General

The turbomolecular pumps from Oerlikon Leybold Vacuum generate a clean high and ultra-high vacuum, are easy to operate and are exceptionally reliable. In connection with a well rated backing pump, pressures below 10^{-10} mbar (0.75×10^{-10} Torr) can be attained.

Oerlikon Leybold Vacuum offers two product lines:

1. **TURBOVAC line**
   Turbomolecular pumps with mechanical rotor suspension
2. **TURBOVAC MAG line**
   Turbomolecular pumps with magnetic rotor suspension

Each of the two product lines contains **"classic" turbomolecular pumps** as well as **turbomolecular pumps with a compound stage**.

Oerlikon Leybold Vacuum is one of the world's leading manufacturer of turbomolecular pumps. Consequently, the TURBOVAC and the TURBOVAC MAG pumps are successfully used in many applications. A list of the most important ones is given in the table "Applications" in the section "General".

Principle of Operation

The turbomolecular pump is a turbine with blades. By the momentum transfer from the rapidly rotating rotor blades to the gas molecules their initially non-directed thermal motion is changed to a directed motion.

TURBOVAC SL 80 turbomolecular pump with frequency converter for attaching or separate and compound stage

TURBOVAC TW 361 turbomolecular pump with mechanical rotor suspension

TURBOVAC MAG W 1500 CT turbomolecular pump with magnetic rotor suspension and compound stage

Hence, the pumping process in a turbomolecular pump results from the directed motion of the gas molecules from the inlet flange to the fore-vacuum port.
In the **molecular flow range** - i.e. at pressures below 10^{-3} mbar (0.75×10^{-3} Torr) - the mean free path of the gas molecules is larger than the spacing between rotor and stator blades (typically some tenths of a millimeter). Consequently, the molecules collide primarily with the rotor blades with the result that the pumping process is highly efficient.

In the **range of laminar flow**, i.e. at pressures over 10^{-1} mbar (0.75×10^{-1} Torr) the situation is completely different. The effect of the rotor is impaired by the frequent collisions between the molecules. Therefore, a turbomolecular pump is not capable of pumping gases at atmospheric pressure thus necessitating the use of a suitably rated forevacuum pump.

To create the directed motion of the gas molecules, the tips of the rotor blades have to move at high speeds. Hence, a high rotational speed of the rotor is required. In the case of Oerlikon Leybold Vacuum turbomolecular pumps the rotor speeds vary from about 36,000 rpm for the larger rotor diameters (e.g. TURBOVAC 1000 about 20 cm (7.87 in.)) to 72,000 rpm. for small rotor diameters (e.g. TURBOVAC 50 about 6 cm (2.36 in.))

Characteristic Quantities

Pumping speed (volume flow rate), S, [l x s^{-1}]
The pumping speed for a given type of gas depends on the diameter of the rotor and the high vacuum flange, the rotor/stator design, the rotor speed and the molecular weight of the gas. The pumping speed S is a non-linear function of the inlet pressure p_1:
$S = S(p_1)$.

Gas throughput, Q, [mbar x l x s^{-1}]
Gas throughput Q is linked to the pumping speed S and the inlet pressure p_1 through the relationship
$Q = Q(p_1) = p_1 \times S(p_1)$.
The maximum permissible gas throughput Q_{max} is attained at the maximum permissible inlet pressure $p_{1,\,max}$:
$Q_{max} = Q(p_{1,\,max})$.

Compression, K
For a given type of gas, compression K is defined as the ratio between forevacuum pressure p_{VV} (= pressure on the forevacuum side of the turbomolecular pump) and the highvacuum pressure p_{HV} (= pressure on the highvacuum side of the turbomolecular pump):
$k = k(p_{VV}) = p_{VV} / p_{HV}$
$= p_{VV} / p_{HV}(p_{VV})$.

Compression depends very much on the gas throughput: at a given forevacuum pressure, compression increases when the gas throughput is reduced.

