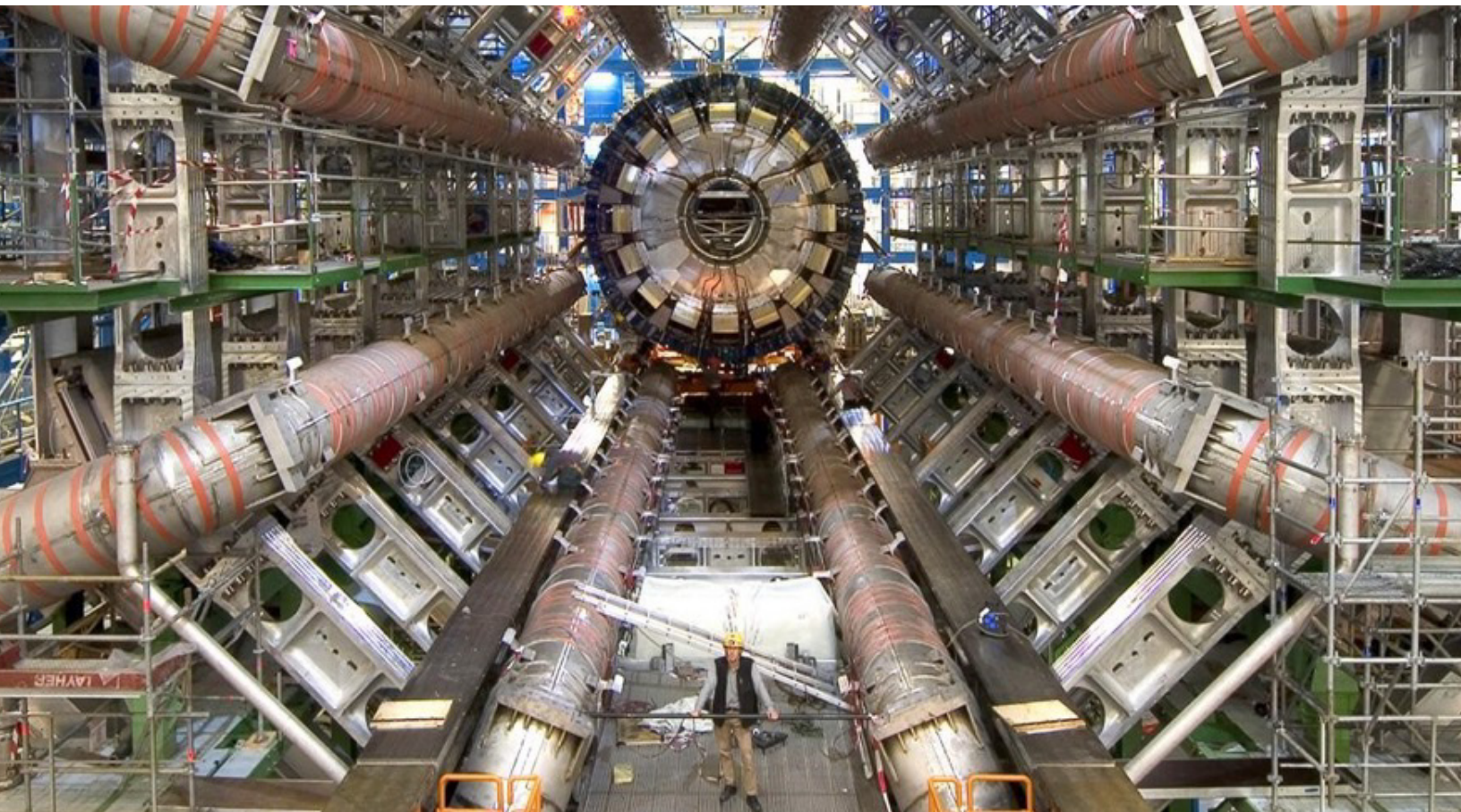


# ULTRA-HIGH VACUUM IN SCIENTIFIC RESEARCH

Unmatched Flexibility and Pressure Range



Large Hadron Collider at CERN

# Ultra-High Vacuum Drives Vital Scientific Research

Ultra-High Vacuum (UHV) conditions are a prerequisite for most complex research conducted by government labs, academia, and private industry.



