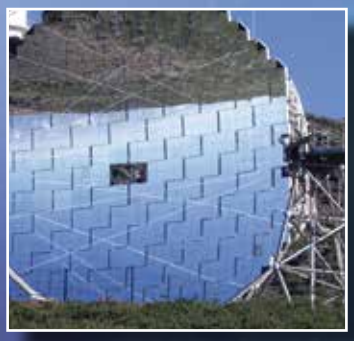
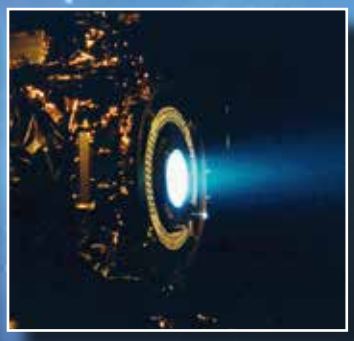
Leybold

Cryogenics
Vacuum Systems for Space Applications





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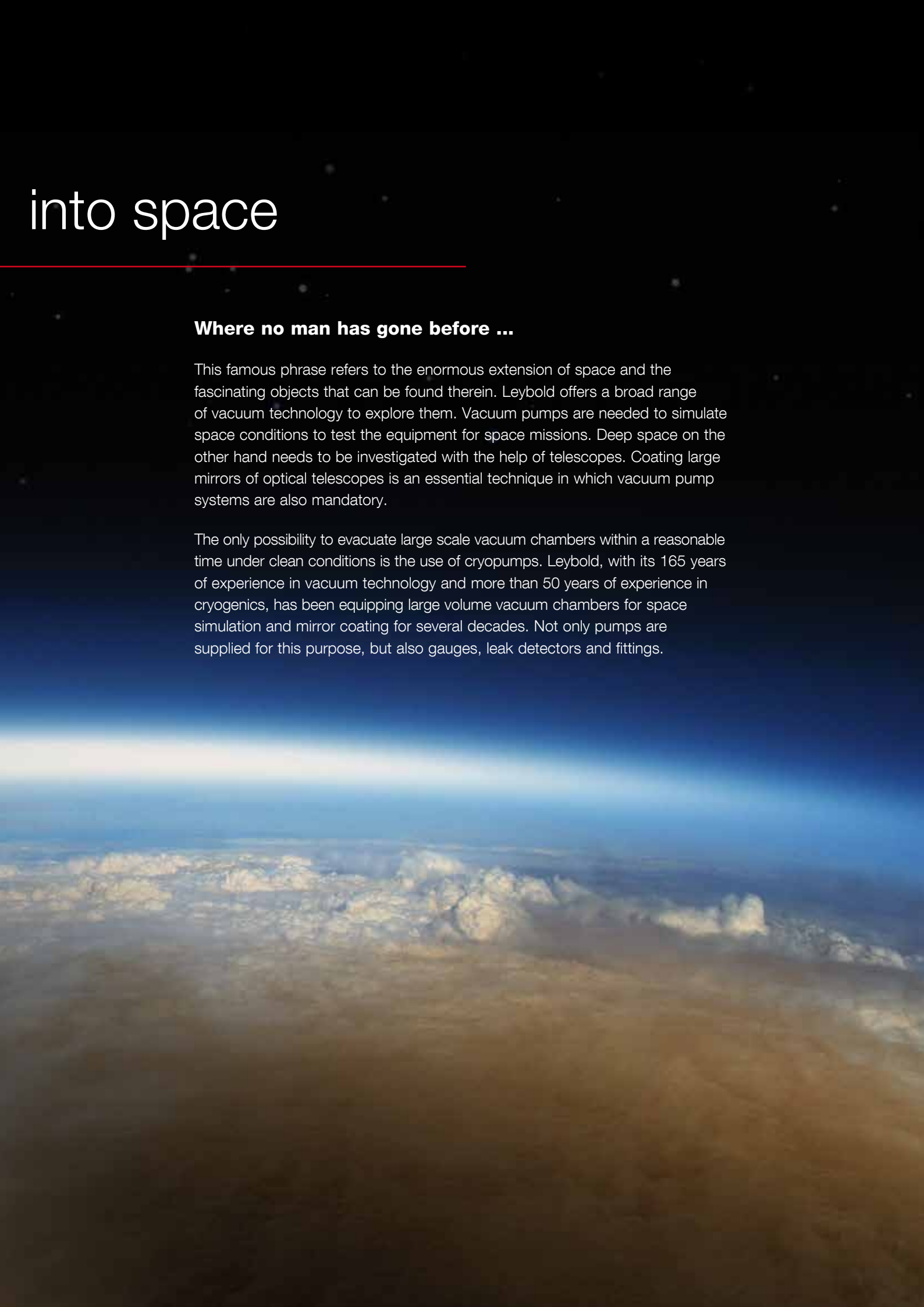
Take a look

into space

Where no man has gone before ...

