

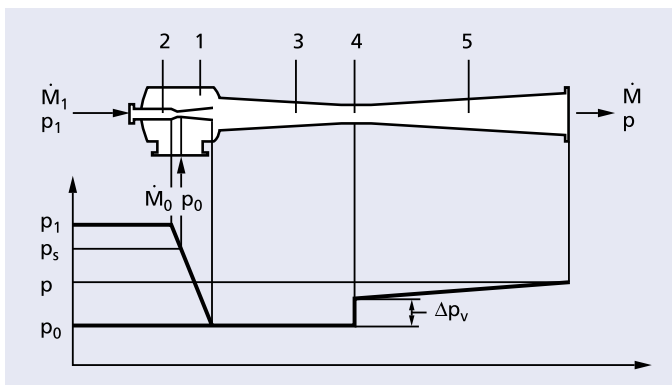


## Jet Vacuum Systems

# 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          | } mixing<br>nozzle |
| 2 | motive nozzle |                    |
| 3 | inlet cone    |                    |
| 4 | throat        |                    |
| 5 | diffuser      |                    |

- |              |                            |
|--------------|----------------------------|
| $p_1$        | motive steam pressure      |
| $p_0$        | suction pressure           |
| $p$          | counter pressure           |
| $p_s$        | pressure at sound velocity |
| $\Delta p_v$ | 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<sup>3</sup>/h to 2,000,000 m<sup>3</sup>/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

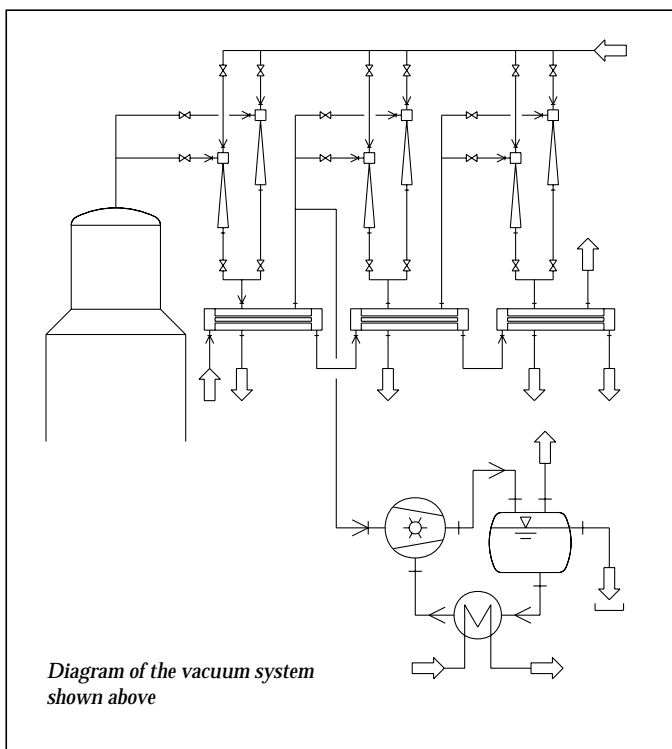
The correct design of a jet vacuum pump requires a great deal of experience. GEA Jet Pumps has been designing and constructing jet pumps for nearly 100 years. You can turn to us with confidence. You will receive a quotation for a jet vacuum pump which is ideally suited to your special requirements.

# 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 m<sup>3</sup>/h  
suction pressure abs: 8 mbar  
counter pressure abs: 1,500 mbar



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 Jet Pumps 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.

