VACUU·LAN®

VACUUM FOR LABORATORIES

VACUU·LAN® LOCAL VACUUM NETWORKS

Vacuum for laboratories in chemistry and life sciences

Information for laboratory planners, architects, casework manufacturers and scientists

vacuubrand

Technology for Vacuum Systems

VACUUBRAND

For more than 50 years, VACUUBRAND has built a reputation for innovations in chemical-resistant vacuum pumps for laboratory facilities.
With the VACU·LAN® system, VACUUBRAND introduced a modular approach to vacuum supply for new laboratory facilities, as well as for lab upgrades or renovations.

VACUUBRAND company premises in Wertheim am Main

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THE CHALLENGE WHEN PLANNING VACUUM IN THE LABORATORY

Vacuum supply is usually an integral part of planning for laboratories in public or private buildings. It is more complex than other piped utilities because the requirements for vacuum technology are different in a synthesis laboratory than, for example, in an analytical or cell biology laboratory. These different requirements cannot be met with the same vacuum supply. To address the need for vacuum supply tailored to the applications, the specific requirements should be clarified early in the planning phase.
"The right tool saves time" is old saying of craftsmen that applies to the vacuum supplied to each laboratory. Whether because vacuum is poorly understood, because the piping systems seem so similar to piped gases, or because traditional practice has dictated a single building-wide system, the unique requirements of vacuum supply are frequently overlooked in the lab planning process. Nonetheless, for many applications, tailored vacuum is invaluable. Appropriate vacuum allows the scientist to achieve desired results faster, more safely, more conveniently and also reproducibly. This brochure is intended to be an initial orientation for laboratory planners, architects, casework manufacturers and scientific users to the important consideration in planning vacuum supply for laboratories.

WHAT IS LABORATORY VACUUM?

Vacuum as used in the laboratory is simply pressure below atmospheric pressure. The essential qualities of the vacuum that determine its usefulness in any particular laboratory application are the depth of vacuum – how much below atmospheric pressure – and the pumping speed, that is, how quickly can air, vapors or gases be removed from the vessel being evacuated.

Why vacuum?

Many scientists use vacuum every day. But *how* do they use it? Vacuum is used for many standard applications in the preparation and processing of samples. In most cases, the vacuum is not the focus, but plays an essential supporting role. The most familiar lab vacuum applications are filtration and drying. Of course, you could filter without vacuum - like brewing coffee - by letting gravity do the work for you. The problem is that, in the laboratory, the process often proves to be too slow due to the broad spectrum of solvents and solid substances. To speed up the process, low-pressure – i.e., vacuum – is created in a filter flask. In a drying process, on the other hand, the goal is to change the state of a sample from liquid to gaseous. We could simply allow drying to happen, just as we air-dry laundry. As with filtration, this process would also take too much time, so a vacuum is used here as well to accelerate the process. Heat could be used to accomplish the same effect, but by decreasing the pressure level, less heat energy is necessary to evaporate solvents. Thus, use of vacuum makes possible the efficient drying of heat-sensitive sample materials.

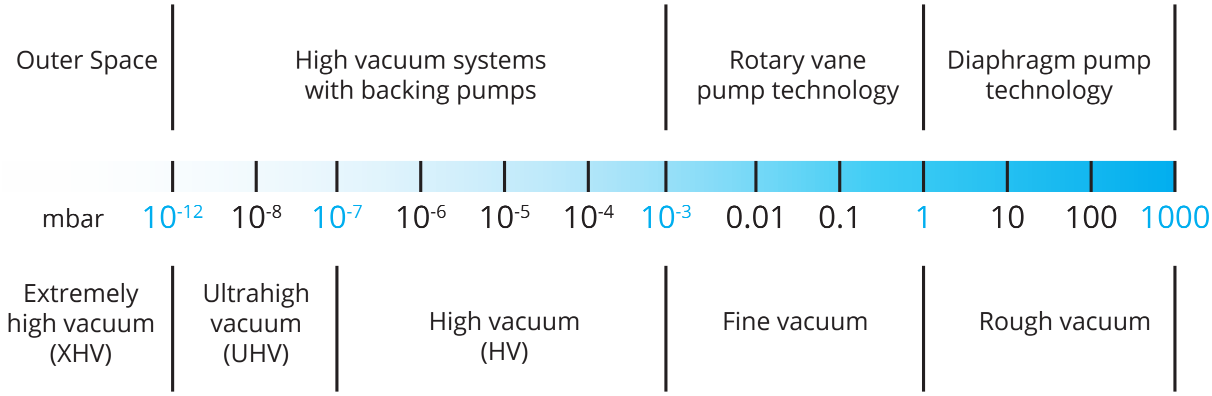
Filtration with the aid of a chemical-resistant vacuum pump

