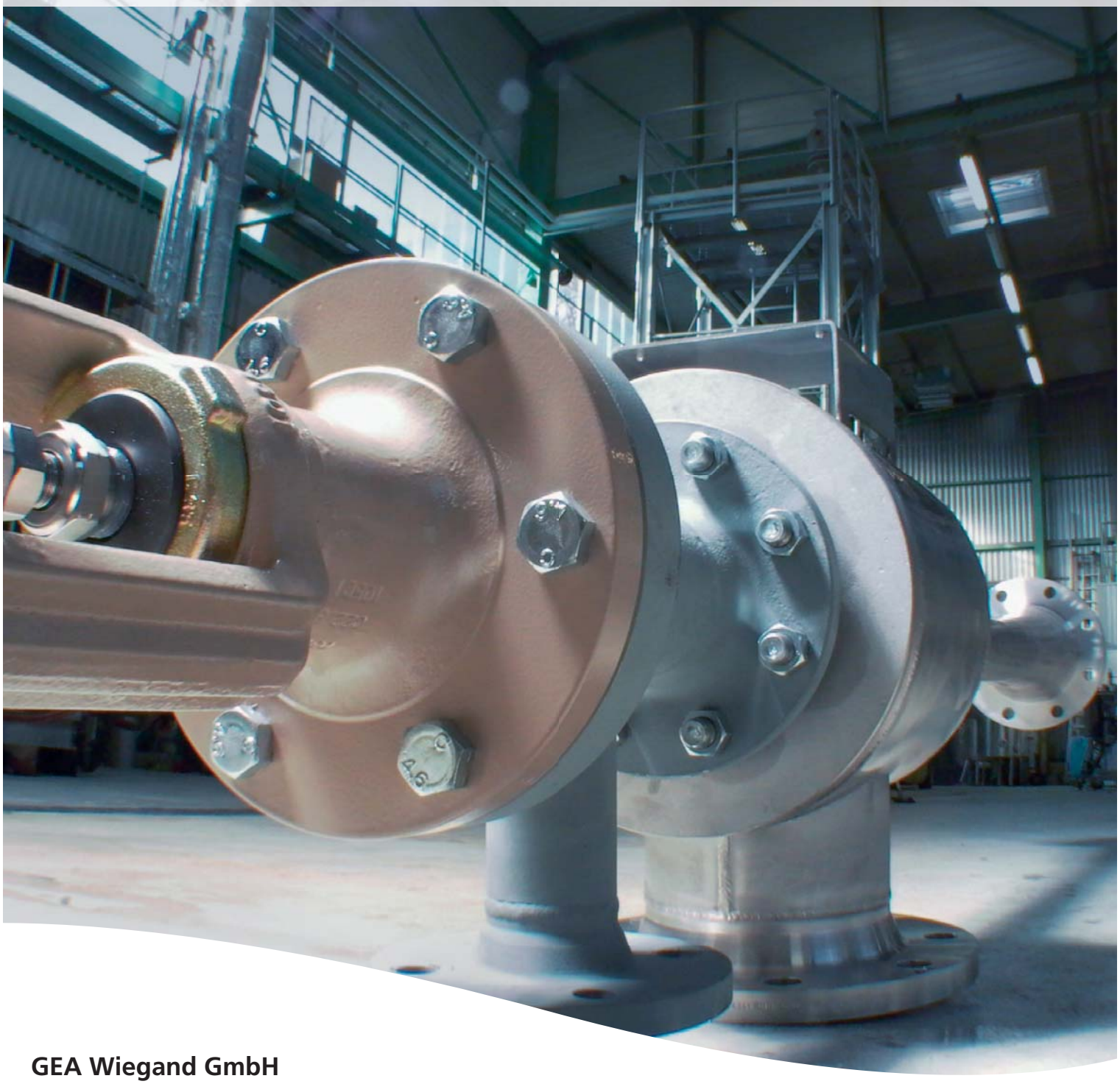
Jet Vacuum Systems

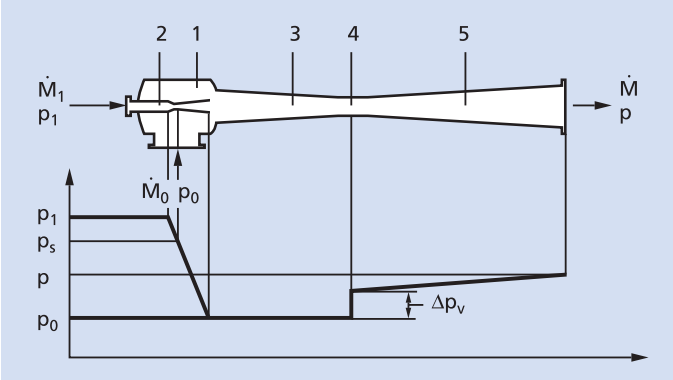


GEA Wiegand GmbH

The basics of jet vacuum pumps

Jet vacuum pumps are used to create and maintain the vacuum in evaporators, driers, in distillation and rectification plants, and in the processes of freeze drying, polycondensation, degassing and deodorizing.

These sorts of equipment consist fundamentally of jet pumps and condensers or of a combination with other vacuum pumps such as, e.g. liquid ring vacuum pumps.



Working principle of a steam jet pump and the pressure differences over the flow path

1 *head*
2 *motive nozzle*
3 *inlet cone* } *mixing nozzle*
4 *throat* }
5 *diffuser* }

p_1 *motive steam pressure*
p_0 *suction pressure*
p *counter pressure*
p_s *pressure at sound velocity*
Δp_v *compression thrust*
$\dot{M}_1$ *motive steam flow*
$\dot{M}_0$ *suction flow*
$\dot{M}$ *mixing vapour flow*

How does this sort of pump work?

Jet pumps use the expansion work of a motive medium to create the vacuum. A high velocity jet is generated in the motive nozzle; at low suction pressure, this jet entrains the suction medium and accelerates its path. Through transformation of the kinetic energy, this mixture is brought up to a higher pressure level in the throat and the diffuser of the ejector.

Jet pumps have three connections:
- for the motive medium with the highest pressure p_1
- for the suction medium with the lowest pressure p_0
- for the discharge of motive and suction media with a medium pressure p.

Given a sufficiently high expansion ratio of p_1/p_0, single stage jet pumps achieve a compression ratio (p/p_0) up to 20. The higher the expansion ratio, the less motive medium you will need. The higher the compression ratio the more motive medium you will need.

