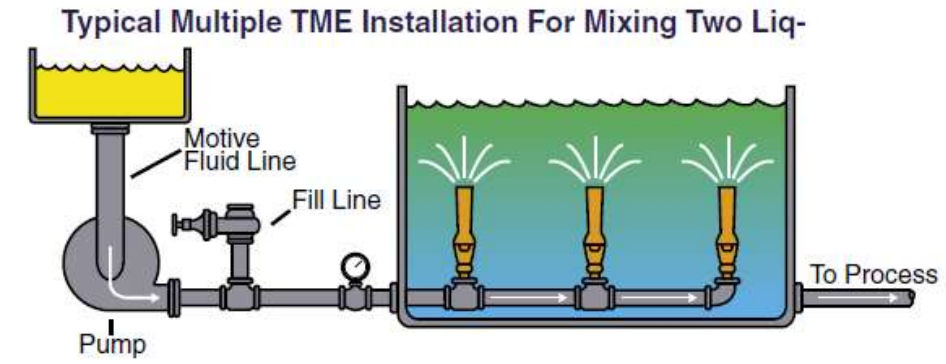
SUCTION:

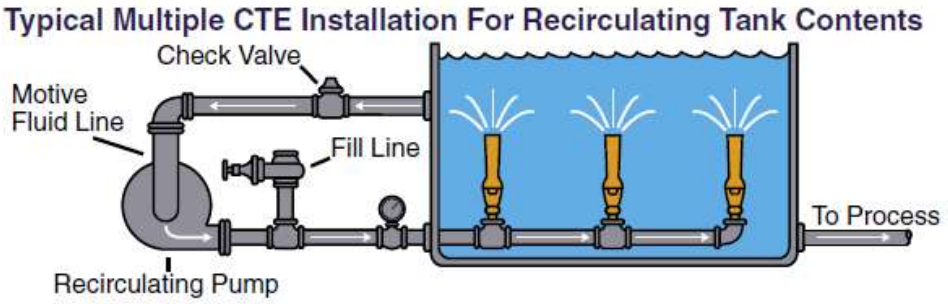
- Liquid
- Suction Lift or Static Head
- Specific Gravity/Viscosity
- Temperature/Vapor Pressure
- Required Pumping Capacity

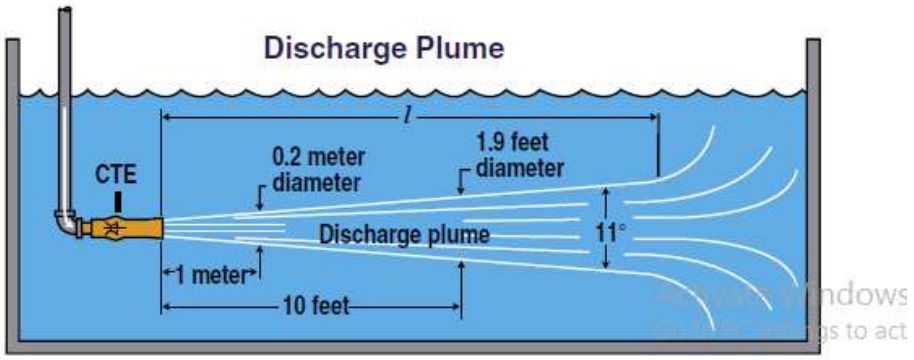
DISCHARGE:

- Pressure or Discharge Head

If any part of your processing operation requires mixing, then YETCO circulating tank eductors, also known as in-tank mixers, may provide a low cost alternative over other mechanical methods. These units promote more thorough mixing action than either mechanical mixing or air sparging. The flow pattern is easily controlled and provides more complete integration of substances in a wide variety of viscosities and liquids. Penberthy in-tank mixers are inherently non-clogging, and with no moving parts require little or no maintenance. Slurries containing abrasive solids can wear out mechanical mixer blades, involving constant maintenance and process down time.




## Scrubbers

Packed bed scrubbers

A packed scrubber consists of a tower with packing material inside. This packing material can be in the shape of saddles, rings, or some highly specialized shapes designed to maximize the contact area between the dirty gas and liquid. Yetco Packed towers typically operate at much lower pressure drops than venturi scrubbers and are therefore cheaper to operate. They also typically offer higher $SO_2$ removal efficiency. The drawback is that they have a greater tendency to plug up if particles are present in excess in the exhaust air stream.

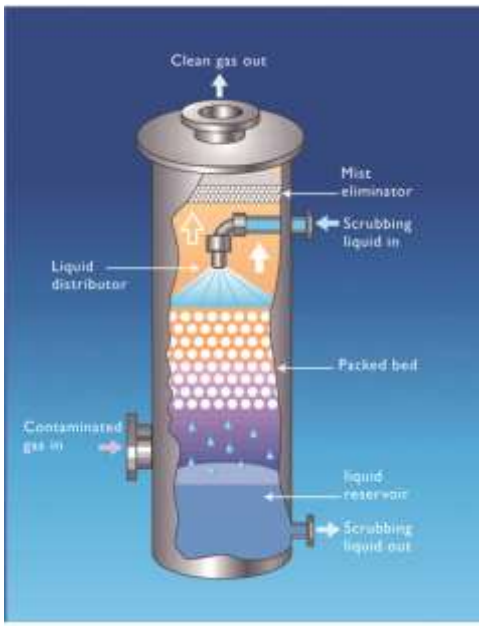
Spray towers

A spray tower is the simplest type of scrubber. It consists of a tower with spray nozzles, which generate the droplets for surface contact. Spray towersare typically used when circulating a slurry. The high speed of a venturi would cause erosion problems, while a packed tower would plug up if it tried to circulate a slurry. Counter-current packed towers are infrequently used because they have a tendency to become plugged by collected particles or to scale when lime or limestone scrubbing slurries are used.