Drying cabinet with pumping unit

VACUUM FOR CHEMISTRY AND LIFE SCIENCES LABORATORIES

Vacuum applications used in laboratories vary with the scientific discipline, and the different applications have distinct vacuum requirements. Filtration is a process used in nearly all laboratories, while the aspiration of liquids using vacuum is an important task in laboratories with a focus on cell culture. Biochemical laboratories in which genome or proteome experiments are performed commonly use vacuum for drying. These applications all require vacuum in the “rough vacuum” range – between 1 and 1000 mbar. At the same time, life science laboratories often need vacuum for freeze-drying, as well. For this process, vacuum in the pressure range between 10^{-3} and 10^{-1} mbar – that is, the “fine vacuum range” – is applied.
In chemistry laboratories, numerous vacuum-driven technologies are used for evaporative separation of mixtures of substances. The best known example of this is rotary evaporation, for which the precise control and pressure regulation impose significant requirements with regard to pump and control technology in the rough vacuum range. In contrast, Schlenk line and molecular distillation, also common in chemistry labs, demand vacuum in the fine vacuum range.

The following graphic illustrates the various vacuum ranges common in the laboratory. The distinguishing features are intended to help you match the appropriate vacuum technology to the demands of the applications.



Pressure ranges and vacuum technologies

Rough vacuum (atm. - 1 mbar)

In chemistry and life sciences, this describes the range between 1018 mbar atmospheric pressure and 1 mbar. At 1 mbar, 99.9% of the atmospheric pressure is already removed. Most laboratory applications work in this vacuum range. This is where diaphragm technology is used. Applications include filtration, rotary evaporation, drying and aspiration of liquids.

Fine vacuum (1 mbar - 10^{-3} mbar)

Describes the range below rough vacuum to 10^{-3} mbar. Typical applications are Schlenk lines, freeze-drying and molecular distillation.

High vacuum (10^{-3} mbar - 10^{-6} mbar)

In these applications, typically found in physics labs, mostly high-vacuum systems are required, in combination with dry-running but also oil-sealed backing pumps.

Ultrahigh vacuum (at or above 10^{-7} mbar)

Only very few devices can generate such low final pressures, which are also primarily needed in physical research. Ion getter pumps, turbomolecular pumps or cryopumps are often used.

WELL-KNOWN SYSTEMS IN VACUUM SUPPLY IN THE LABORATORY

As in nearly every technical area, there are a wide variety of potential solutions for achieving an objective. This is also true in the laboratory and in research and production facilities in which vacuum technology represents an essential technology for a number of applications. For reasons of clarity, we are focusing below on the solutions with stand-alone systems, central vacuum and local vacuum networks.

Prior to making investment decisions for or against a vacuum system or technology, the individual requirements should be clearly defined.

Vacuum supply options in the laboratory

STAND-ALONE SOLUTION

As the name suggests, each application has its own vacuum pump or system. Each application receives a pump customized with regard to performance data and control options for the application. Organizationally, however, this means a broad range of pumps to be selected and the occupancy of far more work surface in the laboratory. The costs of the initial investment and maintenance are significantly higher here than central and decentralized vacuum supply systems. In the fine, high and ultrahigh vacuum range, stand-alone solutions are the only option; the physics of operation in this vacuum range would lead to unacceptable losses in final vacuum with central and decentralized systems. Stand-alone solutions usually sit on the lab bench next to the application and therefore require the corresponding work surface. During project planning for a laboratory, stand-alone solutions can also be integrated into furniture. The vacuum pump is placed, for example, in a pump cabinet under the exhaust hood. From there, it is connected with a vacuum tube through the rear wall into the exhaust hood (figure on right).

Stand-alone solution: Fine vacuum, Schlenk line

With stand-alone solutions, stringent requirements with regard to precise vacuum regulation and automatic evaporation of solvents can be achieved with speed-regulated chemical pumping units (figure, lower left).
Stand-alone solutions are also useful for liquid aspiration in cell biology laboratories to ensure isolation of biologically contaminated residues in biosafety cabinets (figure, lower right).