National Laboratories, large global research universities, and industries such as defense, aerospace, and analytical instrument manufacturing utilize a wide range of vacuum equipment to achieve required levels of vacuum, and many of these organizations rely on Leybold for highly-specific vacuum pumps, instruments, and systems.

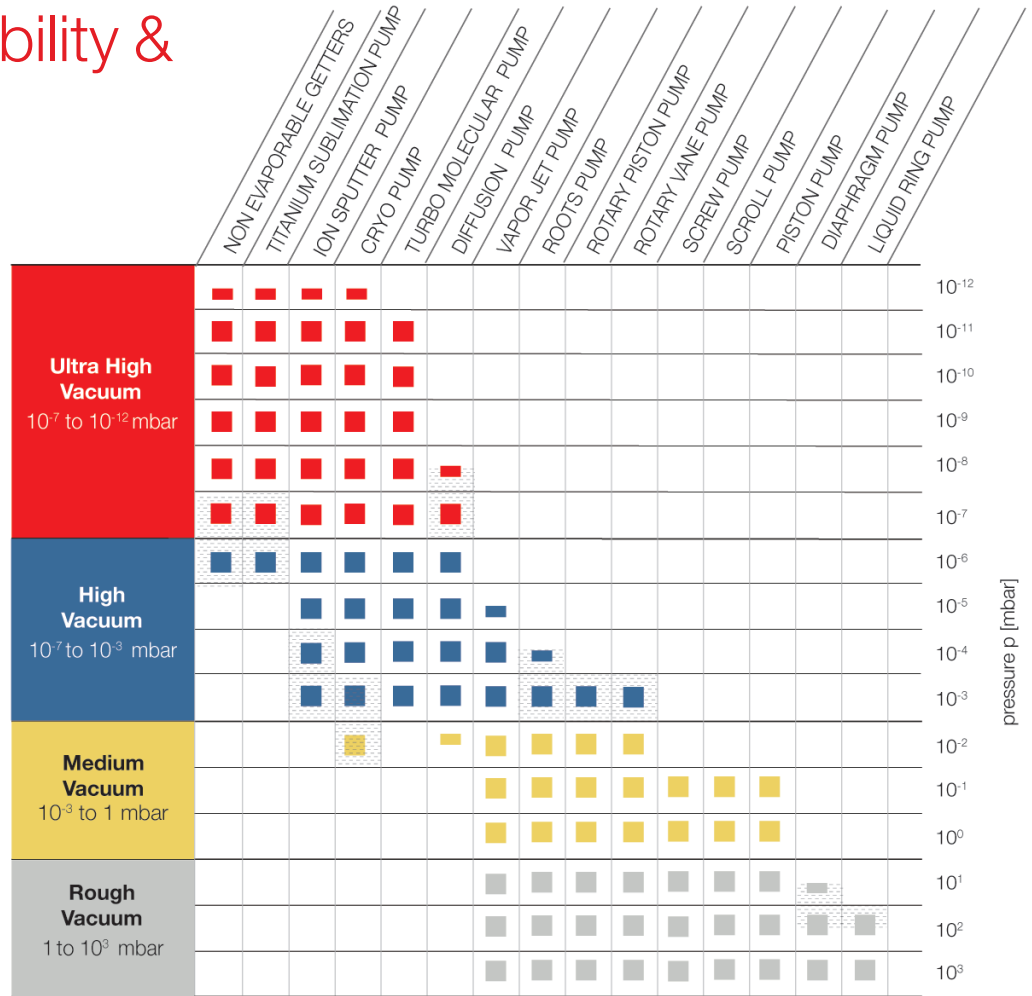
## Unmatched Flexibility & Pressure Range

A pioneer in the field of scientific and industrial vacuum equipment for 170 years, **Leybold** is synonymous with scientific vacuum technology.

Our mission has always been to provide the scientific community with the tools that enable cutting-edge discovery and innovation. We offer our customers the most flexible range of vacuum equipment on the market, from roughing pumps to gauges to custom UHV equipment.

### A One-Stop Solution

From offering a single vacuum pump to custom-designing highly complex, modular UHV systems, Leybold is the go-to partner of research scientists and physicists around the globe.



