HEIDENHAIN

Technical Information

Linear Encoders for Vacuum Technology

Vacuum is a space entirely devoid of matter, i.e. a volume not filled with air or another gas.
A vacuum is classified as a low, medium, high or ultrahigh vacuum, depending on its purity.

Vacuum technology plays a major role in many modern production processes and research tasks. Vacuum technology has therefore become indispensable in electronics, thin film technology, the development of new materials, biotechnology, as well as medical 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 designed 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

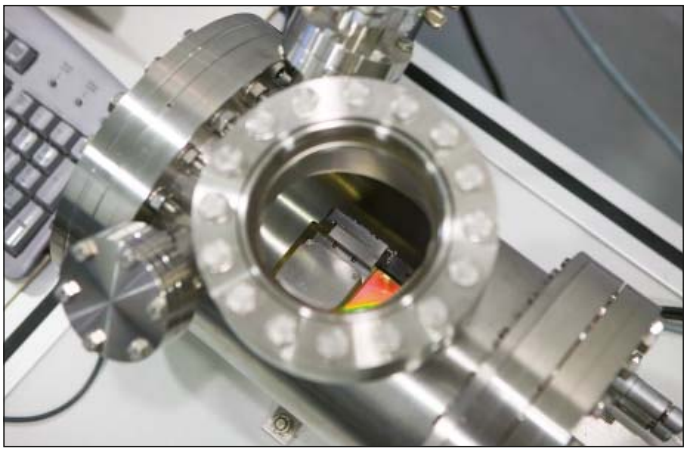
Vacuum classes
When air is pumped out of a sealed space, it becomes airless. The air in the room becomes thinner, the pressure drops, and a vacuum is created. The smaller the amount of air in an enclosed space, i.e. the lower the pressure, the higher the resulting vacuum is classified. There are four classes of vacuum. Pressure above 1 mbar is called a **rough vacuum**. Below that, it becomes a **fine vacuum.** A vacuum below 0.001 mbar is a **high vacuum,** and at 0.000 000 1 mbar or less it is called an **ultrahigh vacuum**.

Vacuum	**Pressure** *in mbar*	**Height** *in km* above sea level	**Mean free path** *in m* without collision of two gas molecules	**Time** *in s* for covering a surface with particles
Rough	10^{+3} to 1	< 50	$< 10^{-5}$	$< 10^{-5}$
Medium	1 to 10^{-3}	50 to 100	10^{-5} to 10^{-1}	10^{-5} to 10^{-2}
High	10^{-3} to 10^{-7}	100 to 500	10^{-1} to 10^{+3}	10^{-2} to 10^{+2}
Ultrahigh	$< 10^{-7}$	> 500	$> 10^{+3}$	> 100

Vacuum applications
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 angle encoders in a vacuum include electron microscopes, manipulators, multiple actuators, XY tables, e-beam microscopes, wafer inspection in the semi-conductor industry, or spectrometer axes for measuring synchrotron radiation.

Requirements for encoders in a vacuum
Standard encoders from HEIDENHAIN are suitable in a limited temperature range 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. Some plastics, for example, exhale solvents. Such plastics are contained in printed circuit boards, adhesives, or coating materials and should be completely omitted in devices intended for an ultrahigh vacuum. HEIDENHAIN uses PCBs and adhesives suited to vacuum applications. The usual paints have been replaced by materials appropriate for vacuum technology. For application in ultrahigh vacuum, the number of components must be reduced to a minimum— interface and pulse-shaping electronics must be located outside of the vacuum chamber. HEIDENHAIN therefore offers encoders with external interfacing hardware. For high-vacuum applications, one option is to place the interfacing hardware within the vacuum chamber.



Proper ventilation of hollow spaces
To generate a vacuum, the air must be removed from a sealed 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. HEIDENHAIN encoder housings are therefore provided with additional air vents, blind threaded holes are opened, and air vents are drilled into hollow spaces.

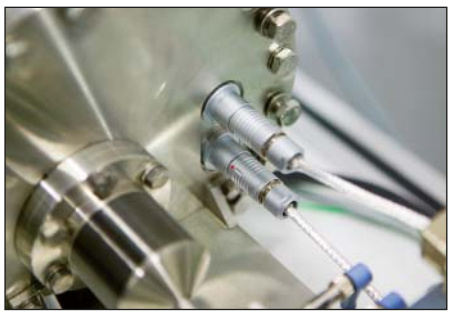
Avoidance of ferromagnetic materials
Depending on the processes in the vacuum chamber, the use of certain materials in the encoders are not be permitted. Ferromagnetic materials must not be used in cathode-ray microscopes for examining microelectronic circuits. The measuring standards and scanning heads of vacuum-technology encoders from HEIDENHAIN are therefore made of non-magnetizable materials. Only the interface electronics contain ferromagnetic materials. HEIDENNHAIN therefore offers encoder variants in which the interface electronics can be placed outside the vacuum.

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 greases and oils, even fingerprints, exude gases in a vacuum and are therefore not permissible. 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. The interface electronics can be installed directly on the device for high vacuum applications. For ultrahigh-vacuum applications, the interface electronics must be outside the vacuum chamber. 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 accordingly. However, only the original scanning principle, opto-electronic 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:

- No magnetizable 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 to 10^{-11} mbar
	LIC 4113V/LIC 4193V	**LIF 481V**	**LIP 481V**	**LIP 481U**
Measuring lengths*	240 mm to 3040 mm[1)]	70 mm to 1020 mm	70 mm to 420 mm	
Accuracy grade*	± 1 µm (Robax); ± 3 µm; ± 5 µm	± 3 µm	± 1 µm; ± 0.5 µm	
Interface	EnDat 2.2; Fanuc α_i; Mitsubishi; Panasonic	∿ 1 V_{PP}		
Signal period	–	4 µm	2 µm	
Graduation-carrier material*	• Robax glass ceramic $\alpha_{therm} \approx (0 \pm 0.5) \cdot 10^{-6}\ K^{-1}$ • Glass	• Zerodur glass ceramic $\alpha_{therm} \approx 0\ K^{-1}$ • Glass $\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$		
Baking temperature	100 °C			120 °C
Special features	–		• Low power consumption • Heat dissipation via housing	
PCB material	–	FR4	Ceramic	
Adhesives	Default		Ultrahigh vacuum compatible, temperature resistant	
Cables, connectors	• High-vacuum-compatible D-sub connector (male), 15-pin	• High-vacuum-compatible round connector, 16-pin (APE in atmosphere) • Option: interface electronics integrated in connector (APE in vacuum)		UHV-compatible plug connection without feedthrough (APE in atmosphere)

* Please select when ordering

[1)] Robax glass ceramic for up to 1640 mm measuring length

Robax is a registered trademark of Schott-Glaswerke, Mainz, Germany.

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Further information:

- Brochure: *Exposed Linear Encoders*
- Product Information: *LIF 481V*
- Product Information: *LIP 481V/U*
- Product Information: *LIC 4113V/LIC 4193V*

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