Stand-alone solution: Rough vacuum with a chemical-resistant pumping unit on the rotary evaporator

Stand-alone solution: Rough vacuum, aspiration of liquids

CENTRAL VACUUM

With this approach to vacuum supply, a centrally located, powerful vacuum pump supplies an entire laboratory complex with vacuum via a pipe system. Multiple oil-lubricated rotary vane pumps or liquid ring pumps are commonly used in central vacuum systems. These extensive piped networks are still widely used in existing laboratories and laboratory buildings, despite the following shortcomings in day-to-day operation:

- **Unsatisfactory vacuum technology operation**
  The final vacuum is limited and frequently not sufficient for applications beyond liquid aspiration and filtration, in particular if another user introduces large quantities of air or gas into the system. Further, it is difficult to avoid cross-contamination between vacuum applications, the potentially hazardous mixture of conveyed vapors, and reciprocal interference due to unintentional backflow of pumped gases. In addition, condensates can form in the tubing system and thus limit the final vacuum which can be achieved.

- **All-or-nothing operation with high energy and maintenance costs**
  Availability must be ensured through a redundant pump; otherwise, when the central pump is down for maintenance, nobody can work. Both pumps run on an alternating basis, generally 24 hours a day, 7 days a week, even if the building is unoccupied or if there is no need for vacuum. This results in unnecessarily high maintenance and energy costs.

Zentralvakuumanlage

- **Environment and safety**
  Central vacuum systems are convenient for laboratory staff since building services is responsible for system maintenance and the investment is generally made from the construction budget. However, users do not feel responsible for a system which they cannot see. Gases, vapors and liquids, carelessly drawn into a central system form unpredictable toxic and potentially explosive mixtures which can also often be corrosive to pipe systems. An unmixed, controlled collection of vapors is not possible. In the case of life sciences applications, the use of networked systems can appreciably increase the risk of uncontrolled release of bacteria and infectious materials.

- **Oversizing**
  The central vacuum pump must be designed for maximum operation. Project planning with regard to this requirement is consequently based on an assumption of a maximum number of users and a maximum need of each individual user, including provision for unforeseen additions over the life of the building. This typically includes the specification of the pump size, pipe conduits, valves and couplings which are likely used only rarely, if at all. The energy, maintenance and servicing costs of these systems are correspondingly high.

- **Limited performance and risks for experimental safety**
  Applications with special vacuum requirements need specially selected pumps. Distillations or evaporations require precise vacuum regulation and a deeper final vacuum. Drying processes require high process flows. Liquid aspirations of biological material can represent a hard-to-control risk for the entire network. Highly sensitive instruments should not be contaminated and often require a specially coordinated vacuum conditions which are different from the central vacuum supply. In all of these cases, further investments in vacuum technology add to the total costs of centrally supplied vacuum.

VACUU·LAN® LOCAL VACUUM NETWORK

The VACUU·LAN® local vacuum network makes it possible to support multiple applications within a lab from a single chemical-resistant pumping unit. The approach makes possible lab-by-lab adaptation of the vacuum supplied to the nature of the lab work. With a single pump supporting multiple users, it is a quiet, cost-effective and space-saving approach to bench, fume hood and biosafety cabinet vacuum in a laboratory, and can be scaled from a single lab bench to multi-use network solutions. The local vacuum network can accommodate modest budgets as well as the highest performance research needs, while avoiding many of the numerous disadvantages of a central vacuum supply.

Chemical network pumping unit under the exhaust hood, with solvent recovery

Benefits of the VACUU·LAN® local vacuum supply:

- **Quiet operation**
  Each VACUU·LAN® network is supported by an oil-free, chemical-resistant pump that operates at a decibel level well below that of a quiet, face-to-face conversation. By replacing numerous stand-alone pumps, the local vacuum network contributes to a quiet, pleasant working environment in the lab.

- **Optimal, needs-oriented design**
  The system avoids oversizing, because it provides vacuum on the scale of actual user requirements. The suction capacity and final vacuum of the vacuum pump can be selected based on the applications intended for each lab.