Working range of different vacuum technologies offered by Leybold.

special operating range



## Take a Look into the Future

Giant telescopes like the ones used at Mauna Kea Observatory in Hawaii, the Instituto de Astrofisica in the Canary Islands, and the European Southern Observatory in Chile rely on their flawless mirrors whose reflective coatings would not be possible without vacuum technology provided by Leybold.



## Ultra-High Vacuum Applications:

- Surface Analysis
- High-Energy Physics
- Molecular Beam Epitaxy (MBE)

# Leybold's Equipment in Action

Our systems can be found in material sciences, optical coatings, high-energy physics, surface analytics, and nuclear research environments that require High to Ultra-High Vacuum conditions. These areas include Particle Accelerators, Gravitational Wave Detectors, Synchrotrons, and Large Space Simulators (LSS).

## High Vacuum Applications:

- Thin-Film Deposition
- Nuclear Physics
- Space Simulations
- Analytical Instruments



## High-Energy Physics/National Laboratories

Leybold's vacuum equipment plays a pivotal role in sustaining the vacuum needs of all National Laboratories in the United States, as well as many others around the globe.

We work with physicists across the world to design and customize vacuum systems for particle accelerators, enabling them to bring their ideas to life.

For example, CERN—one of the world's most celebrated accelerators—relies on vacuum conditions created by Leybold's vacuum pumps. Leybold continues to push the boundaries of innovation to deliver cutting-edge pumps, gauges, leak detectors, and complete systems.



## Material Science

The most critical aspect of advanced materials development research is the ability to analyze and characterize material properties at atomic and molecular level. A continuous research effort is devoted to gradually replace empiricism with robust computational strategies derived on the basis of the fundamental understanding of materials. Surface science in particular is capable of providing this fundamental information because of the advent of a multitude of novel surface characterization techniques.

Surface analytical tools operating under ultra-high vacuum conditions can characterize materials with respect to composition, crystallographic, and electronic structure.

## Aerospace/Space Research

Space research laboratories around the globe rely on technology provided by Leybold for qualification of mission-critical applications.

Space simulation chambers are systems used to recreate the environmental conditions that spacecraft experience in space. They also serve to qualify components and materials used in spacecraft. Space simulation chambers are capable of analyzing system behavior, evaluating thermal balance, and verifying functionalities to ensure mission success and survivability.



# Modular Ultra-High Vacuum Platforms

From simple standardized offerings to complex customized systems, Leybold's M-UHV Platforms facilitate a wide range of research and analysis techniques that require ultra-high vacuum conditions.

The highly versatile turn-key set-up, multi-flanged confocal chamber and the UHV transfer station allows for virtually endless experimental possibilities.

## M-UHV Platform Capabilities

Sample preparation procedures including ion sputtering, annealing over 1000 K, substrate cooling under 100K, precursor or adsorbate dosing, etc.