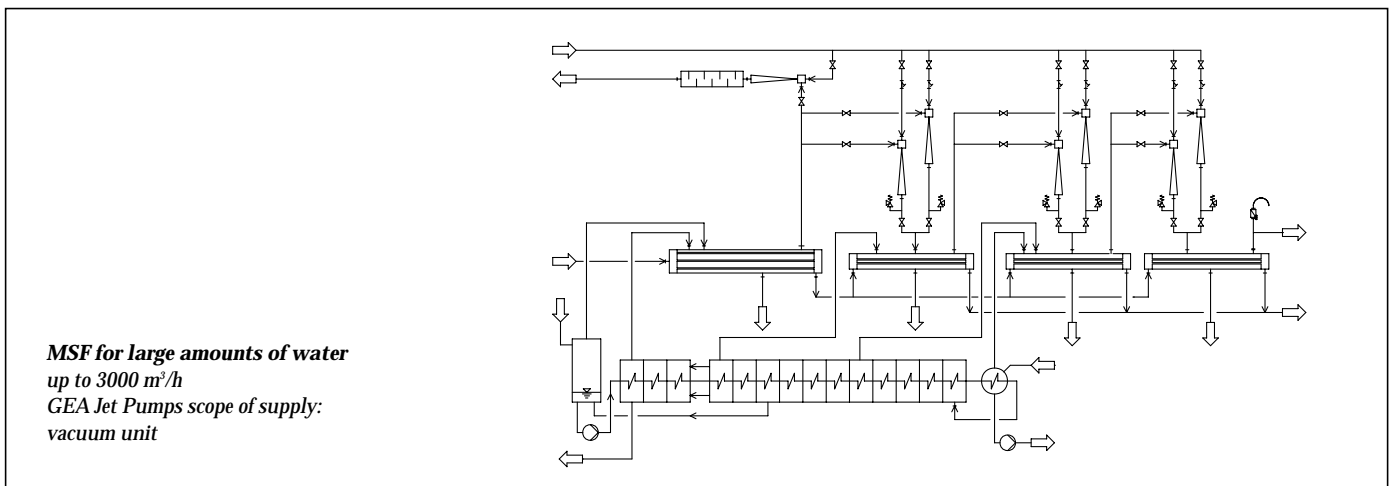
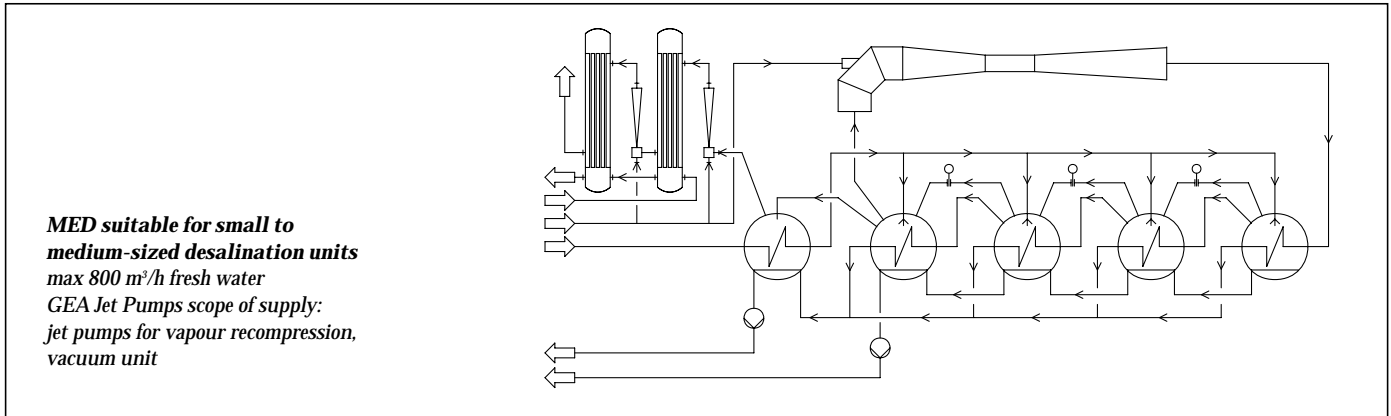
Together with the corresponding condensers, these vacuum pumps are an integral part of the evaporation plant and are therefore becoming an increasing focus of attention.