- **Depth of vacuum & control**
In contrast to central vacuum system supply, which rarely provides vacuum deeper than 200 mbar, VACUU·LAN® networks can supply vacuum as deep as 2 mbar, or virtually the entire rough vacuum range. This means that evaporative applications that would otherwise require a dedicated pump – even in cases in which central vacuum supply has been installed – will now be able to operate from the network ports. For programmable vacuum, only a controller at the vacuum port is needed, and not a dedicated pump.
- **Prevention of reciprocal interference**
Cross-contamination and interference between the applications are minimized by reliably reacting check valves which are integrated into the vacuum connections.
- **Active environmental protection and safe operation**
Dry-running, chemical-resistant diaphragm pumps do not consume any resources such as oil or water. Fluid-operated vacuum pumps generate wastewater and waste oil results from oil-sealed pumps. In chemistry, these waste fluids are contaminated with chemicals and solvents which are not environmentally friendly and their disposal is therefore costly. Users of local vacuum networks within a laboratory are familiar with the substances they are working with in their own lab, and can estimate the risks of interactions; this reduces the risk of formation of explosive mixtures or mixtures hazardous to health. Chemistry diaphragm pumps let corrosive gases pass without damage to the pump, enable solvent recovery at the pump outlet, and facilitate as well as clean recycling of waste solvents. The uncontrolled emission of solvents is kept to the minimum technically feasible.
- **Reduced maintenance, energy and operating costs**
Service intervals can be easily adapted to the actual run times of the system. The surfaces of pipes and vacuum ports which come into contact with corrosive media are made of fluoroplastics and similar highly chemical-resistant materials. They can be easily disassembled without special tools for cleaning by laboratory staff. The network pump is only operated when it is needed. Energy costs are therefore reduced and maintenance intervals are extended.
- **Modularity and flexibility of the system**
The system can be easily expanded and the vacuum ports can be modified if requirements change. There are built-in as well as add-on elements which can be placed and flexibly connected via pipes on existing laboratory or wall elements without any problems.

VACUUM SUPPLY OPTIONS IN COMPARISON

	Stand-alone supply	Central vacuum	Local vacuum network
Initial investment	-	+	+
Chemical resistance	+	-	+
Mutual interference	+	-	+
Environmental compatibility	+	-	+
Noise	o	+	+
Availability	+	o	+
Operating costs	o	-	+
Space requirement	-	+	+
Depth of vacuum	+	-	+

+ good, o neutral, - poor

COMPOSITION OF A VACUU·LAN® LOCAL VACUUM NETWORK

The local vacuum network VACUU·LAN® consists of three components: the network pumping unit, the vacuum ports and the piping.

NETWORK PUMPING UNIT

The local vacuum network consists of a vacuum pumping unit with chemical-resistant, dry-compressing diaphragm pump with an inlet separator to protect the pump and a pressure-side emission condenser.
A network controller switches the vacuum pump on and off as needed and adjusts the rpm of the pump to the amount of gas and vapor present. The condenser is an insulated glass cooler which is connected to a coolant source, such as a recirculating chiller, permitting a high degree of recovery of the pumped solvent vapors. In the case of the PELTRONIC emission condenser in which Peltier elements perform a cooling function, there is no need to install cooling medium supply and return piping or shutoff valves and cooling water valves. Through savings resulting from these avoided water consumption and installation costs, the additional costs of the investment are recouped in a short time. The network vacuum pump can be housed out of sight and away from the laboratory workstation in a casework or exhaust hood base cabinet. The quiet pump operation and remote location ensures that the pump is not disruptive. The optional filling level sensor prevents the collection container on the condenser from overflowing increasing safety during everyday laboratory operation.