Ultimate System Pressure <math>1 \times 10^{-10}</math> mbar

**A wide range of UHV surface analysis techniques, including:**

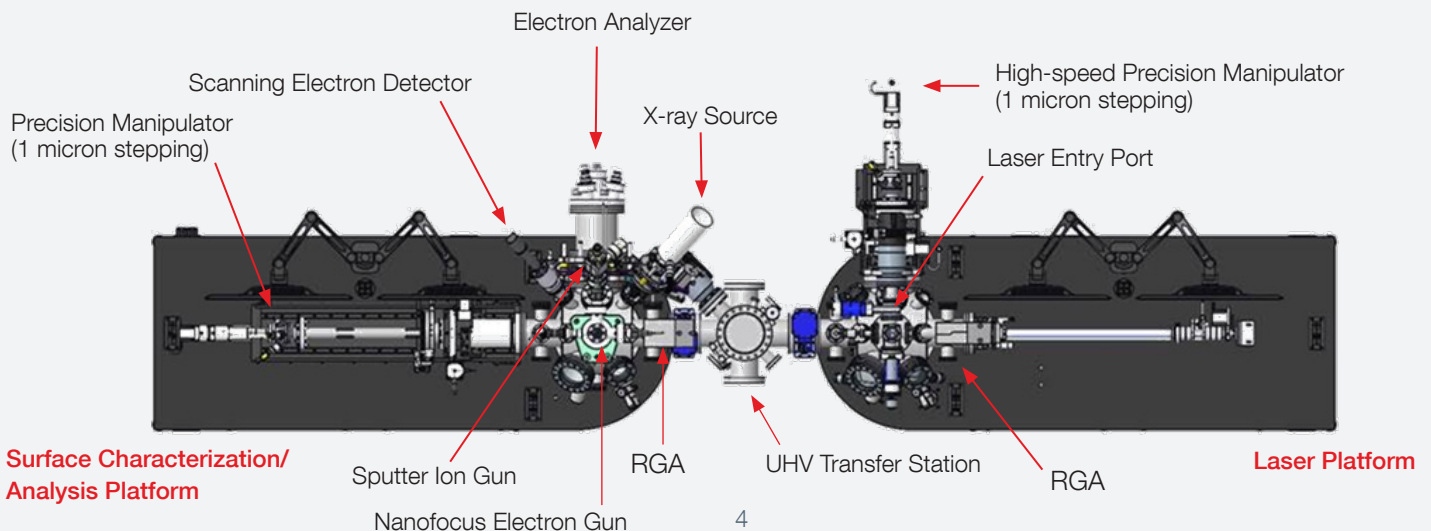
- X-Ray Photoelectron Spectroscopy (XPS)
- Auger Electron Spectroscopy (AES)
- Scanning Electron Microscopy (SEM)
- Low Energy Electron Diffraction (LEED)
- Scanning Tunneling Microscopy (STM)
- Ultra-violet Photoelectron Spectroscopy (UPS)
- Temperature Programmed Desorption (TPD)
- Scanning Auger Microscopy (SAM)
- Secondary Ion Mass Spectroscopy (SIMS)



**Thin-Film Growth & Preparation Techniques, including:**

- Molecular Beam Epitaxy (MBE)
- UHV Chemical Vapor Deposition (CVD)
- UHV Pulsed Laser Deposition (PLD)

## Cluster Tool Assembled Using M-UHV Platforms



“

Leybold was instrumental in helping UNL customize a UHV cluster tool design. The combination of this tool with the attached femtosecond laser (FSLP) source is an extremely powerful setup and the only system of its kind in the United States.

Dr. Dennis Alexander, Kingery Engineering Professor

”



## Customer Spotlight: The University of Nebraska-Lincoln

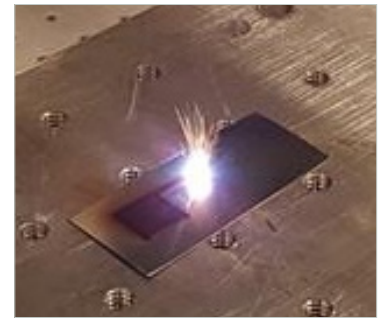
### The University's Research Interest

UNL's research focuses on understanding the fundamental principles of laser interaction with surfaces i.e. light-matter interactions. UNL is particularly vested in studying ultra-fast lasers along with their applications and propagation of ultra-short femtosecond pulses.

### The UNL & Leybold Partnership

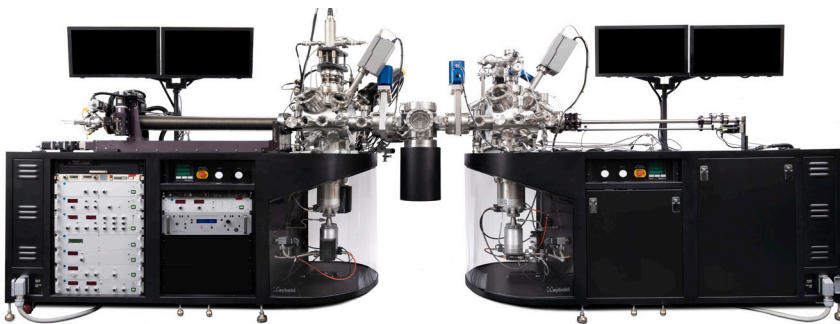
One of the core areas of UNL's research involves surface structuring of materials using femtosecond lasers. Essentially, this results in generation of well-defined nanostructures rendering the surfaces with some very interesting properties including super-hydrophobicity, extremely high emissivity, anti-icing properties, and reduced drag. These aspects, once understood, will have a profound impact in the area of functional surfaces and interfaces.

UNL partnered with Leybold to develop a highly specialized UHV processing and surface analysis tool that was based on Leybold's Modular UHV Platforms product line.