This famous phrase refers to the enormous extension of space and the fascinating objects that can be found therein. Leybold offers a broad range of vacuum technology to explore them. Vacuum pumps are needed to simulate space conditions to test the equipment for space missions. Deep space on the other hand needs to be investigated with the help of telescopes. Coating large mirrors of optical telescopes is an essential technique in which vacuum pump systems are also mandatory.

The only possibility to evacuate large scale vacuum chambers within a reasonable time under clean conditions is the use of cryopumps. Leybold, with its 165 years of experience in vacuum technology and more than 50 years of experience in cryogenics, has been equipping large volume vacuum chambers for space simulation and mirror coating for several decades. Not only pumps are supplied for this purpose, but also gauges, leak detectors and fittings.



Coating telescope mirrors

Nowadays, mirrors of high-performance telescopes have diameters of several meters and are usually produced using coating techniques in large vacuum chambers.
One example is the 8 m mirror at the Gemini telescope on Mauna Kea (Hawaii). It is not feasible to transport big mirrors to the enhanced altitudes where most of the optical telescopes are situated. Thus, big mirrors must be coated on site. Due to environmental influences, further re-coating – usually with aluminum or silver – is necessary every 1 to 2 years.
At the Gemini telescope, this is performed in a 150 m^3 vacuum chamber by magnetron sputtering using three large cryopumps COOLVAC 30.000 reaching a base pressure of 10^{-6} mbar within 6 hours.

The COOLVAC series is equipped with original Leybold pneumatic and mechanic cold heads. The cold heads are not only used for cryopumping, but for any application that requires cryogenic temperatures such as the cooling of sensor chips in telescopes.

Low temperatures reduce the thermal noise and allow for high resolution pictures. This way, telescopes benefit twice from the use of cold heads: by mirror coating and by sensor cooling.

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Unusual conditions demand

Preparing for space missions

If space equipment fails during a mission, it is nearly impossible to fix it. Such a failure would trigger astronomical costs and hence producers of space equipment are making a big effort to test their products as long as they are on earth. Space travel, scientific and commercial satellites, as well as extraterrestrial research can only be successful if all materials, components and devices involved are successfully tested under high-vacuum conditions. Extreme temperatures in space often range from -200°C to +150°C. All products for space missions must withstand these conditions.

Space simulation chambers are equipped with vacuum pumps and a shroud to thermally decouple the test equipment from the surroundings. Electrical heaters inside the chamber simulate the temperature conditions in space. The vacuum equipment must resist the resulting heat radiation. A high tolerance against this influence is provided by the COOLVAC series which consists of cryopumps with the highest thermal stability on the market.

The required pumping speed of a vacuum system is determined by several parameters like chamber size, desorption rates, or utilized materials. In addition, the sealings define the total leak rate which limits the reachable ultimate pressure.
When process gases are used, the desired working pressure is crucial.
Depending on these requirements, Leybold configures an appropriate vacuum system consisting of cryopumps, turbomolecular pumps and corresponding forevacuum pumps.

Carlos III, Madrid, Spain

unusual solutions

Optimized solution for ion thruster testing

Today, electrical propulsion is the keyword for the movement of space crafts beyond our atmosphere where the high vacuum of space is entered. In comparison to chemical propulsion systems, electrical propulsion has the advantage that the thruster material does not need to resist high temperatures. Electrical propulsion uses ionized particles, usually xenon, which are accelerated by an electric field. Xenon has the highest mass of all stable noble gases. Thus, it produces a large thrust per particle.

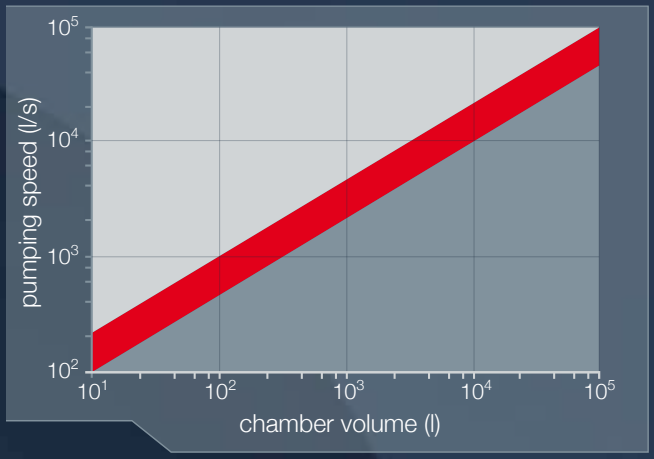
State-of-the-art xenon thrusters emit a gas flow of 0.1 to 10 mg/sec. In order to maintain a high vacuum pressure at this flow in thruster test chambers, a large pumping speed is required, often in the range of 10,000 to 100,000 l/s for xenon. The benefit of a large mass for propulsion on the one hand is an enormous challenge for vacuum pumps on the other hand.

