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SANITARY SYSTEMS MADE TO PLEASE.

With its unique design flexibility, Jets Sanitary systems are suitable for any marine installation. Simple-in-line installation, no need for tanks, small footprint and scope for tailor made configurations make Jets the preferred solution for vessels from fishing boats to cruise ships.

PROVEN TECHNOLOGY - THOUSANDS OF INSTALLATIONS WORLD WIDE

The number of Jets installations is accelerating. Every second new built ship with a vacuum toilets system is fitted with Jets.

GLOBAL SUPPORT

We have a close network of enthusiastic, highly qualified representatives with professional experience. The know-how in marine sanitation, developed over the years since the start of Jets in 1986 is one of Jets’ most important assets. Every response from customers gives us an opportunity to improve performance and reduce cost.

Combining this feedback with our practical expertise gives us a strong basis for fulfilling your needs and providing sanitary systems made to please.
Atmospheric pressure:
Air pressure at sea level

Vacuum:
Any air pressure below atmospheric pressure

Grey water:
Water from showers, wash basins and laundry

Black water:
Water and effluents from toilets

Vacuum generator:
Equipment which generates and maintain vacuum

Vacuumator:
A vacuum generator developed by Jets which generates vacuum, macerates sewage and transfers sewage in one and the same operation. The pump of the vacuumator is a specially developed Helivac pump.

Vacuum unit:
A unit consisting of one or more vacuum generators or Vacuumators with control equipment.

Vacuum system:
A complete system consisting of vacuum unit, vacuum toilets and in some cases also interface units for grey water and urinals.

EFD valve:
Electronic flushing and discharge valve. The mechanism operating the flushing and discharge of toilets.

ED valve:
Electronic discharge valve. The mechanism operating the discharge of the content in a grey water interface unit or a urinal tank.

FD valve:
Flush and discharge valve. Used together with the VPC controller for operation of toilets.

VPC controller:
Vacuum powered cam controller. Mechanism for pneumatic operation of the FD valve.

VPC-V controller:
Vacuum powered cam controller. Mechanism for vacuum operation of the FD valve.

Sealing liquid ring:
Liquid ring created by the rotor when a vacuumator is in operation.

Sealing liquid:
Liquid needed for safe operation, normally re-supplied black water from the pipes on the pressure side.

Grey water interface unit:
Tank (normally 8 or 16 ltr) fitted with an ED valve and a level sensor for activating the ED valve and discharge of the tank. Unit to be used to interface grey water by gravity with the Vacuum system.

Collecting tank:
Tank for collecting of black and in some cases also grey water from a Vacuum system.

Holding tank:
Tank for holding (storage) of black and in some cases also grey water.

Vacuum breaker:
Device to prevent back flow (siphon effect) with contaminated water going from a toilet and into the fresh water supply system.

Sewage Treatment plant:
Plant for treatment of black water and in some cases also grey water before overboard discharge.
We consider the air to be homogeneous
Talking about atmospheric air, we actually talk about a mixture of several gases and steam. In the following we consider air to be a homogeneous mass. We assume that air consists of particles equal in size, weight and behaviour. We ignore the fact that air normally contains steam.

Particles in movement
At sea level 1m³ air has the weight of approximately 1,2 kg. This air consists of a great amount of particles that are in constant movement. To illustrate this one can imagine a great amount of small balls buzzing around in a limited space, resulting many collisions between the particles and the environment. The environment may be the walls in a tank, a piping system or a liquid surface. This is of great importance for the pump technique.

Atmospheric pressure
All these collisions acts as a constant pressure on the environment. This pressure we call the

Atmospheric pressure
It acts in all directions and is equal to the weight of the air mass in a given area.

Absolute pressure
The pressure decreases proportionally with the altitude as the air gets thinner. In the empty space some hundred kilometres above sea level the pressure has decreased to zero. The amount of particles and the collisions are then so rare, that a pressure cannot be measured.
We have to emphasize that a completely empty space does not exist, and it can also not be practically created. The pressure existing in the imagined empty space is at the absolute zero point. Going down through the atmosphere a rising pressure can be measured. These levels of pressure are called absolute pressures.

Measuring units
The pressure measured at sea level is called one atmosphere; 1 atm. Several measuring units have been used to define this pressure.

1 atm equals:
1 kp/cm² = the weight of a 760 mm quicksilver pillar = 760 Torr = the weight of a 10,33 m water pillar

The normal atmospheric pressure is internationally fixed at 1013 mbar. Pressure is to be measured in mbar or N/m². N/m² is seldom used as a measuring unit today. For simplicity pressures in a vacuum sanitary system are normally measured in % vacuum.