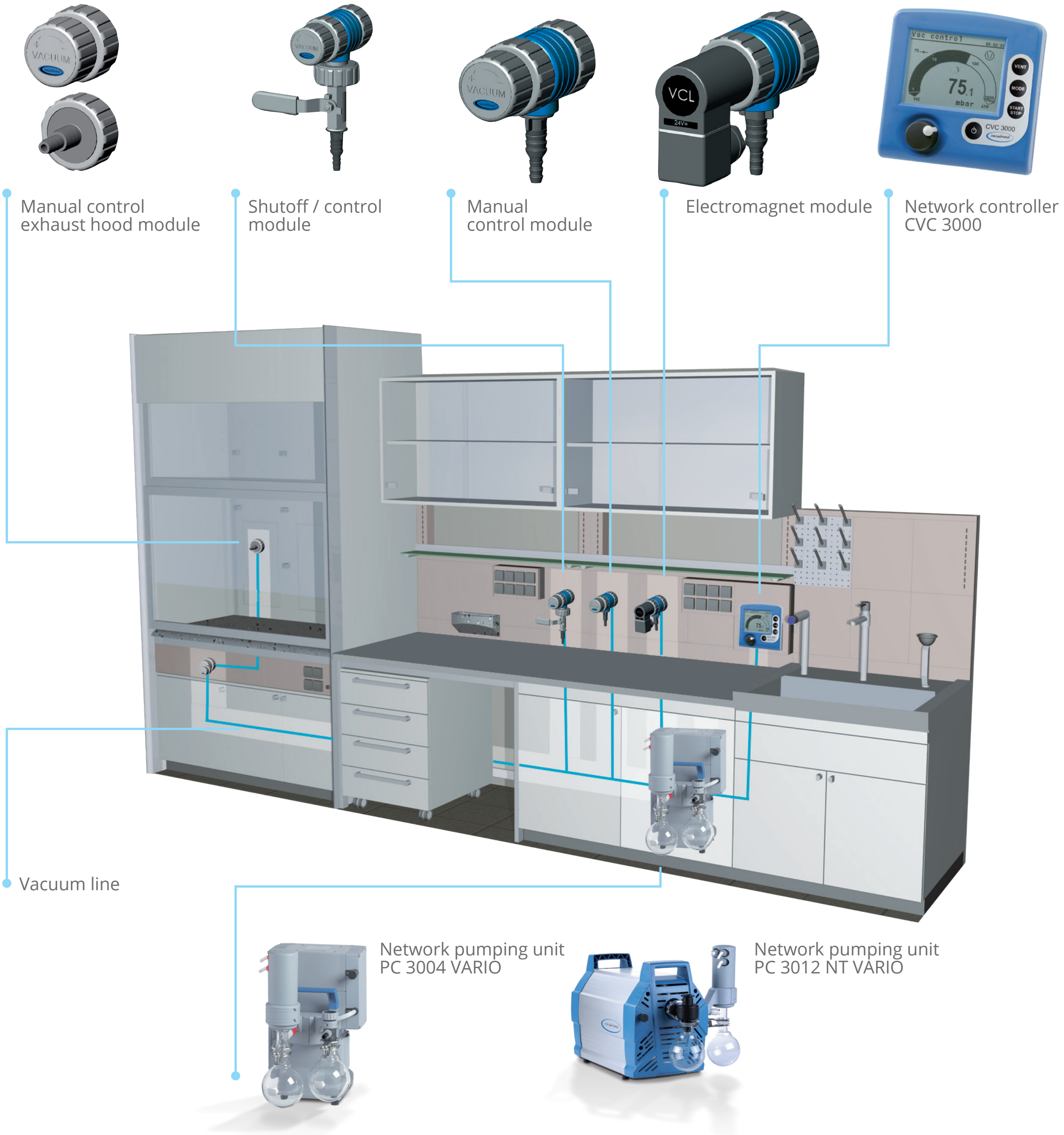
Vacuum network pumping unit under the exhaust hood, with solvent recovery, operation via the media console

VACUUM PORTS

In the case of all other fittings in the laboratory, it is immediately clear which medium flows through them (for example, water or specific gases). In contrast to this, various chemical substances and contaminated solvent vapors are drawn into the vacuum connections. These accumulate in the fittings and can thus lead to malfunctions. For this reason, it is important that the vacuum fittings are both chemically-resistant and can be disassembled and reassembled quickly, easily and without tools for cleaning purposes. In addition, fittings should have an integrated check valve which reacts to pressure differences within the network piping and thus prevents reciprocal interference and cross-contamination. VACUU·LAN® fittings meet these requirements.
Vacuum ports for the individual workstations can be added at any time. All vacuum ports can be installed new as well as into existing laboratory furniture.

VACUUM LINES

The individual vacuum fittings are networked with one other and with the network pumping unit by means of a PTFE tubing with an external diameter of 10 mm and an internal diameter of 8 mm. It can be laid easily and flexibly. The tubing connections and branches are made using angle and T compression connectors which seal reliably and can be quickly and easily assembled with simple hand tools.