Leybold has developed an optimized and simple cryogenic solution for xenon pumping. A COOLPOWER 140 T cools a metal disc down to cryogenic temperatures which freezes solid xenon to this cryopanel. This solution supplies a nominal pumping speed of more than 10,000 l/s for xenon. Prior to the thruster test, a high vacuum is usually supplied by turbomolecular pumps and dry forevacuum pumps. During the thruster test, they remove gases, e.g. from external leaks, which cannot be removed by the cryopanel as this is at a temperature that is optimized for the pumping of xenon gas.

Leybold can equip chambers of different sizes with appropriate systems

chamber size in m^3	COOLVAC 3.000	COOLVAC 10.000	COOLVAC 30.000	COOLVAC 60.000	LEYVAC 80	LEYVAC 250	DRYVAC 650	DRYVAC 5.000 * with additional roots stage
3 m^3	1				1			
10 m^3		1				1		
30 m^3			1				1	
100 m^3				1				1
1.000 m^3				2				2
3.000 m^3				4				4 *

Typical configuration for space simulation chambers of different sizes. The actual pump configuration can be adapted if required by the application.



Empirical diagram which describes the required pumping speed for a space simulation chamber depending on its size.

A full-range vacuum supplier

Leybold has a broad portfolio of COOLVAC cryopumps in the range between 1,500 l/s and 60,000 l/s pumping speed for nitrogen. Not only is the vacuum completely oil-free, but a major advantage of this type of pumps is their large pumping speed for water vapor. The largest cryopumps can also be equipped with liquid nitrogen connections to cool the pump's heat radiation shield. This way, several built-in cold heads and their supplying compressors can be omitted and costs can be saved. Of course, „dry" solutions with fully automatic control electronics are also available.

As a full liner, Leybold also supplies the appropriate forevacuum pumps – if required with control system – for space simulation chambers. Experienced application engineers configure the full vacuum system and work out the important parameters such as pump down time.

Additionally, Leybold delivers leak detectors and vacuum gauges – if required with calibration in own labs. Upon request, installation and service support is supplied by the worldwide service network as well as customer training by the renowned Leybold Vacuum Academy.

Vacuum Components for Space Applications

COOLVAC
Cryopumps

COOLVAC vacuum pumps are refrigerator cryopumps which generate a vacuum when gaseous substances are bound to the cold surfaces within the pump by means of cryocondensation. Thanks to the pumping principle, COOLVAC cryopumps have a high effective pumping speed for all gases.

RUVAC WH
Roots Blowers

RUVAC WH Roots pumps attain high pumping speed and best ultimate vacuum with maximum safety in modern industrial applications.
The smart design of the pumps combines highest robustness with the most compact roots pump design on the market. Operation with frequency converter optimizes the power consumption and protects the roots pump against thermal overloads.

DRYVAC
Screw Vacuum Pumps

The DRYVAC is a new family of dry compressing vacuum pumps. Depending on the application the pumps are available with various equipment components. All versions of the DRYVAC family are water cooled, very compact and can simply be integrated into various pumping systems.

LEYVAC
Screw Vacuum Pumps

This new pump series shows an outstanding pumping speed, also in the high pressure area similar to oil-sealed vacuum pumps. Their robustness, dust compatibility and thermal monitoring capabilities of the motor and pump casing ensure high process reliability.

TURBOVAC MAG
Turbomolecular Pumps

Smaller space simulation chambers with volumes of 1 m^3 or less are evacuated by large turbomolecular pumps like MAG W 2800 or MAG W 2200 iP. In very large chambers these turbomolecular pumps are often used to evacuate chambers to the starting pressure of the cryopump in a fast and cost effective way.

Vacuum gauges
and controllers

A broad range of vacuum gauges measuring from 10^{-12} to 1500 mbar is available. These are either active gauges with integrated electronics or passive gauges using a 19” rack controller. The gauges can be equipped with different interfaces to communicate with control systems. The latest development is the unique GRAPHIX controller with touch screen operation. All gauges can be delivered with calibration certificates by Leybold calibration labs.

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