Vacuum area
The pressure area from the absolute zero point to the atmospheric pressure is called the vacuum area or the underpressure area. We have to emphasize that there is no such thing as a negative pressure. Underpressure or vacuum is therefore pressure level, which are beneath the atmospheric pressure.
Boyle-Mariotte’s law

If the temperature is kept constant for a defined amount of gas, the pressure and the volume will be inversely proportional.

This can be illustrated in the following way:

Cylinder A contains 1 m³ air at atmosphere pressure (1013 mbar).

The air pressure is called: \( P = 1013 \text{ mbar} \)
The volume is called: \( V = 1 \text{ m}^3 \)

In cylinder B the piston has been pushed so far down that the volume in the cylinder has become 0.5 m³.

This means that the air particles have been compressed, so that the particle density is twice as big as in fig. A. We assume that the temperature has not been changed from A to B.

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Boyle-Mariotte’s law gives us the following equation:

\[ P \times V = K \]

\( P = \text{pressure}, \ V = \text{volume}, \ K = \text{constant value} \)
Vacuum theory & background

It is the pressure within the mass of air that pushes the air particles into the empty space beneath the piston.

Within a locked up mass of air, the pressure is equal.

This capability of “pushing” is the basis for all pump technique. The capability applies to air- and liquid pumps. All the time there must be a certain pressure on the inlet or the suction side of a pump.

The principle of a vacuum pump

A thin pipeline connects the tank with the inlet side of a hand pump. The pressure side of the hand pump opens to the atmosphere. Non-return valves are placed in the pipeline on each side of the pump. The pump has a 10 litres piston displacement. We now ignore the volume in the pipeline.

When the piston is in position 1, the total volume is:

\[ V_1 = 100 \text{ ltr} \]

When the piston is in position 2, the total volume is:

\[ V_2 = V_1 + 10 \text{ ltr} = 110 \text{ ltr} \]

The starting point for the pump operation is:

\[ P \times V = 1000 \times 100 = 100000 \]

When the piston has been pulled to position 2, the pressure in the tank will push air particles over to the pump, until the pressure is the same in both tank and pump. The new pressure level, after the first piston stroke, is called \( P_1 \).

This means that when the piston is pulled to the top (position 2), the total volume in the system is 110 ltr.

According to Boyle Mariotte’s law \( P \times V = \text{constant} \)

This gives us the following:

\[ P_1 \times 110 = 100000 \]

By solving the equation, we find that

\[ P_1 = 909 \text{ mbar} \]

Thereafter, when the piston is pushed to the bottom (position 1), we will get the following result:

\[ \text{Volume in the system} = V = 100 \text{ ltr.} \]

Pressure, \( P_1 = 909 \text{ mbar} \)
Comparison table between new and old vacuum measurement units:

<table>
<thead>
<tr>
<th>mbar</th>
<th>N/m²</th>
<th>atm</th>
<th>% Vacuum</th>
<th>mH₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>1013</td>
<td>101300</td>
<td>1,0</td>
<td>0</td>
<td>10,33</td>
</tr>
<tr>
<td>1000</td>
<td>100000</td>
<td>0,98</td>
<td>1,3</td>
<td>10,20</td>
</tr>
<tr>
<td>900</td>
<td>90000</td>
<td>0,88</td>
<td>11,1</td>
<td>9,17</td>
</tr>
<tr>
<td>600</td>
<td>60000</td>
<td>0,59</td>
<td>40,8</td>
<td>6,11</td>
</tr>
<tr>
<td>300</td>
<td>30000</td>
<td>0,29</td>
<td>70,4</td>
<td>3,05</td>
</tr>
<tr>
<td>100</td>
<td>10000</td>
<td>0,10</td>
<td>90</td>
<td>1,02</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

By the next piston stroke we will get:

\[909 \times 100 = P_2 \times 110\]

By solving the equation, we find that

\[P_2 = 826 \text{ mbar}\]

Continuing this process, we will find the following:

- \(P_3 = 750 \text{ MBAR}\)
- \(P_4 = 681 \text{ MBAR}\)
- \(P_5 = 619 \text{ MBAR}\)
- \(P_6 = 562 \text{ MBAR}\)
- \(P_7 = 513 \text{ MBAR}\)
- \(P_8 = 464 \text{ MBAR}\)
- \(P_9 = 424 \text{ MBAR}\)
- \(P_{10} = 385 \text{ MBAR}\)

Concluding that the pressure drop per piston stroke is getting less and less.

The pressure will never reach zero.

To illustrate the function, the figure showed a simple piston pump. With some exceptions, the principle is the same for all pump types:

The working element in the pump (e.g. piston or rotor) creates an empty space which will be filled because of the pressure in the suction pipeline.

