MECOS Magnetic Bearing Technology
for turbomachinery in oil & gas application

Modern turbomachinery for oil & gas applications, such as hermetically sealed compressors with integrated electric motor or turboexpander drives, requires the use of magnetic bearing systems.

Together with MECOS, MAN Diesel & Turbo provides state-of-the-art magnetic bearing solutions for oil & gas applications.

MECOS has extensive experience with digitally controlled magnetic bearing systems. Our experience with leading OEMs in the oil & gas and other markets (such as semicon industry, high-power lasers), enables us to understand today's requirements and to provide solutions for tomorrow. Whether superior digital control, proven upstream gas technology or leading user interfaces, MECOS can provide the perfect magnetic bearing solution.

Main features of MECOS AMB technology	Main advantages of MECOS AMB technology
▪ Modular control cabinet architecture	▪ Supports systems with up to 9 axes from a single cabinet
▪ Advanced amplifier control	▪ High dynamic control ▪ Stable rotor system under surge conditions
▪ Most advanced processor board with high computation power and sophisticated control algorithms	▪ Low noise, stable systems
▪ Remote monitoring support capability	▪ Enables preventative maintenance ▪ Short response time for first-level troubleshooting
▪ Fully integrated robustness assessment capability according to ISO 14839	▪ No additional measurement equipment required, short commissioning and downtime
▪ Software tool for field balancing of completely assembled machines	▪ Reduces pre-balancing requirements ▪ Increases quality of balancing
▪ Fully digital signal processing and control ▪ Superior PC tools for online measurement and postprocessing	▪ High flexibility, easy adaptation to changing turbomachinery duties ▪ All sensor parameters are adjusted/optimized by means of the digital controller, no hardware adaptations necessary ▪ Massively reduced commissioning time

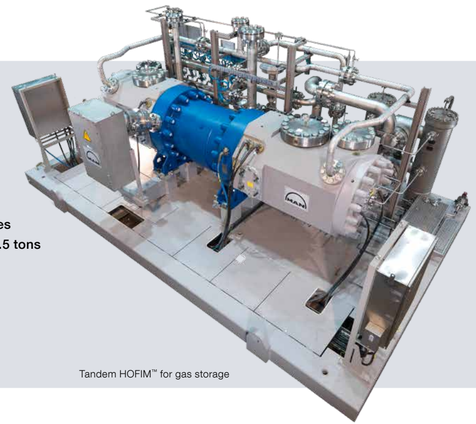
Application Examples

Compressor

Large gas compressors for pipeline and storage application

All power level classes of HOFIM™/ MOPICO® compressor types

- **Multistage compressors**
- **AMB systems for control of up to 9 axes**
- **Typical rotor weights between 2 and 3.5 tons**
- **Rotational speed up to 12.000 rpm**



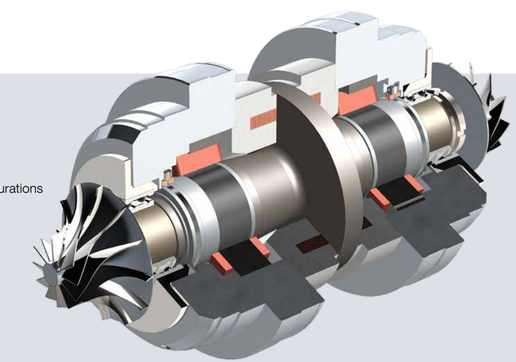
Tandem HOFIM™ for gas storage

Turboexpander

Large turboexpanders for the oil & gas and petrochemical industry

Designed typically for natural gas treatment or pressure-let-down (PLD) applications in configurations such as expander/compressor, expander/ generator or expander/brake.

- **Power range of up to 10 MW**
- **High compressor/expander system power densities**
- **Compact design**



Compressor/expander with AMB for cryogenic applications, including natural gas, petrochemical, and air separation

Control Cabinet Family MBX10/20

The MBX10/20 is a high-power, state-of-the-art control system cabinet designed for turbomachinery magnetic bearing systems. With its high supply voltage and advanced digital control architecture, it is the industry's most dynamic control cabinet in this class.