Idle compression, K_0
Idle compression K_0 of a turbomolecular pump is defined as the amount of compression of this pump at "Zero" gas throughput. What is problematic about this definition is the fact that the demanded "Zero" throughput can never be implemented in practice (finite leak rate, degassing of sealing components, desorption from wall surfaces). Data on idle compression need therefore to be gained from measurements run at extremely low throughputs.
Idle compression of a pump equipped with metal seals is significantly higher compared to the same pump sealed with O-rings.

Ultimate pressure (base pressure), p_{ult}, [mbar]
The ultimate pressure of a turbomolecular pump is defined as that pressure which is attained in the test chamber 48 hours after a 24 hour degassing period of the measurement system. The ultimate pressure will chiefly depend on the foreline pump used and the type of seal used at the highvacuum flange.

TURBOVAC Product Line

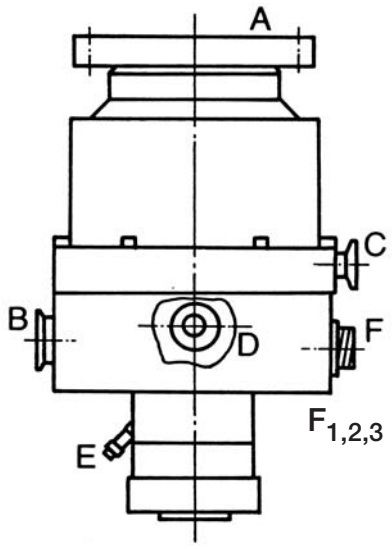
The **TURBOVAC pumps** are **turbomolecular pumps with mechanical rotor suspension** which are used in **the pressure range from 10^{-1} mbar (0.75 x 10^{-1} Torr) to 10^{-10} mbar (0.75 x 10^{-10} Torr). Pumping speeds for air vary from 35 l x s^{-1}** (inlet flange diameter = 40 mm (1.57 in.)) **to 1,600 l x s^{-1}** (inlet flange diameter = 250 mm (9.84 in.)).
Through the compact design, the most reliable ceramics ball bearings and the simplicity of operation, this line of pumps is used in all high-vacuum and ultrahigh vacuum areas of application.
In particular the TURBOVAC pumps are very successfully operated in mass spectroscopy applications, gas and liquid chromatographic analysis, CD, DVD and hard disk production, manufacturing of large-surface optical layers, and non-corrosive semiconductor fabrication processes.

The **most important advantages of the TURBOVAC product line** are:

- Oil-free pumps for the generation of clean high and ultra-high vacuum conditions
- Highly performance in any orientation
- Highly degree of operating reliability
- Easy to operate
- Compact design

Ceramic Ball Bearings Technology

All TURBOVAC pumps are fitted with **ceramic ball bearings**, i.e. **ceramic balls** are running in steel races. The bearings are **lubricated for life by grease**.
Ceramic balls are lighter, harder and smoother than balls made of steel. Therefore, with ceramic balls the wear on the races is significantly reduced. Consequently, the lifetime of the bearings, and hence the lifetime of the pump, is increased.
The **TURBOVAC pumps** fitted with grease-lubricated ceramic ball bearings **can be mounted in any orientation**. As the ball bearing is encapsulated, the grease can not enter the highvacuum space, even if the pump is mounted up-side-down.



A Highvacuum flange
B Forevacuum flange
C Venting flange
D Purge gas flange
E Water cooling connection
F Electrical connection
F_1 Connection for DC motor
F_2 Connection for regulator
F_3 Connection for axial sensor

Flange designations used in this product section

Components supplied with the Turbomolecular Pumps

Highvacuum Flange
KF, ISO-K and ISO-F models
- Accessories need to be ordered separately

ANSI Models
- O-ring included in the delivery

CF Models
- Without gaskets [1], but with screws [2]

Forevacuum Port
- Centering rings, O-rings and clamps for all KF type forevacuum flanges are included.