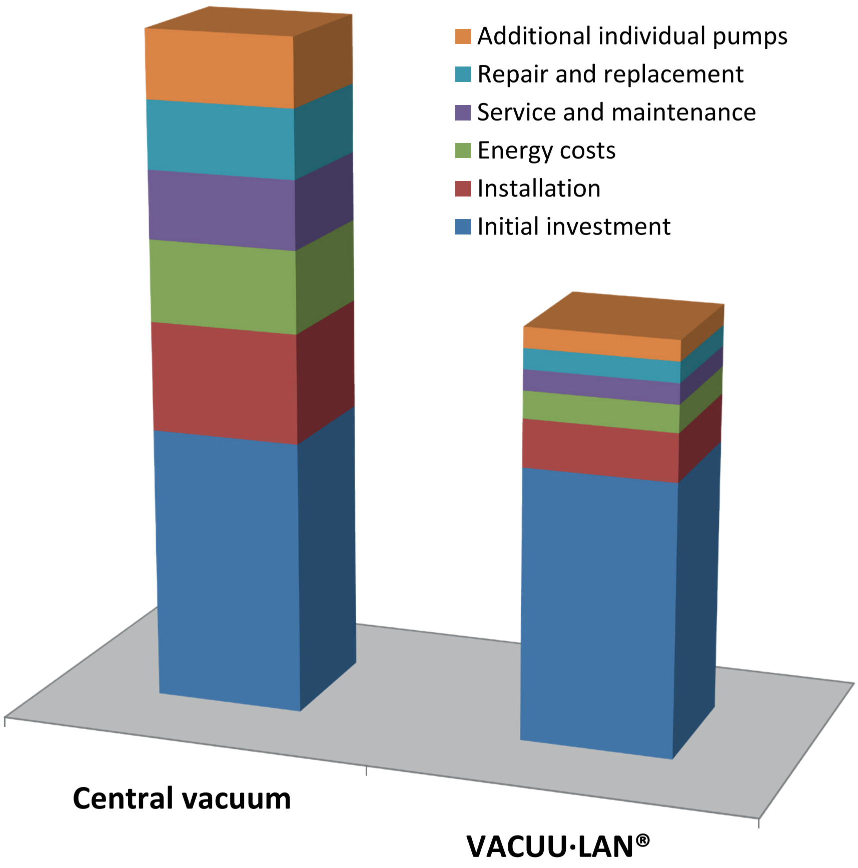


Schematic representation of a VACUU·LAN® installation

INVESTMENT AND OPERATING COSTS

To determine total cost of ownership (TCO), all costs incurred for vacuum supply in the laboratory are added up. The following graphic contrasts the total cost of ownership of a VACUU·LAN® local vacuum network with that of a central vacuum supply. The acquisition, installation, energy, service and repair costs are taken into account in this case, as an example. In addition, the costs for a redundant system pump – particularly in the case of a central vacuum system – also need to be estimated. The greatest savings in the case of the local vacuum network result from the installation, energy, service and repair costs. All in all, this clearly leads to higher TCO in the case of a central vacuum system.

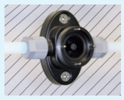
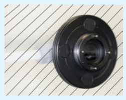
While the specific system costs of each will vary regionally, especially because of differences in energy costs, it is clear that, in terms of TCO, local vacuum networks in the laboratory are a more economical choice than central vacuum systems.



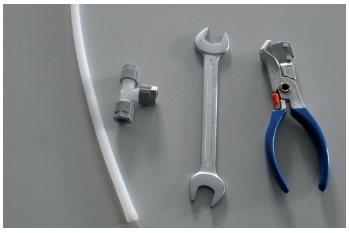
Cost comparison: central vacuum and VACUU LAN®

PLANNING AID FOR THE VACUU·LAN® LOCAL VACUUM NETWORK

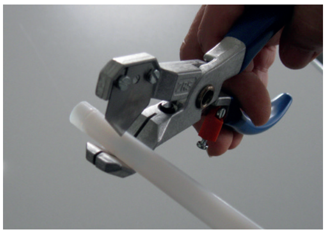
The VACUU·LAN® local vacuum network has been developed exclusively for applications in the rough vacuum range. Stand-alone solutions in the fine vacuum range integrated into the furniture should be planned separately.