Venturi-rod scrubbers

A venturi scrubber is a converging/diverging section of duct. The converging section accelerates the gas stream to high velocity. When the liquid stream is injected at the throat, which is the point of maximum velocity, the turbulence caused by the high gas velocity atomizes the liquid into small droplets, which creates the surface area necessary for mass transfer to take place. The higher the pressure drop in the venturi, the smaller the droplets and the higher the surface area. The penalty is in power consumption.

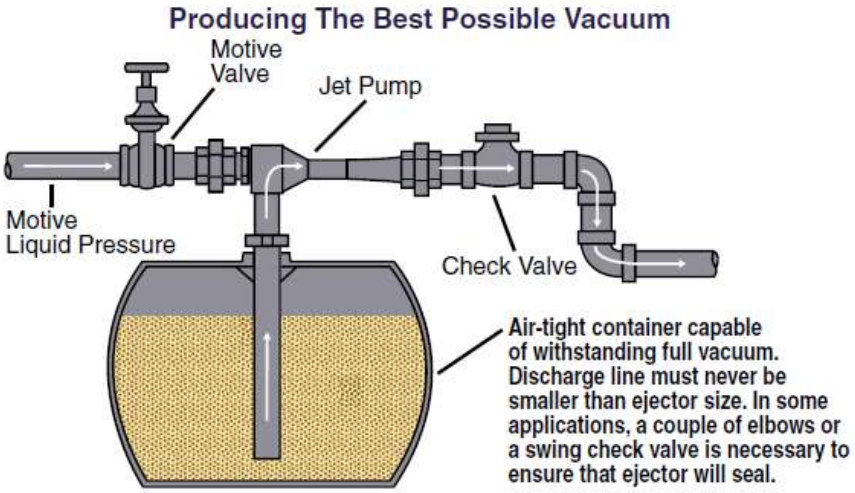
For simultaneous removal of $SO_2$ and fly ash, venturi scrubbers can be used. In fact, many of the industrial sodium-based throwaway systems are venturi scrubbers originally designed to remove particulate matter. These units were slightly modified to inject a sodium-based scrubbing liquor. Although removal of both particles and $SO_2$ in one vessel can be economic, the problems of high pressure drops and finding a scrubbing medium to remove heavy loadings of fly ash must be considered. However, in cases where the particle concentration is low, such as from oil-fired units, it can be more effective to remove particulate and $SO_2$ simultaneously.

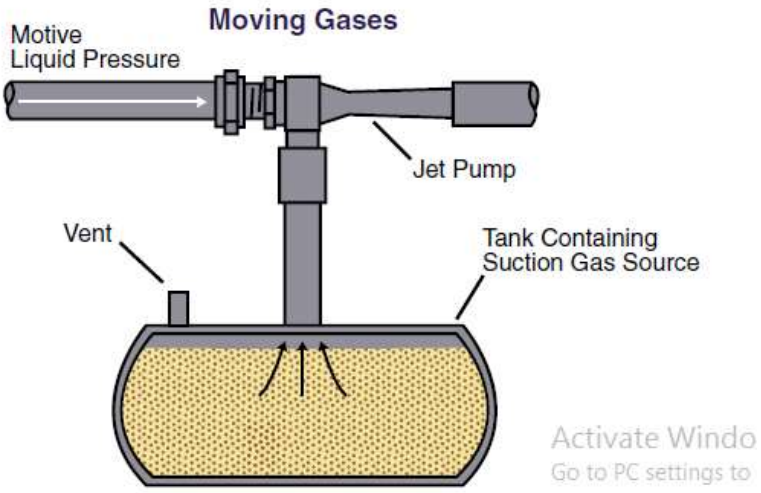



Packed Tower Scrubber

## Gas jet ejectors

YETCO jet pumps can also use steam or a gas (air) as the operating media for exhausting, evacuating or priming operations. Primary uses of these types of pumps are for exhausting or evacuating gases. Exhausting means removing gases from an area at a continuous rate while maintaining pressure at a constant level. Evacuation means drawing gases from a defined volume by pumping the vessel down from an initial pressure to a final lower pressure.




These steam/gas motive jet pumps meet the industry's most stringent requirements, while providing a simple, low-cost method of transporting gases, operating flawlessly even in the harshest work environments.

Typical applications involve either exhausting or evacuating. Similar information is needed in order to determine the specific jet pump for your application. Fill in the needed information on the application form below, and then consult your Penberthy sales representative on the correct pump match.

If Exhausting (Continuous Suction Flow)

MOTIVE:

- Liquid
- Pressure (Available)
- Flow Rate (Available volume)
- Specific Gravity
- Temperature

SUCTION:

- Gas To Be Pumped
- Pressure (Vacuum)
- Flow Rate
- Temperature/Molecular Weight

DISCHARGE:

- Pressure (That unit must overcome)

CONVEYING SOLIDS AND POWDERS WITH GAS JET SOLID EJECTORS