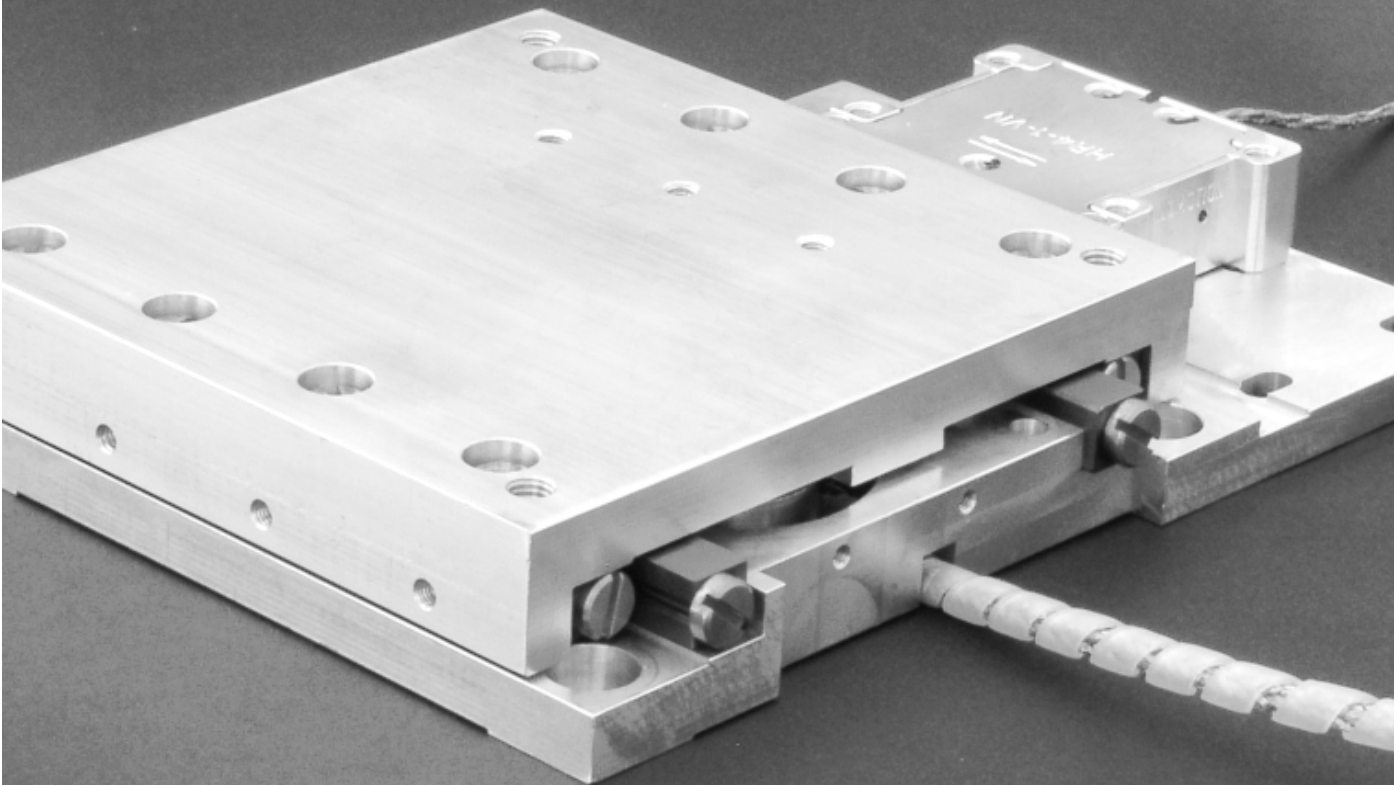


Non-Magnetic Stages

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Non-Magnetic Stages

Motion Systems Meet Demanding Requirements

“Non-magnetic” is a key characteristic in certain applications. But what does “non-magnetic” really mean? This article explores the details and describes ways to meet such requirements.