Generally, multi-stage vacuum pumps are used for suction pressures under 100 mbar. For the most effective use of energy, the motive medium and the condensable compounds are condensed between two stages.

The condensation pressure depends on the temperature of the cooling medium and characteristics of the motive medium. If you use water vapour as motive medium and if you have cooling water of 25 °C available, this pressure will be around 60 mbar.

Surface condensers are usually preferred as inter condensers to avoid any possible contamination of the cooling water with the suction medium.

For the most effective design of a jet vacuum pump the following data are required:

suction medium
- composition, mol mass [kmol/kg]
- suction flow $\dot{M}_0$ in [kg/h] or [kg/s]
- suction pressure p_0 (absolute pressure) [mbar]
- temperature T_0 [°C]
- counter pressure p (absolute pressure) [mbar]

motive medium
- pressure, p_1 (over pressure or absolute pressure) [bar]
- temperature T_1 [°C]

cooling medium
- temperature [°C]
- head pressure [bar]

These data determine arrangement, number of stages, motive and cooling medium consumption.

Advantages of jet vacuum pumps

- simple construction
- operationally safe
- low wear and tear and minimum maintenance
- resistant to corrosion if appropriate material is chosen
- supplied in all materials used in the equipment
- can be used for suction flows of 10 m^3/h to 2,000,000 m^3/h
- suitable for vacuum up to 0.01 mbar (abs.)
- driven by water vapour or **other vapour**; with vapour pressure above atm. and below atm.
- can be combined with mechanical vacuum pumps

The correct design of a jet vacuum pump requires a great deal of experience. GEA Wiegand has been designing and constructing jet pumps for nearly 100 years. You can turn to us with confidence. You will receive a quotation for a jet vacuum pump which is ideally suited to your special requirements.