### A Flexible Solution for a Highly Complex Challenge

The state-of-the-art UHV cluster tool that resulted from the partnership with Leybold now resides in a university lab. While one section of the tool is used for laser processing of surfaces under UHV conditions, the other is used for atomic studies, molecular studies, and electron imaging of the processed surfaces. The combination of this tool with the attached femtosecond laser (FSLP) source is an extremely powerful setup and the only system of its kind in the United States.

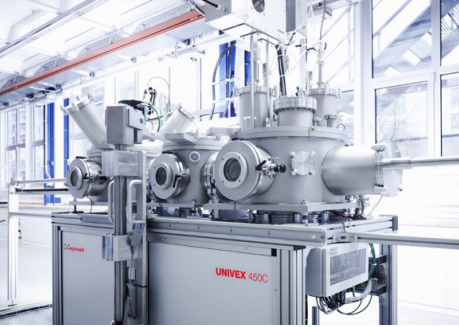


UNL's FSLP system was configured using Leybold's M-UHV Platforms product line. The system was customized per customer specification and can be used for UHV processing and characterization utilizing a wide range of surface science techniques.

The specific experimental capabilities of the UHV cluster tool include precision substrate manipulation, x-ray photoelectron spectroscopy, auger electron spectroscopy, scanning electron microscopy, scanning auger microscopy, depth profiling and temperature desorption spectroscopy, all under ultra-high vacuum conditions.

### Measurable Impact on UNL's Research Needs

Thanks to this new investigative capability, UNL is able to work on a wide array of projects with unique applications, including drag reduction, enhanced heat transfer, stem cell growth on surfaces, imparting surfaces with anti-icing properties, producing black metal surfaces with extremely high emissivity.



# Product Line Overview

Leybold has been on the forefront of providing industry-leading vacuum pumps and equipment for 170 years. Our product line covers the entire spectrum of vacuum equipment, from basic roughing pumps to highly customized UHV systems.

## Ultra-High & High Vacuum Systems

### M-UHV Platforms

#### Modular Ultra-High Vacuum Experimentation Platforms

Automation Based Options Include

**100 | 200 | 300 | 400**

Ultimate Pressure

**< 5 x 10<sup>-10</sup> mbar**

For more information on our M-UHV Platforms, please see Page 4.

- Substrate temperature variation from 100K - 1000K
- Accurate temperature measurement
- Modular concept along with UHV transfer station facilitates easy assembly of cluster systems
- Plug and play configuration for a wide range of UHV experimentation tools
- Incorporates flag-style sample holders



### UNIVEX

#### Thin-Film Deposition and Experimentation Systems

Established range of experimental coating and thin-film deposition systems.

Size Based Options

**UNIVEX 250 | 400 | 600 | 900**

Ultimate Pressure

**5 x 10<sup>-3</sup> mbar**

Other offerings in the UNIVEX series include:

**UNIVEX G**  
Glove box systems

**UNIVEX C**  
Cluster tool systems

**UNIVEX S**  
Space simulation systems

**UNIVEX D**  
Dactyloscopy systems

- Configurable for almost all vacuum PVD coating processes
- Multiple deposition techniques in the same chamber
- Cleanroom compatible
- Ease of access and operation



# Ultra-High Vacuum & High Vacuum Pumps

## TiTan Ion Pumps

### PUMPING SPEED OPTIONS

Small Ion Pumps

**Mini (0.2) | 3 | 10 | 25 | 45 | 75 I/s**

Low Profile Ion Pumps

**100 | 200 | 300 | 400 | 600 | 800 | 1200 I/s**

Tall Profile Ion Pumps

**150 | 300 | 600 I/s**

Ultimate Pressure

**$<1 \times 10^{-11}$  mbar**

### Three Element Options

#### TiTan CV (Conventional)

Two titanium cathodes for high pumping speed of reactive gases

#### TiTan DI (Differential)

Combination of titanium and tantalum cathodes for stable handling of reactive & noble gases

#### TiTan TR (Triode)

Classic triode element for handling noble gases and stable operation at higher pressures



## BoostiVAC

### Titanium-Sublimation Pumps (TSP)

TSP H<sub>2</sub> Pumping Speed Options\*

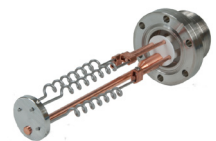
**1600 - 12,000 I/s**

\*depends on implementation of recommended cryoshroud or ambient sputter shield

Ultimate Pressure

**$<1 \times 10^{-11}$  mbar**

- Ultimate vacuum level in a short time
- Hydrocarbon-free, vibration-free vacuum conditions
- Extremely easy to implement and operate