Demand for non-magnetic stages has increased steadily over the past years. Such systems are used in life science applications as well as microelectronics and nanotechnology. Depending on the nature of the application, the motion system’s magnetic field must either be very weak so it does not interfere with measurements taken in the outside magnetic field, or the system is subjected to very strong outside magnetic fields, and non-magnetic properties of the stage are necessary to keep the forces generated inside the system low enough to ensure proper operation within specification.

It’s not just the question “how magnetic is non-magnetic?”

The main issue when designing non-magnetic motion systems is certainly material selection. Magnetic properties represent an additional specification besides those that are already necessary in standard motion systems. For example, linear and rotary bearings as well as ball

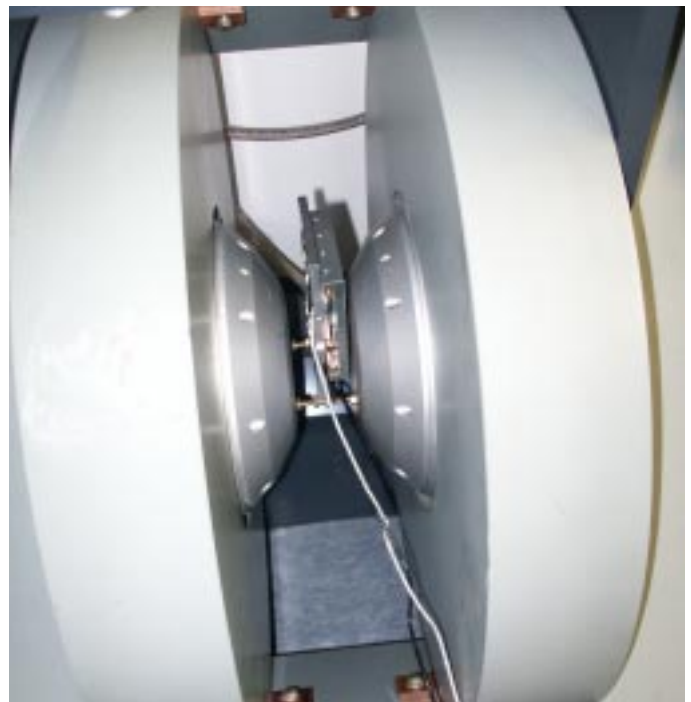
Applications requiring very low system-inherent magnetism (<1 mG):

Ion beam lithography
Electron beam lithography
Electron beam inspection
Electron microscopy

Application with high magnetic fields:

Material inspection
Magnetic resonance imaging

The non-magnetic version of an MT105-50 stage between the magnets of a magnetometer, being tested at a flux density of 2.5 Tesla. It performed normally.



screws must have a certain hardness at their load bearing surfaces, and to a certain depth. Normally, steel is used for such components, since it can be hardened and offers all other mechanical properties necessary for rolling contact with high localized stress. But steel is generally magnetic, and even stainless steel, which is normally seen as “non-magnetic”, may have still enough remaining magnetism to cause trouble in certain applications.

Of course, once a suitable material has been found, it then has to be processed with the necessary precision, because such motion systems are very often used to execute moves with extreme accuracy and repeatability. This poses another problem, since materials that meet all requirements of the application are often hard to ma-

chine with the necessary precision, or they are prohibitively expensive. Unfortunately, they are often both!

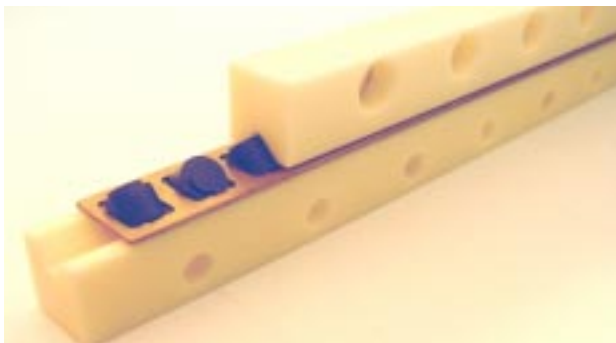
Besides material selection, designers also have to deal with possible interference of external magnetic fields by motor, encoder and other electronic systems used to drive and control the stage. It is obvious that the object is not just answering the question “how magnetic is non-magnetic?”, but also ensuring that each component and the whole system performs to its specifications.