Jet vacuum pumps for vacuum distillation columns in oil refineries

Steam jet liquid ring vacuum pump for the distillation column of a refinery

suction stream: *6,198 kg/h or 689,337 m³/h*
suction pressure abs.: *8 mbar*
counter pressure abs.: *1,500 mbar*

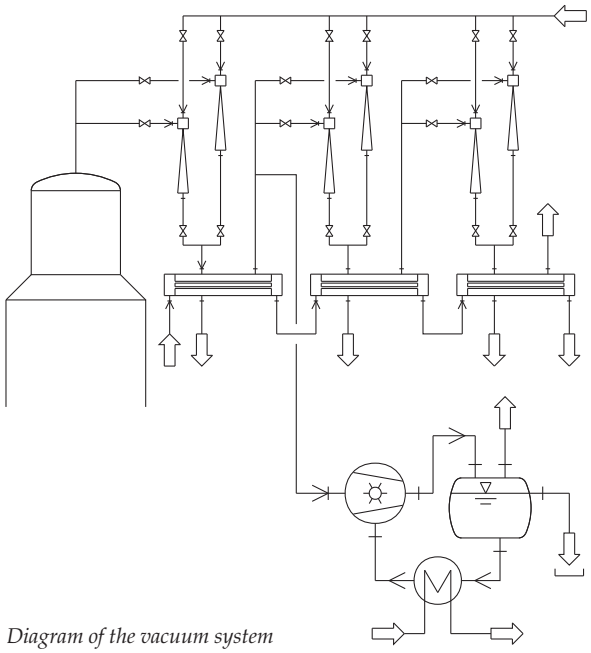


Diagram of the vacuum system shown above

Jet vacuum pumps are used in combination with liquid ring pumps to create vacuum in crude oil distillation columns.
The combination of the two pump types together with simple but appropriate control systems facilitate a low consumption of cooling water, power and motive medium.

Condensers are arranged between the jet vacuum pumps. As far as possible, the drawn-off vapours and the motive medium are condensed thus reducing the flow which the liquid ring pump has to handle.

GEA Wiegand jet vacuum pumps are perfectly suited to this application. They convey large quantities of gas, operate smoothly and need very little maintenance.

A wide choice of materials means that corrosion can be reduced or eliminated.

Vacuum plants for sea water desalination

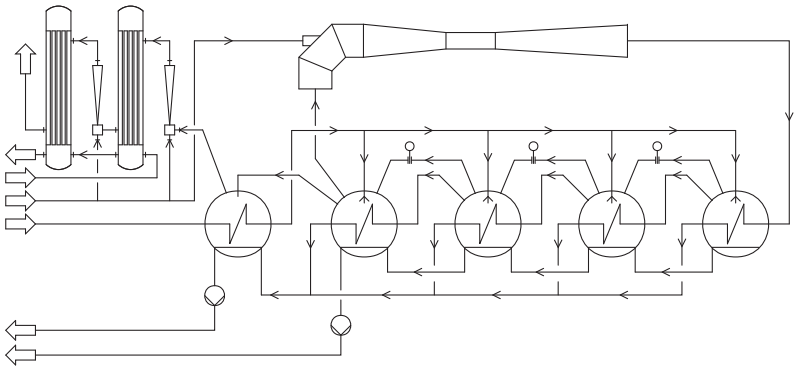
Water is in increasingly short supply world-wide. Many countries do not have a sufficient number of water reservoirs and are forced to cover their water needs by taking sea water. The three most important processes in sea water desalination are:
RO – Reverse Osmosis (membrane process)
MED – Multi-effect distillation
MSF – Multi-stage flash

Evaporators are used in the MED- and MSF-processes. These operate under vacuum in order to achieve the best performance rate. In all cases, the vacuum is created using multi-stage steam jet vacuum pumps.
Together with the corresponding condensers, these vacuum pumps are an integral part of the evaporation plant and are therefore becoming an increasing focus of attention.