Purge / vent ports are blanked-off

[1] For CF gaskets, see Product Section C13
[2] Only for MAG pumps

TURBOVAC MAG Product Line

The **TURBOVAC MAG pumps** are **turbomolecular pumps with magnetic rotor suspension** which are used in the **pressure range from 10^{-1} mbar (0.75 x 10^{-1} Torr) to 10^{-10} mbar (0.75 x 10^{-10} Torr). Pumping speeds for air vary from 300 l x s^{-1}** (inlet flange diameter = 100 mm (3.94 in.)) **to 3,200 l x s^{-1}** (inlet flange diameter = 320 mm (12.6 in.)).
The TURBOVAC MAG pumps are mostly installed on semiconductor processing lines like etching, CVD, PVD and ion implantation, i.e. in applications where corrosive gases need to be pumped. Also electron beam microscopy is an important area of application for these pumps.

The **most important advantages of the TURBOVAC MAG product line** are:

- Hydrocarbon-free pumps for the generation of clean high and ultra-high vacuum conditions
- High performance in any orientation
- High degree of operating reliability
- Extremely low vibration
- Designed for pumping of corrosive gases
- Almost maintenance-free

Use of Turbomolecular Pumps in Analytical Instruments

All modern analytical methods for gas, liquid and plasma analysis – like for example GC-MS, LC-MS and ICP-MS – rely on mass spectrometers and for this reason require adequate highvacuum conditions. Also in electron microscopes and many surface analysis instruments the production of a high-vacuum is essential.

In over 90% of all highvacuum applications, the turbomolecular pump has been found to be ideal. Thanks to the hydrocarbon-free vacuum, most simple operation, compact design and almost maintenance-free operation it has in most cases displaced above all the diffusion pump.

On the basis of decades of experience and in cooperation with research facilities and the manufacturers of analytical instruments,

Oerlikon Leybold Vacuum has continually optimized its products.

Through the TURBOVAC wide range series, a further improvement has been attained, making available to users in the area of analytical engineering highly flexible and reliable products.

Owing to the modular concept the user may

- adapt his vacuum system precisely to his requirements
- perfectly integrate the components within his system and
- find the most cost-effective system configuration for his needs.

Moreover, in response to special customer requirements, though Oerlikon Leybold Vacuum has, through the introduction of the TURBOVAC multi inlet series, achieved a major step ahead for analytical instruments.

Up to three analysis chambers can be pumped down simultaneously by a single multi inlet pump. These pumps are fine tuned with regard to pumping speed and gas throughput so as to attain higher detection sensitivities for analytical systems, a smaller footprint and an increased sample throughput.

The benefits for the customers are the extreme compactness of the vacuum systems without sacrificing performance density, simple installation, stable vacuum connections and, compared to the use of discrete individual pumps, significantly lower investment costs for the entire system. The cartridge solution, moreover, allows for an innovative and cost-effective design of the customer's system and during servicing a simple replacement of the active unit without involved assembly work and leak searching.

Cartridge benefits, which convince

- Higher effective pumping speed
- No losses in conductance
- Compact vacuum system
- Easy pump replacement without having to disassemble the highly sensitive mass spectrometer chambers

The benefits for the customers using Oerlikon Leybold Vacuum products are reflected by the efficiency of the analytical instruments:

- Increase in detection sensitivity
- Smaller analytical systems
- Increase in sample throughput
- Reduction of system costs
- Lower maintenance costs

In combination with backing pumps like the TRIVAC or Scroll pump, Oerlikon Leybold Vacuum is able to offer the best vacuum system optimized for all major applications in the area of analytical instrumentation.

TURBOVAC multi Inlet TW 220/150/15 fitted in an analytical instrument
(by courtesy of Thermo Fisher Scientific)

Use of Turbomolecular Pumps in the Area of Semiconductor Processes

In the semiconductor industry turbomolecular pumps are used on the following processes, among others:

- Etching
- Sputtering
- Ion implantation
- CVD
- Lithography.

In these applications pumping of aggressive gases is often required.