In the basic configuration, the MBX10/20 controls 5-axes machines. Due to its modular design it can easily be extended to 7- or to full 9-axes control and therefore drive turbomachines with up to 4 radial and one thrust bearing.

Advanced controller functions

Fully digital controller
The MBX10/20 features a very powerful, digital multi-core control system.
For high robustness and ultra low noise, the sensor signals are processed fully digitally. As a result, the MBX10/20 is highly insensitive to external electrical disturbances.
To provide the best dynamics, the power amplifiers are also controlled by the digital controller which allows for compensation of bearing non-linearity.

Superior vibration reduction
The main source of machine vibration and noise is the residual unbalance of the rotor as well as higher harmonic sensor disturbances induced e.g. by scratches on the sensor targets. The MBX10/20 offers different control strategies to reduce the level of vibrations resulting from the named sources.

- Adaptive tracking filters minimize synchronous forces due to unbalance (UFRC).
- Unbalance force counteracting control (UFCC) is essential for crossing bending criticals.
- Open-loop runout compensation filters are used to cancel out higher harmonic disturbances and to avoid potential amplifier saturation.

- **Industry's most dynamic cabinet in its class**
- **Reactive power of 20 kVA per channel, maximum 18 channels**
- **Recommended for machinery up to 20 MW**
- **Flexible system interface options: PROFIBUS, Modbus RTU/TCP, etc.**
- **Remote access via Ethernet**
- **Sensor interface: inductive or eddy current position probes, current sensors, voltage measurement**

Monitoring and supervision
The MBX10/20 features versatile monitoring and supervision capabilities to protect the machine and the control cabinet from excessive load and damage.
- Supervision limit values are set according to customer requirements.
- Advanced trip data logging. Each trip event triggers not only the storage of the current system state but also data recorders at different sampling rates.

- Supervision of rotor elongation caused by thermal expansion (redundant axial position sensor).

Highly efficient service interface
The key to short commissioning times and unmatched dynamic identification capabilities, is the service and measurement interface to the MBX10/20. Installed on a remote PC, it allows for multivariable transfer function and signal spectra measurements.
Furthermore, these functions allow the system dynamics to be identified, compared with previous rotordynamic modelling and optimized prior to rotation as well as during rotational testing.
These capabilities eliminate the need for bulky dynamic signal analysis equipment on site. The robustness assessment of the control system according to ISO 14839 is virtually built into the system.

Magnetic Bearing System

Bearing Components

MECOS offers a very robust magnetic bearing design. Based on our extensive experience with high-volume applications in many different fields, MECOS can provide bearing components in standard, molded or liquid-proof technology.

- FE-optimized magnetic design and minimized eddy currents.
- High-load capacity up to 30 kN radial and 80 kN thrust.
- Validated by force measurements.
- No use of non-ferrous metals in order to increase insensibility to gas residues in pipelines (e.g. glycol).
- Vacuum pressure impregnation (VPI) for use in harsh environments (e.g. sour-gas environment).

Sensors

Reliable sensor technology is fundamental to Active Magnetic Bearing systems. Accurate and highly dynamic sensors are the basis for position control. Measurement of the rotational speed is needed to implement speed-dependent control parameters and supervision limits.

Extensive experience in sensor electronics and signal processing helped us establish our leading position: Due to the digital signal processing, all sensor parameters (excitation signals, demodulation circuits) are adjustable by software. No hardware modifications are required during tuning and therefore commissioning time is greatly reduced.

- Inductive or eddy current type.
- 4 sensed channels in one sensor unit (3 displacements, 1 rotation) spare pulse sensor.
- Low noise and high resolution design. Integrated shielding against external magnetic fields.
- Signal quality is independent of cable length. Cable lengths of up to 300m and more. No impedance conversion necessary.
- Rugged design scalable in size. Qualified for harsh environments, such as sour gas environments.

Sour-gas-proven technology

Based on thousands of hours of industrial operational experience with the materials used in our bearings, MECOS can offer active magnetic bearings for wet and sour gas applications. The selected bearing materials thus complement compressor, expander, and/or motor material selection for integrated wet and sour gas rotating equipment solutions.

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MECOS
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for turbomachinery in oil & gas applications

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LEADERS IN MAGNETIC BEARINGS

Engineering the Future – since 1758.
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