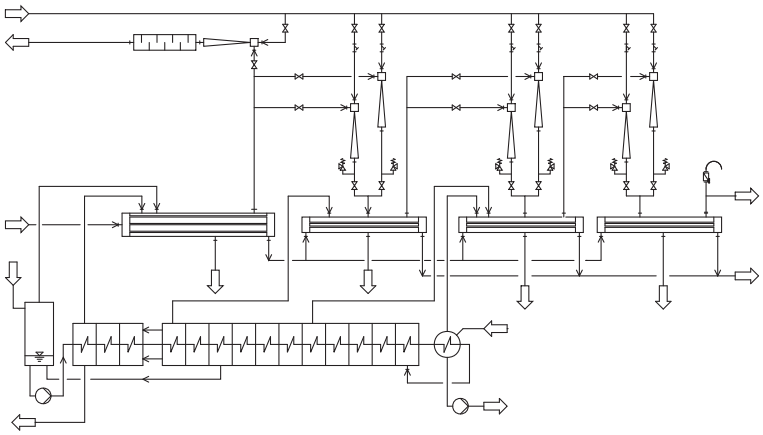
What is special about the design of this plant is its optimum energy consumption. At the same time, the size of the equipment has been reduced on account of the investment costs which are greatly affected by the use of high quality materials such as titanium, nickel bronze and/or stainless steel.
Selecting steam jet pumps as vacuum generators ensures a high level of reliability in the plant as a whole, while maintenance costs are kept to a minimum. In order to achieve the best operating costs, the steam jet pumps are designed for all the process conditions in the plant.

Vacuum unit for an MSF sea water desalination plant

MED suitable for small to medium-sized desalination units
max 800 m³/h fresh water
GEA Wiegand scope of supply:
jet pumps for vapour recompression,
vacuum unit



MSF for large amounts of water
up to 3000 m³/h
GEA Wiegand scope of supply:
vacuum unit



Product vapour driven jet vacuum pumps

Jet vacuum pumps are generally driven by water vapour. Water vapour is easily obtained in industry and has proved itself as a good motive medium. When the motive steam in the jet vacuum pump condenses, condensate is produced which in some cases must be regarded as waste.

This can be avoided if the product vapour which is produced during the process, is used as the motive medium for the jet pumps. The motive steam condensate is then either put to further use in the process or is re-evaporated and is used again as the motive medium. Product vapour driven jet pumps are also used if it is essential that no water enters the system.

Product vapour driven jet vacuum pumps do not differ in their functioning from water vapour driven jet vacuum pumps and therefore offer the same fundamental advantages. In addition, the energy requirement is in part substantially lower than is the case with water vapour driven jet vacuum pumps because of the low evaporation heat of organic vapours.

Suitable motive media for product vapour driven jet pumps are organic vapours such as monochlorobenzene, trichlorethylene, toluol, butandiol, ethylene glycol, furan, phenol, methylene chloride etc.

above: GEA Wiegand vacuum unit in the largest polyester production plant in the world

below: 2-stage vacuum pump with product vapour generator motive fluid: methylene chloride suction capacity: 120 kg/h from 4 mbar, corresponding to 7,000 m³/h

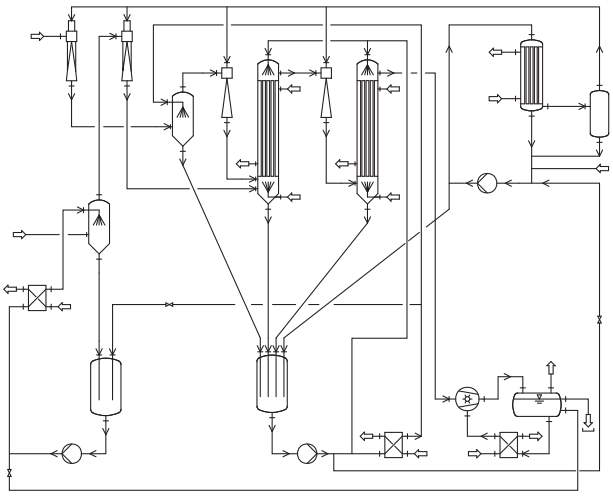


Diagram of a typical product vapour driven jet vacuum pump with mixing and surface condensation