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



# 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, trichloroethylene, toluol, butandiol, ethylene glycol, furan, phenol, methylene chloride etc.



above: GEA Jet Pumps 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 m<sup>3</sup>/h

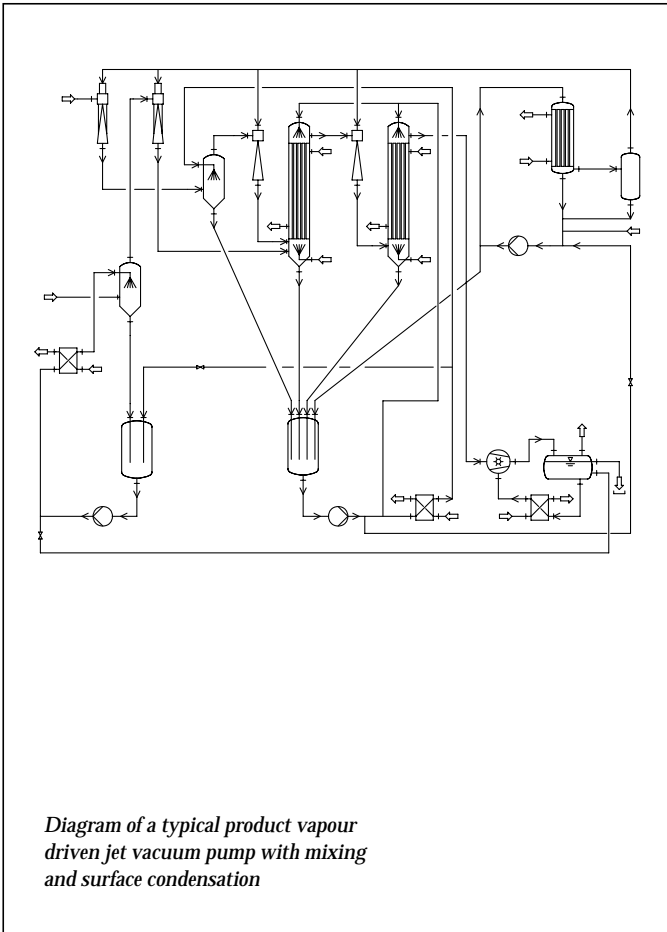


Diagram of a typical product vapour driven jet vacuum pump with mixing and surface condensation



# Jet vacuum plants for the chemical industry



Versatile pump units have been developed by GEA Jet Pumps 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 Jet Pumps 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<sup>3</sup>/h  
right: suction capacity: 13.1 kg/h from 1.5 mbar corresponding to 7,212 m<sup>3</sup>/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:

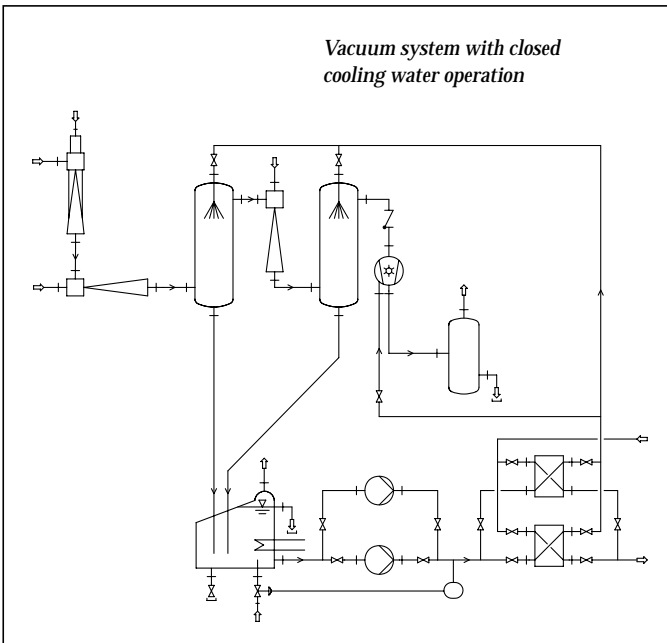
- rapid evacuation of the process tank to the required pressure. This means that the suction capacity of the jet vacuum pumps has to be very high at the beginning (generally several thousand kg/h).
- maintenance of vacuum while at the same time sucking out a large flow of inert gas (up to 2,000.000 m<sup>3</sup>/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<sup>3</sup>/h, suction pressure abs.: 0.6 mbar*