### Non-Evaporable Getter (NEG)

NEG H<sub>2</sub> Pumping Speed Options

**50 | 100 | 200 | 300 | 400 | 400 I/s**

Ultimate Pressure

**$<1 \times 10^{-11}$  mbar**

- Compact form factor
- High and uniform pumping speed
- Reactivated without venting to atmosphere



## TURBOVAC i/iX Turbomolecular Pumps with Hybrid Bearing Technology

Helium Pumping Speed Options

**90 | 250 | 350 | 450 | 850 | 950 l/s**

Ultimate Pressure

**$8 \times 10^{-8}$  mbar (ISO-K/F variant)**

**$5 \times 10^{-10}$  mbar (CF variant)**

- Oil-free hybrid bearings
- Excellent light gas compression
- Easy to operate, compact design



## TURBOVAC MAGiNTEGRA Magnetically Levitated Turbomolecular Pumps

Pumping Speed Options

**300 | 400 | 600 | 700 | 1300 |  
1600 | 1700 | 2100 l/s**

Ultimate Pressure

**$1 \times 10^{-8}$  mbar (ISO-K/F variant)**

**$1 \times 10^{-10}$  mbar (CF variant)**

- Absolutely hydrocarbon free
- Extremely low vibration
- Maintenance free



## COOLVAC Cryogenic Pumps

Pumping Speed Options

**1500 | 2000 | 3000 | 5000 | 10000 |  
18000 | 30000 | 60000 l/s**

Ultimate Pressure

**$<1 \times 10^{-11}$  mbar**

*Basic options with remote electronics  
and/or baffles cooled using LN<sub>2</sub>*

- Hydrocarbon-free vacuum
- Completely automatic electric regeneration
- High capacity for argon and hydrogen





# Fore Vacuum Pumps

## DIVAC Diaphragm Pumps

### Pumping Speed Options

Two-stage Pumps

**0.6 | 1.2 | 2.2 m<sup>3</sup>/h**

Ultimate Pressure

**8 mbar**

Three-stage Pumps

**0.8 | 1.4 | 3.8 | 4.8 m<sup>3</sup>/h**

Ultimate Pressure

**0.5 – 3 mbar**

- Dry compressing, oil-free pump
- Portable, compact, small footprint
- Excellent for backing turbomolecular pumps



## SCROLLVAC plus Oil-free Scroll Pumps

### Pumping Speed Options

**7 | 10 | 15 | 18 m<sup>3</sup>/h**

Ultimate Pressure

**9 x 10<sup>-3</sup> mbar**

- Robust design
- Low maintenance
- High pumping speed at atmosphere



## ECODRY plus Dry Compressing Multi-Stage Roots Pumps

Pumping Speed Options

**25 | 35 | 40 | 65 m<sup>3</sup>/h**

Ultimate Pressure

**3 x 10<sup>-2</sup> mbar**

- Quietest pump in its class
- Oil and particulate free
- High water-vapor tolerance
- Excellent helium and hydrogen performance



## VARODRY Dry Compressing Screw Pumps

Pumping Speed Options

**65 | 100 | 160 | 200 m<sup>3</sup>/h**

Ultimate Pressure

**1 x 10<sup>-2</sup> mbar**

- Rust-free materials of construction
- Oil and particulate free
- Air cooled pumps



## SCREWLINE DryCompressing Screw Pumps

Pumping Speed Options

**630 m<sup>3</sup>/h**

Ultimate Pressure

**5 x 10<sup>-3</sup> | 1 x 10<sup>-2</sup> mbar**

- Possible to clean the pumps on-site
- Air cooled pumps
- Rust-free materials of construction



## DRYVAC Dry Compressing Screw Pumps

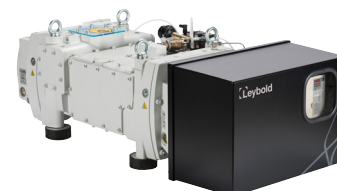
Pumping Speed Options

**300 | 450 | 650 | 1200 m<sup>3</sup>/h**

Ultimate Pressure

**5 x 10<sup>-3</sup> mbar**

- Oil-free pumping chamber
- Water cooled pumps
- Best-in-class energy consumption