Thereafter, the connection between the suction pipeline and the rotor/piston will be closed, and the air is pushed out through the pump’s discharge pipe.

If the pump’s working element only consists of mechanical parts, the capacity per stroke or rotation will be the same all over the pressure area in which it operates.
What is a vacuum toilet system?

The basic principle behind a vacuum toilet system is to use differences in air pressure to transport sewage from toilets and urinals and eventually also grey water from sinks and showers. In a modern vacuum system the vacuum is generated directly on the piping, keeping the total system at a constant vacuum, normally between 35 and 50 % vacuum.

When a toilet is flushed approximately 60 litres of air is “sucked” into the piping together with approximately 1 litre of water. The water and sewage create a “slug” and the transport proceeds in such “slugs” as a result of the difference in air pressure in front of and behind the slug.

During the transport in the piping system the “slug” is effected by gravity and will after a time flatten out. Because of this it is necessary to have low point in the piping in order to re-form “slugs” and thus re-establish the pressure difference needed for further transport.
Vacuum toilet system

Advantages

During the last 10 years vacuum toilet systems have become common on all types of ships. Designers and builders of passenger ships and special vessels have for many years used vacuum systems as a standard. In recent years however, the trend goes in direction of vacuum systems on all types and sizes of ships. The majority of South Korean Shipyards are now using vacuum toilet systems as a standard. The main reason for this is of course the fact that the vacuum system is the most cost effective solution. Due to:

- High level of installation flexibility
- Total independence of gravity
- Small pipe diameter
- Simple installation
- Low water consumption
First generation
Vacuum tank - Vacuum pump

The Swede Joel Liljendahl developed the first Vacuum toilet system in the 1950’s. The idea of Liljendahl was to use vacuum toilets in buildings to reduce water consumption in order to be able to utilize waste products for soil improvement.
Vacuum is created on a vacuum tank by conventional vacuum pumps
Vacuum tank system has good vacuum generating capacities, but also some drawbacks.
Liljendahl sold his concept to Electrolux, who saw a great potential in the ship market. Gradually the Electrolux system became quite common on passenger ships and larger ferries.

Second generation
Atmospheric tank og Ejector

In 1975 a Finnish company introduced a new technology for operating a vacuum toilet system. The new solution was to make use of an atmospheric collecting tank and to pump black water through an ejector to create vacuum. This system was simpler and more economical than Electrolux’ vacuum tank/vacuum pump system. In 1985 the Finnish company acquired Electrolux’ vacuum toilet system and established a monopoly in the market.

Third generation
Jets Vacuumarator

Jets was established in 1986 and introduced in 1987 radical new technology for marine vacuum toilet systems. Combining the Helivac technology invented by the Dane Willy Johst with a highly efficient macerator - Jets first Vacuum generators brought down the monopoly and offered customers new, highly competitive solutions.
In 1989 Jets introduced the now famous Vacuumarator – a helical screw pump with a built-on macerator. This refinement of the technology introduced by Jets in 1987 gave the market a unique in-line vacuum generator suitable for installation in any type of ships.
The first generation of Jets Vacuum generators from 1987 is patented. Jets Vacuumarator technology is also patented. Continuously developing the Vacuumarator technology a second version was introduced in 1993, a third in 2000, and the latest and currently most efficient was introduced in 2006.
The vacuum tank system is a well-known principle and has for more than 100 years been used in a long range of industrial applications. This solution was introduced for use in Vacuum sewage applications early in the 60’s.

A tank is put under vacuum by use of a vacuum pump. Effluents are collected in this tank, which is constantly kept under vacuum.

The system has a great efficiency, but it has also some drawbacks:

- A vacuum tank is needed.
- For large systems the tank will be large and bulky due to the special shape that is needed.
- The system is difficult to install in ships, a lot of free space is required.
- The system is expensive and complicated.
Use of an ejector to create vacuum is an old and well known principle.

An ejector is a nozzle and vacuum is created by pumping liquid via this nozzle. The speed of the liquid creates a vacuum. In order to operate the ejector, a centrifugal pump and a pipe between the pump and the ejector, are needed. A considerable volume of liquid is at all times needed in the tank just in order to generate vacuum.

Vacuum is created in the pipeline by pumping liquid from the tank - via the ejector and back into the tank. There is no vacuum created in the tank. Therefore the pressure in the tank will be atmospheric.

Ejector systems have in general low power to efficiency rate and they also have some other drawbacks.

a. Large circulation of liquid, especially at low liquid level in the tank may result in foaming. A cure against foaming is use of anti foaming agents, which can be quite expensive.

b. The collecting tank may overheat due to large circulation of the liquid.  
c. A considerable volume of liquid is at all times needed in the tank just in order to generate vacuum.

d. Ejectors can only handle very small amounts of grey water.
The Vacuumarator system is based upon a technical principle invented by Jets Vacuum A/S.