Jet vacuum plants for the chemical industry

Versatile pump units have been developed by GEA Wiegand for the chemical industry.
The multi-stage jet vacuum pumps reach suction pressures of up to 0.01 mbar and are thus able to handle nearly all areas of application. When designing the plants, particular emphasis is placed on the standards and safety regulations demanded in the chemical industry.

Jet vacuum pumps can be manufactured in almost any material, even porcelain, graphite and glass, in correspondence with process engineering demands. GEA Wiegand jet vacuum pumps are robust, operationally safe, durable and need very little maintenance.

Two 2-stage jet vacuum pumps in compact construction with plate condensers
left: suction capacity: 13.3 kg/h from 7 mbar abs. corresponding to 1,172 m^3/h
right: suction capacity: 13.1 kg/h from 1.5 mbar corresponding to 7,212 m^3/h

Jet vacuum pumps for steel degassing

In the manufacture of high quality steel, the raw steel is treated under vacuum. Multi-stage jet vacuum pumps are used to create and maintain the vacuum.

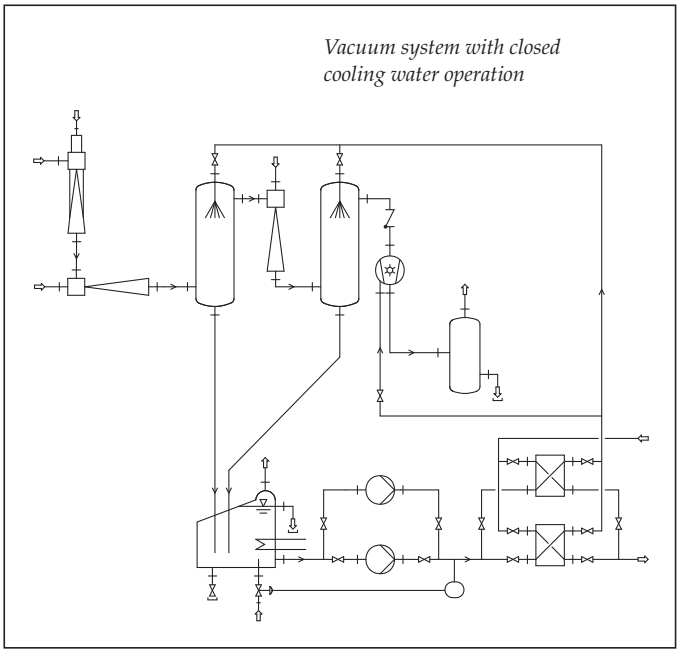
The pumps used in the steel degassing process have the following principle duties to perform:

- rapid evacuation of the process tank to the required pressure. This means that the suction capacity of the jet vacuum pumps has to be very high at the beginning (generally several thousand kg/h).
- maintenance of vacuum while at the same time sucking out a large flow of inert gas (up to 2,000.000 m^3/h corresponding to 1,500 kg/h at a vacuum of approx. 0.6 mbar).
- immediate availability
- resistant to dust
- operationally safe even under the roughest conditions

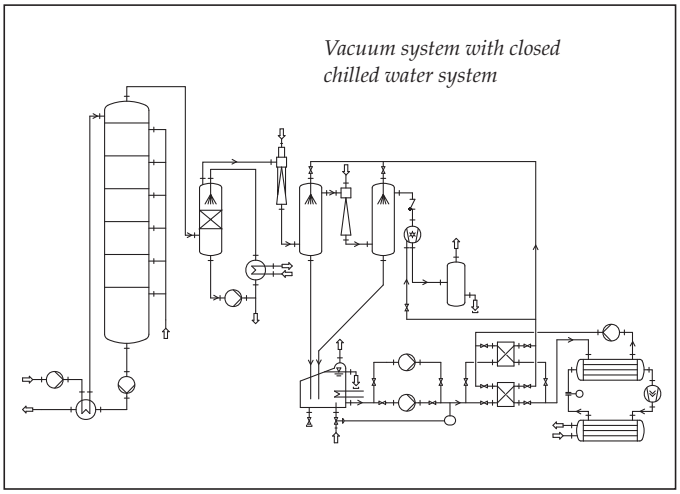
Jet pump for a 4-stage jet vacuum pump for steel degassing
suction flow: 1,100 kg/h or 1,387,000 m^3/h, suction pressure abs.: 0.6 mbar