This often requires extensive testing with the system exposed to magnetic fields. Even lubricants can bear surprises! Stages to be used in weak magnetic fields normally use stainless steel components. For example, linear bearings made from

► **Non-Magnetic Stages**

stainless steel normally have a magnetic field of less than the Earth's magnetic field (0.35 Gauss or 3.5×10^{-5} Tesla). If the process measurement sensors have resolutions of this magnitude or above, then using stainless steel components is generally acceptable. Even electron beam applications in vacuum with sensor resolutions below the Earth's magnetism are possible with stainless steel components.

■ *Ceramic cross-roller linear bearings made by PM Bearings. The ceramic material is not just non-magnetic, but also bears superior mechanical properties such as hardness and e-modulus.*



■ *A dual, concentric rotation unit for ion-beam lithography*



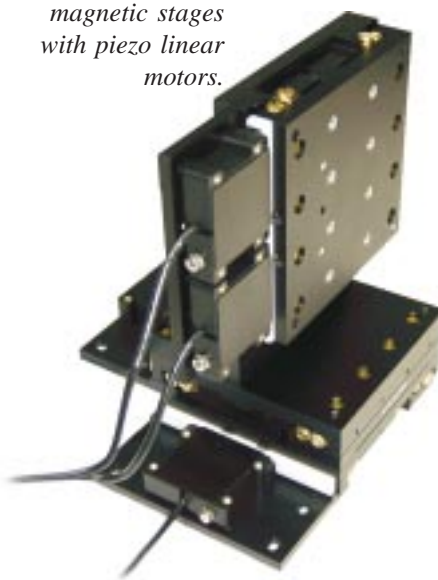
In a test a stage that uses stainless steel linear bearings was subjected to a powerful magnetic field of 2.5 T using a "Lake Shore" magnetometer. After exposure the stage's own magnetic field was about 0.8 G, measured with a Gauss-meter by Hirst Magnetic Instruments.

This slightly elevated magnetism (the bearings measured about 0.02 G before the test) was only detected in close proximity to the bearings. And since this is still a low value given the powerful field to which the stage was exposed, the design is suitable for many applications.

For more demanding specifications in terms of magnetic flux density, FMD uses linear bearings made from Titanium with a special surface treatment for sufficient hardness at the surfaces on which ceramic balls are running. Operated for several hours in the Lake Shore magnetometer at the same flux as in the previ-

ous test, our model MT105-50-LM-NM picked up no more than 0.005 G. The stage operated normally while exposed. Immunity against magnetic fields is not just ac-

■ *Three-axis unit composed of non-magnetic stages with piezo linear motors.*



complished by using suitable materials to keep forces low, but also by using electric or electronic components that will not be disturbed by these fields. Because the magnetic flux density decreases with the square of distance, conventional motors such as

DC or steppers can be used if they are placed outside the immediate area influenced by the field. On the other hand, it is usually desirable for motion systems to be as compact as possible. This often eliminates the possibility of using conventional drives, including magnetic linear motors. Good results have been obtained, regarding accuracy, performance, and reliability, with piezo linear motors. By their nature they are immune to magnetic fields.

Optical linear encoders are the only option for position feedback. Limit switches must be based on optical signals since hall effect sensors are not usable. And there is a possibility that strong magnetic fields cause electronic circuitry to fail or malfunction. This has to be verified in tests. Generally it is better, at least in highly sensitive applications, to position interpolators and controllers outside the critical area to avoid interference with or distortions of the field.

