



Technical Information

Linear Encoders for Vacuum Technology

The word "vacuum" is used to describe an empty space, meaning a volume not filled with air or any other gas. A vacuum is classified as a rough, fine, high or ultrahigh vacuum, depending on its purity.

Vacuum technology plays a significant role in many modern production procedures and research tasks. Procedures using vacuum technology have become indispensable in the electronics industry and biotechnology, in thin-film deposition technology, in the development of new materials, and in medicine and analytical technology.

The components used in a vacuum are subject to especially high demands, which of course also affect the encoders necessary for the positioning tasks. The linear encoders created by HEIDENHAIN specifically for use in high and ultrahigh vacuums satisfy these demands with their specialized design measures:

- Vacuum-compatible PCBs, adhesives and paints reduce the amount of outgassing
- Vented hollow spaces reduce the pumping time
- Temperature resistance permits high heating temperatures
- Doing without ferromagnetic materials increases the process reliability
- Production in a clean room guarantees the highest degree of cleanliness

Vacuum classes

When air is removed from an enclosed space, it gets thinner and, as a result, exerts less pressure: a vacuum has been generated. The smaller the amount of air in an enclosed space, i.e. the lower the pressure, the higher the resulting vacuum is classified. There are four classes of vacuum. An atmospheric pressure above 1 mbar is called a **rough vacuum**; below 1 mbar one speaks of a **fine vacuum**. A vacuum below 0.001 mbar is a **high vacuum**, and at 0.0000001 mbar or less it is called an **ultrahigh vacuum**.

Vacuum	Pressure in mbar	Height in km from earth's surface	Mean free path in m without collision of two gas molecules	Time in s for covering a surface with particles
Rough	$10^{+3} \dots 1$	< 50	$< 10^{-5}$	$< 10^{-5}$
Fine	$1 \dots 10^{-3}$	50 ... 100	$10^{-5} \dots 10^{-1}$	$10^{-5} \dots 10^{-2}$
High	$10^{-3} \dots 10^{-7}$	100 ... 500	$10^{-1} \dots 10^{+3}$	$10^{-2} \dots 10^{+2}$
Ultra high	$< 10^{-7}$	> 500	$> 10^{+3}$	> 100

Applications for encoders in a vacuum

A vacuum in the sense of enclosures free of air and therefore also of suspended particles is required wherever the presence of "foreign" particles must be prevented. In some cases, dimensional measurements are required within the area of a vacuum, for example if very fine

structures must be inspected in the submicron range or particles must be split and examined. Widely known applications for linear and angular encoders in a vacuum include electron microscopes,

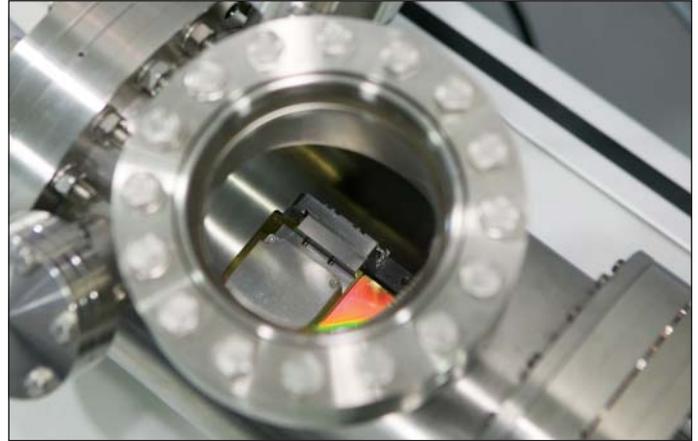
manipulators, multiple actuators, X-Y tables, cathode-ray microscopes, wafer inspection in the semi-conductor industry, or spectrometer axes for measuring synchrotron radiation.

Requirements for encoders in a vacuum

Our standard encoders are suitable for use in a rough or fine vacuum. Encoders used for applications in a high or ultrahigh vacuum need to fulfill special requirements.

Low amounts of gas exhalation

One precondition for encoders used in vacuum applications is that outgassing is kept to a minimum, since otherwise the pressure in the vacuum chamber might increase excessively. In an ultrahigh vacuum, every component is critical. For example, some synthetic materials such as are contained in printed circuit boards, adhesives, or coating materials exhale solvents and must be avoided in devices intended for a high vacuum. HEIDENHAIN uses PCBs and adhesives suited to vacuum applications. The usual paints have been replaced by materials appropriate for vacuum technology. In ultrahigh-vacuum environments, the number of components must be kept to a minimum — interface and pulse-shaping electronics must be positioned outside of the vacuum chamber. HEIDENHAIN therefore offers encoders with external interfacing hardware. For high-vacuum applications, interfacing hardware within the vacuum chamber is available as an option.