## SOGEVAC

### Single-Stage Oil Sealed Rotary Vane Pumps

Pumping Speed Options

**10 | 16 | 25 | 28 | 40 | 65 | 100 |  
120 | 200 | 300 | 630 m<sup>3</sup>/h**

Ultimate Pressure

**0.05 - 1.5 mbar\***

*\*depending on the pump sub-type*

- High pumping speed also at low pressures
- Integrated exhaust filter
- Rugged design with optimum size-to-performance ratio



## TRIVAC

### Two-Stage Oil Sealed Rotary Vane Pumps

Pumping Speed Options

**2.5 | 4 | 8 | 16 | 25 | 40 | 65 | 90  
m<sup>3</sup>/h**

Ultimate Pressure

**2 x 10<sup>-3</sup> mbar**

- Extremely leak-tight (Helium capable)
- High water-vapor tolerance
- Pressure-lubricated sliding bearings



## RUVAC

### Roots Vacuum Pumps

**WA/WAU series with air-cooled  
flange-mounted motors**

Pumping Speed Options

**251 | 501 | 1001 | 2001 m<sup>3</sup>/h**

**WS/WSU series with air-cooled  
canned motors**

Pumping Speed Options

**251 | 501 | 1001 | 2001 m<sup>3</sup>/h**

**WH/WHU series with water-cooled  
hermetically sealed motors**

Pumping Speed Options

**700 | 2500 | 4400 | 7000 m<sup>3</sup>/h**

Ultimate Pressure

**As low as 1 x 10<sup>-5</sup> mbar possible.**

- Shift the operating pressure into the medium/high vacuum range
- Enhanced pumping speed in combination with appropriate FV pumps
- Wide range of options to suit specific process requirements



# Ancillary Products & Services

## TURBOLAB

### Turnkey Turbomolecular Pump Systems

Pumping Speed Options

**90 | 250 | 350 | 450 l/s**

Ultimate Pressure

**$5 \times 10^{-10}$  mbar (CF variant)**

- Completely preassembled plug-and-play system
- Compact mobile design, small footprint
- Built-in webserver for system



## LEYSPEC

### Residual Gas Analyzers

AMU Range-based Options

**VIEW 100 | 200** with and without SEM option

**ULTRA 200S | 300S**

Min. Detectable Partial Pressure

**$1 \times 10^{-14}$  mbar (View with SEM)**

**$1 \times 10^{-15}$  mbar (ULTRA with SEM)**

- Excellent AMU Range
- Direct partial pressure display feature on the unit
- Ease of operation
- Differentially pumped cart system available



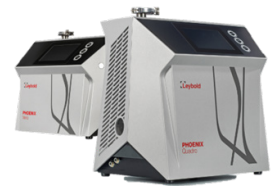
## PHOENIX

### Helium and Hydrogen Tracer Gas Leak Detection Systems

FV Pumping Based Options

**Vario | Quadro | Cart Mounted Systems**

- Vacuum and Sniffer (over pressure) leak detection capabilities
- Quick startup, measurement, and calibration process
- Wi-Fi accessible with any web enabled mobile device



## COOLPOWER Coldheads

### Pneumatically Driven

Single Stage **50 | 140i**

Lowest Attainable Temperatures  
**26 K | 15 K**

Dual Stage **7/25i | 5/100i**

Lowest Attainable Temperatures  
**1st Stage 35K | 2nd Stage 10K**

### Mechanically Driven

Single Stage **250 MDi**

Lowest Attainable Temperatures  
**25K**

Dual Stage **10 MDi**

Lowest Attainable Temperatures  
**1st Stage 28 K | 2nd Stage 8K**

- Installation possible in any orientation
- Short cool down time with no liquid refrigerants required
- Highly reliable and extremely simple to operate
- On-site displacer changes



## VACUUM MEASUREMENT Active Sensors

### CERAVAC Transmitters

Capacitance Diaphragm Gauges

Pressure Range

**Atm to  $10^{-5}$  mbar**

- Extremely accurate and reliable forevacuum pressure measurement
- Simple, cost and space-saving installation
- Smart monitoring and control