1. NETWORK PUMPING UNIT: SELECTION OF PUMP, DEPENDING ON USE		
Final vacuum		mbar
Suction capacity		m³/h
Speed-regulated pump	 	yes/no
Solvent recovery		yes/no
Exhaust air		yes/no
2. INTEGRATION IN THE LABORATORY FURNITURE OR OPEN INSTALLATION ON THE WALL: Selection of connecting elements		
Connection element A1 - exposed vacuum line surface mounted on the wall		yes/no
Connection element A5 - concealed vacuum line integrated in the furniture		yes/no
3. VACUUM PORTS: SELECTION OF THE MODULES ACCORDING TO OPERATING FUNCTION		
Manual control module		Number
Shut-off control module		Number
Manual control exhaust hood module		Number
Workstation controller CVC 3000		Number
4. PIPING: SELECTION OF THE PTFE PIPE		
Length of piping		m
Connection elements (corner connectors, T connectors, extension)		Number/type

Simple and cost-effective placement of vacuum lines. The entire piping and installation of the vacuum network can be performed easily and quickly without advanced special knowledge or materials. At www.youtube.com/vacuubrandgmbh you will find a variety of videos about VACUU·LAN® and also about the installation of the PTFE lines.



Tools for VACUU·LAN® installation



Shortening the PTFE pipe

Tightening the coupling nut

HELP FROM VACUUBRAND SPECIALISTS

At VACUUBRAND, specialists determine the exact needs for each object using checklists and experience and provide comprehensive advice. This determination in the early stage of planning can save much time, cost and resources over the course of the construction work – as well as in later ongoing operation. Well-known suppliers of laboratory furniture already offer laboratory planners solutions with VACUU·LAN® technology. Dialogue among laboratory planners, furniture manufacturers and the vacuum specialists of VACUUBRAND is advisable for designing the ideal vacuum system. Hundreds of buildings worldwide are equipped with this technology from VACUUBRAND. VACUUBRAND's decades of experience in planning public as well as commercial laboratories ensure the ideal solution for the customer.

EXAMPLES

One pump - many users: network installation with Peltronic cooling without water connection for solvent recovery

Convenient operation below the work surface

Controller installation within the media column

Vacuum supply of a laboratory line with safety exhaust hoods

ATEX-protected laboratory area

Installation in an under cabinet with control option in the handle area

SUMMARY

In modern chemistry and life science laboratory buildings, vacuum is among the basic equipment for laboratory workstations. Consequently, vacuum supply is already an integral part of the planning of new laboratories, since it is needed for many different applications - whether evaporation, distillation, drying or simply aspiration or filtration. These rough vacuum applications are best served by chemistry diaphragm pumps. With the VACUU·LAN® vacuum network, VACUUBRAND offers a vacuum solution which keeps investment costs low, reduces the costs of service and repair during ongoing operation, saves valuable workspace and provides high performance vacuum. At the same time, due to the modularity of the system, all options for upgrading or converting the laboratory can be addressed should future needs change.

Talk to our specialists!

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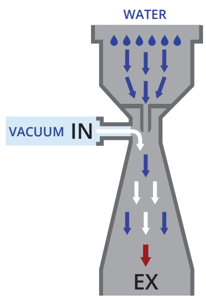
VACUUM PUMP TECHNOLOGY GLOSSARY

Every technology has advantages and disadvantages. Various points should be taken into account when selecting the right vacuum supply. In addition to performance data, the need for chemical resistance and the option for solvent recovery should be reviewed.
As a basic rule, a differentiation is made between dry-running vacuum pumps and pumps which need an operating liquid, for example, as a propellant or for sealing. In the case of fluid pumps, the substances and vapors pumped off mix with the fluid and contaminate it. Separation, and thus recovery, of waste vapors is made practically impossible as a result. This raises questions with regard to the appropriate vacuum system. Wherever possible, the use of a fluid pump should be avoided if the performance data indicate that a dry-compressing pump will suffice. A brief description of a choice of technologies which are commonly used for vacuum generation in the chemistry and life sciences laboratory is given below.