The combination with liquid ring vacuum pumps as pre-vacuum 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



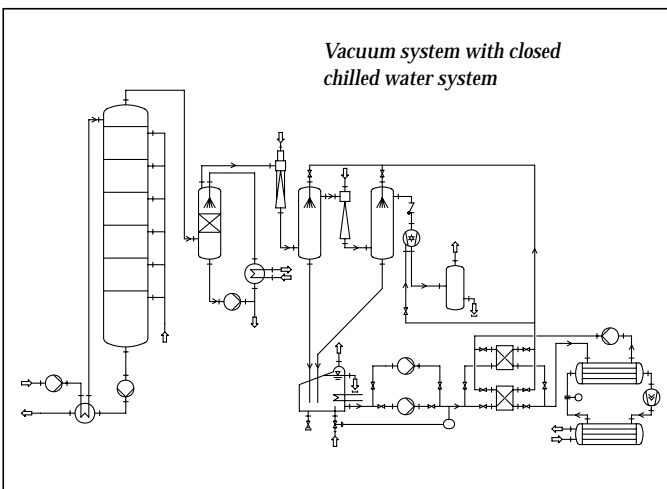
Multi-stage steam jet pumps are employed in the edible oil industry where the product is refined and freed of unwanted aromas by distillation under vacuum (1 - 5 mbar).

Such a vacuum system has to fulfil the following requirements:

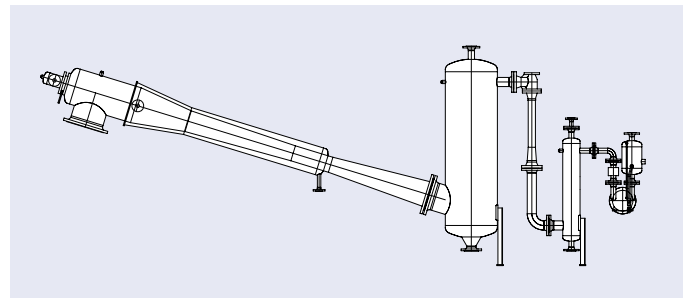
- resistant to condensing fatty acids
- low energy consumption
- environmentally friendly
- reliable with minimum maintenance

Jet pumps from GEA Jet Pumps 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

# Our Range of Products in Summary

## Jet pumps

to transfer 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, for instance for nuclear technology, highpressure technology, etc.

## Steam jet vacuum pumps

made of C-steel, stainless steel, hastelloy, titanium, graphite, glass, porcelaine etc. with suction pressure up to 0.01 mbar, capable of handling both very small and very large capacities; can also be combined with mechanical vacuum pumps; extensive application in the chemical, pharmaceutical and food industries; also in oil refineries and for steel degassing.

## Product vapour driven jet vacuum pumps

using product vapour from many different types of processes.

## Vacuum/steam jet cooling plants

to produce cold water, to cool liquids and product solutions, even of aggressive and abrasive nature, with and without steam jet compressors or mechanical compressors.

## Project studies, engineering

for plants included in our range of products.

All products are based on WIEGAND technology which has been successfully proven over a period of many years.

## Heat recovery plants

to utilize residual heat from exhaust gases, steam/air mixtures, exhaust steam, condensate and product; with mechanical or thermal recompressor.

## Condensation plants

with surface or mixing condensers, with or without vapour recompressors, to condense vapour and steam/gas mixtures under vacuum.

## 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, etc.

## Gas scrubbers

to clean and dedust exhaust air, to separate aerosols, to cool and condition gases, to condense vapours, to recover and generate products from exhaust air, to absorb gaseous pollutants.