### THERMOVAC Transmitters

Thermal Conductivity Gauges

Sensor Type Based Options

**Pirani | Capacitance  
Diaphragm-Pirani**

Pressure Range

**Atm to  $10^{-5}$  mbar**

- Simple, cost-effective and robust sensors
- Suited for heavily contaminated environments
- Smart monitoring and control



### PENNINGVAC Sensors

Cold Cathode Ionization Gauges

Pressure Range

**Atm to  $10^{-9}$  mbar**

- Robust, easy-to-maintain design
- Excellent response time
- High reproducibility and high accuracy



### IONIVAC Transmitters

Hot Cathode Ionization and  
Pirani-based Combination Gauges

Pressure Range

**Atm to  $5 \times 10^{-10}$  mbar**

- Single transmitter covering 13 decades of pressure
- Simple, compact, rugged design in a metal housing
- Model with built-in display for stand-alone operation available



## VACUUM MEASUREMENT

### Passive Sensors

#### THERMOVAC Sensors

Thermal Conductivity Gauges

Pressure Range

**Atm to  $5 \times 10^{-4}$  mbar**

- Cost-effective sensing cell
- Tungsten or platinum filament
- Fully aligned and temperature compensated



#### PENNINGVAC Sensors

Cold Cathode Ionization Gauges

Pressure Range

**$10^{-2}$  to  $10^{-9}$  mbar**

- Robust, fast acting, easy to maintain
- Insensitive to air inrushes and vibrations
- Exchangeable cathode plate



#### IONIVAC Sensors

Hot Cathode Ionization Gauges

Collector type based options

**Bayard-Alpert | Extractor**

Pressure Range

**$10^{-2}$  to  $2 \times 10^{-11}$  mbar (Bayard-Alpert)**

**$10^{-4}$  to  $10^{-12}$  mbar (Extractor)**

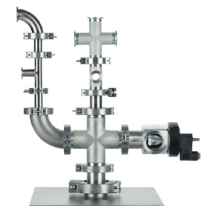
- High accuracy due to individually calibrated sensing system
- Suitable for most demanding applications
- Bakeable models for radiation environment



## Hardware, Valves and Fittings

From atmosphere to UHV, Leybold also offers a complete range of valves, hardware, and fittings with all possible flange types.

- Almost every connection possible to facilitate constructions of any vacuum system
- Support with design and selection
- All components are subjected to helium leak testing



Please see Leybold's catalog for complete product details.

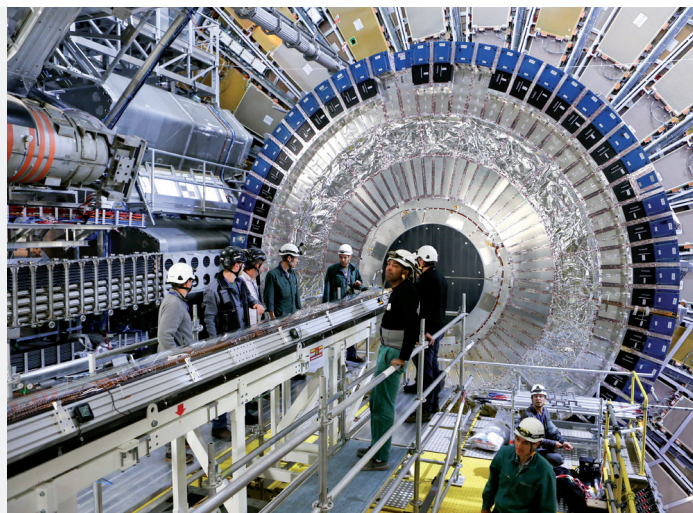


Image descriptions, from top left to bottom right: Particle Accelerator; Mauna Kea Observatory in Hawaii; Large Hadron Collider at CERN; Satellite in Orbit; Scientist Examining a Component Fabricated Using Advanced Metal Alloy.

## Leybold Offers a One-Stop Solution

From replacing a single vacuum pump to custom designing highly complex, modular UHV systems, Leybold is the go-to partner of research scientists and physicists around the globe.

Leybold's product line also features a complete range of vacuum pump flanges and fittings. For more details on our entire line of vacuum equipment and ancillary products, please download our product catalog.



Pioneering products. Passionately applied.

[www.leybold.com](http://www.leybold.com)