Proper ventilation of hollow spaces

To generate a vacuum, the air must be removed from an enclosed space. The time needed for attaining the required low pressure, referred to as “pumping time,” should be kept to a minimum in order to enable the vacuum system to start working as soon as possible. The pumping time is reduced if the air can escape rapidly from the hollow spaces. Therefore, the encoder housings are provided with additional air vents, blind threaded holes are opened, and air vents are drilled into hollow spaces.

No ferromagnetic materials

Depending on the processes in the vacuum chamber, the use of certain materials in the encoders may not be permitted. Ferromagnetic materials must not be used in cathode-ray microscopes for examining microelectronic circuits. Vacuum-technology encoders from HEIDENHAIN are therefore made of non-magnetizable materials.



High resistance to temperature

To further reduce pumping time and attain a high class of vacuum, the vacuum chamber is heated to 100 °C or more. As a result, water molecules clinging to the encoder housing vaporize and can be pumped out more rapidly. Encoders for use in a vacuum must therefore be designed for temperatures of 100 °C and more.

High degree of cleanness

Encoders used in a vacuum chamber must be specially cleansed and exceptionally clean. Most types of lubricants and oils, even fingerprints, emit gases in a vacuum and must be avoided. Otherwise, very fine particles or dust might be set free and, for example, destroy the microelectronic circuits to be examined, or influence the results of experiments. Consequently, our encoders must fulfill specific requirements with respect to cleanliness, the manufacturing process, and proper packaging. HEIDENHAIN manufactures its vacuum-compatible encoders in a clean room. The packaging is also specially designed. The encoder is doubly enclosed and the package is flushed with nitrogen before sealing.

Electrical connection

HEIDENHAIN encoders are equipped with connectors for vacuum housing lead-throughs. The linear encoders of the LIP and LIF series require interface electronics for signal conversion to 1 V_{PP}. This interface unit is located in the D-sub connector that connects directly with the encoder for high-vacuum applications and must be located outside the vacuum chamber for ultrahigh-vacuum applications. The LIP and LIF for high vacuum are therefore available with two cable versions. The cable between the scanning head and interface electronics can be up to 3 meters in length.



Vacuum-compatible housing lead-throughs

Vacuum-Compatible Encoders

The vacuum-compatible encoders from HEIDENHAIN were derived from standard units and modified. However, only the original scanning principle, optoelectronic and optical components have remained intact. The housing, PCBs, adhesives and coatings have been adapted to the requirements of the vacuum class.

The following specialized measures characterize HEIDENHAIN encoders for use in a vacuum:

- Nonmagnetizable materials (except LED housing)
- Laser inscription instead of labels
- Air vents
- Special coating

- Production in a clean room
- Specialized cleaning and packaging
- Cable with PTFE insulation and silver-plated copper braiding



LIP 481V

	For high vacuum to 10^{-7} mbar		For ultrahigh vacuum up to 10^{-11} mbar
	LIF 481V	LIP 481V	LIP 481U
Measuring lengths*	70 mm to 1020 mm	70 mm to 420 mm	70 mm to 420 mm
Accuracy*	$\pm 3 \mu\text{m}$	$\pm 1 \mu\text{m}, \pm 0.5 \mu\text{m}$	$\pm 1 \mu\text{m}; \pm 0,5 \mu\text{m}$
Output signals	$\sim 1 \text{V}_{\text{PP}}$		
Signal period	4 μm	2 μm	2 μm
Graduation-carrier material*	<ul style="list-style-type: none"> • Zerodur glass ceramic $\rho_{\text{therm}} \approx 0 \text{K}^{-1}$ • Glass $\rho_{\text{therm}} \approx 8 \cdot 10^{-6} \text{K}^{-1}$ 		
Bake-out temperature	100 °C		120 °C
Special characteristics	–	<ul style="list-style-type: none"> • Low power consumption • Heat dissipation via housing 	
PCB material	FR4	Ceramic	Ceramic
Adhesives	Standard	Ultrahigh vacuum compatible, temperature resistant	Ultrahigh vacuum compatible, temperature resistant
Cables, connectors	<ul style="list-style-type: none"> • High-vacuum-compatible round plug connection, 16-pin (APE in air) • Option: interface electronics integrated in connector (APE in vacuum) 		UHV-compatible plug connection without feedthrough (APE in air)

* Please indicate when ordering



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For further information

- *Exposed Linear Encoders* brochure