This may necessitate the use of pumps equipped with a purge gas facility or a magnetic suspension in order to avoid damaged bearings. Especially during metal etching, deposits may occur in the fore-vacuum space of the turbomolecular pump. In order to prevent this the pumps must be heated to a certain temperature. Such temperature controlled variants are optionally available for the MAG 1500 C, MAG 2000 C, MAG 2800 and MAG 3200. In contrast to turbomolecular pumps with mechanical bearings, magnetically levitated pumps provide the advantage that they prevent overheating of the bear-ings at high gas flows and effectively exclude any damage to the magnetic bearings by aggressive media.

In electron microscopes and in lithographic equipment, low vibration levels are exceptionally important. For this reason magnetically levitated turbomolecular pumps should be used here.

The recommended backing pumps are either dry compressing ECODRY pumps or rotary vane pumps from the TRIVAC range, possibly fitted with the BCS system.

Use of Turbomolecular Pumps in the Area of Coating Systems

Coating of optical and magnetic storage media, optical components as well as architectural glass requires highvacuum conditions. This is the only way to ensure that the formed layers will be uniform and adhere to the substrate.

The way in which the vacuum is generated has a significant impact on the quality of the coating. By pumping the vacuum chamber down to pressures in the range of 10^{-6} mbar (0.75×10^{-6} Torr), interfering gas and water molecules are removed from the processing chamber. In the case of sputtering the coating process is run in the pressure range between 10^{-3} and 10^{-2} mbar (0.75×10^{-3} and 0.75×10^{-2} Torr), and in the case of evaporation coating, pressures below 10^{-4} mbar (0.75×10^{-4} Torr) are utilized.

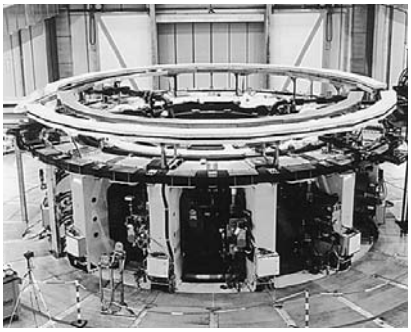
The turbomolecular pump meets all requirements of the customers as to a hydrocarbon-free vacuum, very simple operation, compact design and almost maintenance-free operation in an almost ideal manner. The range of pumps from Oerlikon Leybold Vacuum includes pumps with flange diameters ranging from 40 mm to 250 mm (1.57 in. to 9.84 in.) nominal width. Thus the right pump is available for each application, be it coating of data memories (CD, DVD, hard discs), coating of tools and coating of precision lenses in the area of optical components, displays or architectural glass.

Entire high vacuum equipment of a CD/DVD coating system with TURBOVAC TW 250 S pumps

Research and Development

In the area of research, all types of turbomolecular pumps from Oerlikon Leybold Vacuum are being used.

In the case of particularly stringent requirements such as low vibration levels, a TURBOVAC with magnetic bearings should be selected; the same applies to those applications in which entirely hydrocarbon-free pump systems are required.



Nuclear fusion technology

High performance glass coating plant

TURBOVAC MAG W 1300 C turbomolecular pump with magnetic rotor suspension and compound stage

Magnetic Bearings Technology

The world-wide success of the TURBOVAC MAG product line results from more than **30 years of experience** of Oerlikon Leybold Vacuum in the development and manufacturing of turbomolecular pumps with magnetically levitated rotors.

In 1976 Oerlikon Leybold Vacuum started the market introduction of the famous TURBOVAC 560 M. This was the first magnetically levitated turbomolecular pump which became commercially available. Today, Oerlikon Leybold Vacuum is employing the well-proven and reliable 5 axes active suspension design principle.

Five axes with active bearings
The rotor position is actively controlled by electromagnets in all 5 degrees of freedom. The TURBOVAC MAG 300/400, MAG 600/700, MAG 830/1300, MAG 1500, MAG 2000, MAG 2200 and MAG 2800/3200 are equipped with such a bearing system.