FMD has production proven expertise in supplying precision motion systems with demanding specifications in hostile environments. Materials used include stainless steel, titanium, titanium with ceramics, or solid ceramics. Powered by special piezo linear motors from Nanomotion (Israel) or Piezomotor Uppsala (Sweden), FMD's motion systems can be custom tailored to meet the most stringent requirements. ◀

Magnetic flux densities of typical fields

Bio-signals	<0.001 G (<0.0001 mT)
Earth's magnetic field	0.35 G (0.035 mT)
Strongest stable magnetic field on earth (National High Magnetic Field Laboratory, Tallahassee, FL))	450,000 G (45 T)

Threshold of Different Sensors

SQUID (Superconductive Quantum Interference Device)	0.0001 G
Magnetoresistor	0.001 G
Induction sensor	0.005 G
Hall-effekt sensor	1 G

Innovative Product

As Compact As It Gets

Looking for a compact, sleek, and totally enclosed 2-axis table? Height constraints? Tight budget? Check out the KT-180-50!

Engineers desiring a 2-axis X/Y motion system can buy two individual tables and stack one on top of the other. Most single-axis tables have bolt patterns which allow this but the result is often a bulky assembly with less than optimal performance.

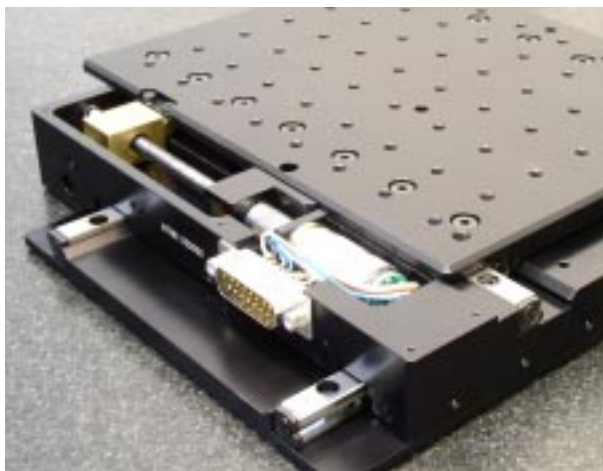
The orthogonal accuracy is dependent on the assembly of the two stages, and the flatness of motion (vertical run-out) can change as the upper stage travels from one side to the other. Generally, the performance of two stacked stages is always inferior to that of its single-axis components. Plus, the height of the stages just doubles, which may be too high for many applications. And the look of such an assembly with its exposed cables is often unappealing.

If this is not acceptable, then the two stages must be integrated into one. This allows better orthogonality, and the plates

weaknesses of a stacked system, but not all of them. Even the total height may not be much lower.

These challenges led to the development of the KT-180-50 stage – an ultra-compact X/Y system with 50 mm travel in ei-

Despite its smart design and quality components, the KT-180-50 offers stunning performance specifications. And its ultra-low profile makes it an ideal replacement for simple manual stages in applications where height constraints prevent use of bulkier, conventional stages or stacked units. At the same time, its sleek and appealing design makes it an attractive upgrade for every machine on which it is used. ◀



Despite its low profile, the KT-180-50 was designed with accuracy and reliability in mind. Preloaded ball screws and cross-roller bearings offer high stiffness, contributing to the 4 micron flatness of motion over the 50 x 50 mm work envelope with a payload of 5 kgs.

can be designed in a way that the motion of the upper plate has less impact on flatness of travel.

But often such two-axis systems are merely two separate single axis stages, with the lower plate of the upper unit, and the upper plate of the lower unit machined from a single piece. This eliminates some

ther axis, integrated into a space of 180 x 180 x 32 mm (with both axes centered). It is equipped with cross roller linear bearings, backlash-free ball screws, limit switches, stepper motors, and a single connector. Everything is completely enclosed with no outside wiring or protruding motors.

KT-180-50-SM

Travel	50 x 50 mm
Accuracy	5 µm
Repeatability	1 µm

Flatness / Straightness Deviation

- over 10 mm	+/- 0.5 µm
- over total travel	+/- 4.0 µm

Max. load

- Fx	30 N
- Fy	30 N
- Fz	50 N

Mass	3.0 kg
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Main Dimensions

180 x 180 x 32 mm