The combination with liquid ring vacuum pumps as prevacuum pumps is possible and is in many cases advantageous from an economic point of view. By using a wet scrubber, the dust load in the off-gas flow from the vacuum pumps can be reduced to acceptable values.

Deodorizing edible oil



Vacuum system with closed cooling water operation



Vacuum system with closed chilled water system

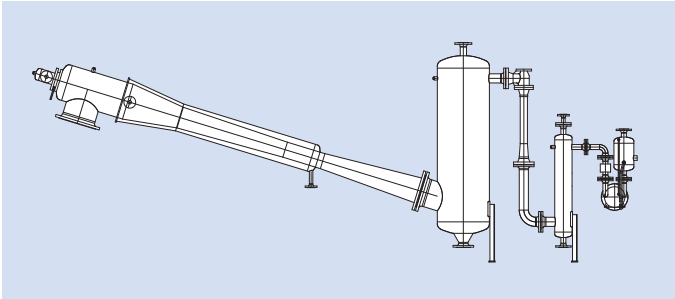
Multi-stage steam jet pumps are employed in the edible oil industry where the product is refined and freed of unwanted aromas by distillation under vacuum (1–5 mbar).

Such a vacuum system has to fulfil the following requirements:

- resistant to condensing fatty acids
- low energy consumption
- environmentally friendly
- reliable with minimum maintenance

Jet pumps from GEA Wiegand have no difficulty in meeting these requirements.
Newly-developed designs mean that these steam jet pumps have favourable consumption values, and, when operating with chilled water, the motive steam consumption is reduced still further.

Typical arrangement of a vacuum system with chilled water system



Further areas of application for jet vacuum pumps

de-aeration of turbine condensers
de-humidification of tobacco
manufacture of film in the plastics industry
production of urea
extruder degassing
drying processes
degassing

Overview on our Range of Products

Evaporation plants
to concentrate any type of fluid food, process water, organic and inorganic solutions and industrial waste water; with additional equipment for heating, cooling, degassing, crystallization and rectification.

Membrane filtration – GEA Filtration
to concentrate and process fluid food, process water and industrial waste water, to separate contaminations in order to improve quality and recover valuable substances.

Distillation / rectification plants
to separate multi-component mixtures, to recover organic solvents; to clean, recover and dehydrate bio-alcohol of different qualities.

Alcohol production lines
for potable alcohol and dehydrated alcohol of absolute purity; integrated stillage processing systems.

Condensation plants
with surface or mixing condensers, to condense vapour and steam/gas mixtures under vacuum.

Vacuum/steam jet cooling plants
to produce cold water, cool liquids, even of aggressive and abrasive nature.

Jet pumps
to convey and mix gases, liquids, and granular solids; for direct heating of liquids; as heat pumps; and in special design for the most diverse fields of application.

Steam jet vacuum pumps
also product vapour driven; also in combination with mechanical vacuum pumps (hybrid systems); extensive application in the chemical, pharmaceutical and food industries, in oil refineries and for steel degassing.

Heat recovery plants
to utilize residual heat from exhaust gases, steam/air mixtures, condensate and product.

Vacuum degassing plants
to remove dissolved gases from water and other liquids.

Heating and cooling plants
mobile and stationary plants for the operation of hot water heated reactors, contact driers.

Gas scubbers
to clean and dedust exhaust air, separate aerosols, cool and condition gases, condensate vapours and absorb gaseous pollutants.

Project studies, engineering for our plants.

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