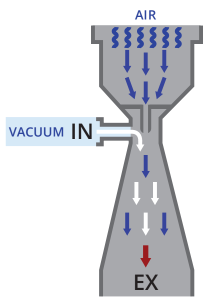
Water jet pump

The water jet pump is a propellant jet pump in which water flows through a nozzle. A vacuum develops as a result of the high flow rate. The final vacuum to be reached depends on the water pressure and temperature. The lower the intake pressure, the more the suction capacity declines. Water jet pumps are distinguished by their very low acquisition costs and corrosion resistance. However, they are stationary. In order to use them, water and wastewater connections must be mounted on laboratory tables and in exhaust hoods. Because of the typical water consumption of several hundred liters per hour - a hundred thousand liters per year, even with moderate use – the water jet pumps generate high operating costs for fresh water and wastewater. Another drawback is the high noise level and the poor environmental compatibility, since all substances and solvent vapors pumped from applications go into wastewater. For these reasons, water jet pumps should not be used in the laboratory.



Compressed-air-driven Venturi nozzles

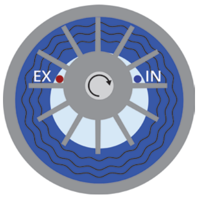
In principle, these systems work comparably to water jet pumps and require compressed air instead of water as the propellant. The core of such a system is a centrally located compressed air system. The vacuum is generated with various nozzles locally near the workstation. The generation and maintenance of clean compressed air uses a great deal of energy and is thus costly to operate. The suction capacity is very low at vacuum levels of less than 100 mbar. As a result, many applications in the area of rotary evaporation and drying are not possible and additional dedicated vacuum pumps become necessary. Vapor recovery and thus orderly disposal is not possible since the



vapors are mixed with the compressed air and thus go into the laboratory exhaust air. This technology is suitable only for the most incidental use of vacuum in the laboratory.

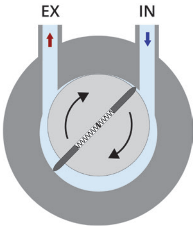
Liquid ring pumps (water ring pumps)

The liquid ring pump is a rotational displacement pump in which an eccentrically mounted rotor with fixed blades displaces a liquid (generally water) against the wall of the stator (housing). The liquid takes the form of a ring concentric to the stator and together with the rotor blades forms several spaces with changing volumes, together with the rotor blades. As a result, the pumped gases are conveyed and compressed. This pump technology is often used for central vacuum supplies. The final vacuum depends on the vapor pressure of the operating liquid. It is limited by the temperature of the liquid and its contamination, such as highly volatile solvents. The power consumption is high due to friction loss and the contaminated operating liquid must be continually replaced and disposed of, leading to very high water consumption and wastewater charges.



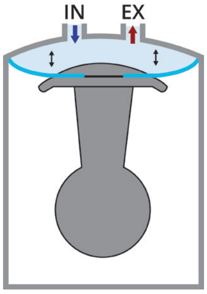
Rotary vane pumps

Like the liquid ring pump, the rotary vane pump also belongs to the rotational displacement pumps. In this technology, an eccentrically mounted rotor rotates in the housing (stator) and the rotor touches the inner wall of the stator between the inlet and outlet opening. There are generally two movable vanes mounted in the rotor slots which slide along the inner wall of the stator and as a result, the pump chamber is divided into spaces with changing volumes. Due to the high compression, a two-stage rotary vane pump achieves a final vacuum of 10^{-3} mbar and is thus suitable for applications in the fine vacuum range. For lubrication and sealing, the rotary vane pump requires oil which is conveyed via an oil pump in a circuit to the moving parts in the pump. Rotary vane pumps are not very suitable for pumping corrosive gases and vapors, since they contaminate the oil. When that occurs, the performance data of the pump are no longer reached and the pump is no longer protected against corrosion. In these cases, suitable protection, such as a cold trap, should therefore always be used.



Diaphragm pumps

In a diaphragm pump, one or more diaphragms are moved up and down so the pump chamber gets larger and smaller, thus producing a pumping effect. The diaphragm hermetically seals the pump chamber (in which the gases and vapors are aspirated and compressed) from drive and motor. As a result the pump chamber is completely dry (no operating materials or lubricants) and can be designed from chemical resistant compound materials. Two mechanical valves ensure that extracted gas is aspirated from the correct tube and then ejected into the other. In this way, a directed gas flow through the pump in the direction of the exhaust is ensured. It is essential for the materials in the pump which come into contact with media to be chemical-resistant, sturdy and stable over the long term. Variable-speed motors and intelligent controllers provide application-specific functionalities. The area of application in this case is rough vacuum down to about 0.5 mbar. Low energy consumption, solvent recovery and low maintenance costs are the key advantages of this pump technology.



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