A Vacuumarator is a screw pump with a built-on macerator. This device will generate Vacuum, macerate sewage and pump the effluent to either a treatment plant or to a collecting tank.

The Vacuumarator principle allows for an in-line installation of a toilet systems’ Vacuum generator. It greatly simplifies the total installation and eliminates the requirement for a tank in order to generate vacuum.

Vacuumarator systems has a high power to efficiency rate and have also a long range of other advantages:

a) In line installation.
b) No tank needed to generate Vacuum
c) Direct interface with sewage treatment plants.
d) Minimum of space requirement.
jets vacuum product catalogue
vacuum theory & background

In a Jets system transport is provided by differential air pressure (Vacuum) and thus the requirement for gravity is totally eliminated. The advantages of the Jets system compared with conventional systems are as follows:

- PIPING INDEPENDENT UPON GRAVITY
- VERTICAL LIFT CAPABILITY
- WATER CONSUMPTION OF 1,2 ltr. pr. flush
- SMALL DIAMETER PIPING
- HIGH DEGREE OF INSTALLATION FLEXIBILITY.

The heart of a Jets system is the patented Jets Vacuumarator. A Jets Vacuumarator is a helical screw pump with a built-on macerator. It can pump any combination of black-grey water and air.

A Vacuumarator can pump the sewage directly to a sewage treatment plant, a collecting tank of any type or, in some cases, directly overboard.

Jets Vacuumarators are available in different sizes and capacities.

A Vacuum unit will consist of one or more Jets Vacuumarators which keep the mains under vacuum. Start and stop of the Vacuumarator are controlled by a pressure switch normally set for operation between 35 - 50 % Vacuum.

Toilets are connected to the pipes via special valves. Jets toilets are available in a range of different models and mechanisms. The connection to piping is only open during the flushing and discharge cycle. When a toilet is operated, sewage waste water and air are sucked into the vacuum mains and transported to the Vacuumarator. The built-on macerator finely pulps the sewage while pumping it to a Sewage Treatment Plant or a collecting tank.
Jets Vacuum AS has a totally new approach to Vacuum toilet system offering the latest, easiest to install and most reliable technology available.

**SOME ADVANTAGES OF THE VACUUMARATOR SYSTEM:**

**IN - LINE INSTALLATION - NO REQUIREMENT FOR TANK**  
A Vacuumarator generates Vacuum directly on the pipeline, macerates the sewage and pumps it to either a sewage treatment plant or a collecting tank. – all in the same operation. The flow of liquid and air is via the Vacuumarator.

**HIGHLY FLEXIBLE SOLUTIONS WITH EASY INSTALLATION**  
A Jets Vacuum unit is totally independent upon location of the sewage treatment plant or a collecting tank (if this is used). It can be located almost any where in the ship. Connecting to the piping is as easy as it can get - pipe in and pipe out.

**EXTREMELY COMPACT AND LOW WEIGHT VACUUM UNITS**  
Jets has the smallest and most compact vacuum generating unit available.

**DIRECT INTERFACE WITH ALL TYPES OF SEWAGE TREATMENT PLANTS**

**SAFE AND HIGHLY EFFICIENT VACUUM GENERATORS**  
Compared to an ejector a Vacuumarator is approx 40 % more efficient. This allows for a large safety margin and a better operation of the system. All Jets equipment is designed with focus on the highest reliability with low life cycle costs.

**BUILT-ON MACERATOR – IMPROVEMENT OF THE TREATMENT PROCESS**  
A built-on macerator with one rotating and one stationary knife finely pulps the sewage while pumping it to the treatment plant.

**NO FOAMING**  
There is no circulation of liquid in a Jets system and accordingly there is no risk of foaming.
A Jets Vacuumarator is a helical screw pump with a built-on macerator.

It will create vacuum, macerate black water and pump it downstream in same operation. A Jets Vacuumarator can pump any combination of black / grey water and air.

The built-on macerator consists of a rotating part bolted to the shaft and a stationary part bolted to the suction chamber. All black water will be macerated before arriving at the suction chamber. Metal objects will not enter the macerator. Such items will be deflected and remain in the suction housing without creating damage or blockage.

In operation black water creates a seal between the helical rotor and the housing.

The thickness of this seal will depend upon the volume of black or grey water arriving from the toilets, showers or wash basins. In peak vacuum generating (air pumping) mode the black water seal will touch the rotor hub on one side and the tip of the rotor on the other. This principle creates a series of progressive crescent shaped cavities travelling from suction to pressure side of the rotor. Air, black and grey water is pulled into those cavities and transported through the vacuumarator.