APPLICATION NOTE
ML Puck Magnetic Field Measurement

Purpose

This application note provides information on the magnetic field levels surrounding a MagneMover LITE magnet array. It also discusses how shielding material can be used to contain the magnetic field for applications requiring it. Finally it defines safety measures to be used when handling the magnet array.

Introduction

The MagneMover LITE puck consists of a modified Halbach magnet array that augments the magnetic field on the bottom of the array while canceling the field to near zero on the top of the puck. Figure 1 shows a diagram of the field surrounding the magnet array. Some materials being transported with a MagneMover LITE system are sensitive to magnetic fields, therefore it is important to characterize these magnetic fields and to reduce the magnetic fields for those applications if necessary.

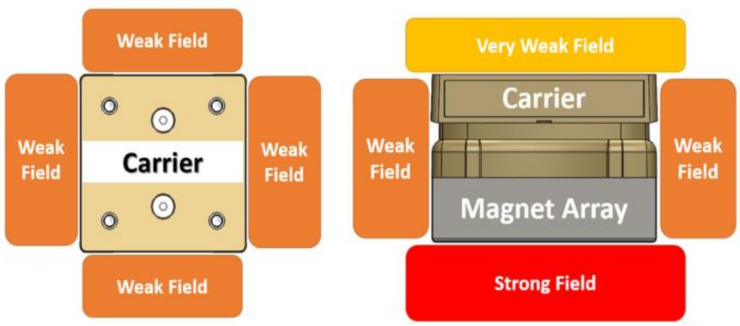

Figure 1: Strength of the magnetic field magnitude for a MagneMover Lite Puck. Diagram for illustration purpose only.

Methods

Magnetic field measurements were taken with an AlphaLab Inc. Vector/Magnitude Gaussmeter, which uses a tri-axial probe measuring between 0G to 799G in magnitude. After the probe is zeroed at the ambient magnetic field, it is used to measure the magnitude of the field at a given point. The magnetic field is described in terms of its magnitude: $|B| = \sqrt{B_x^2 + B_y^2 + B_z^2}$

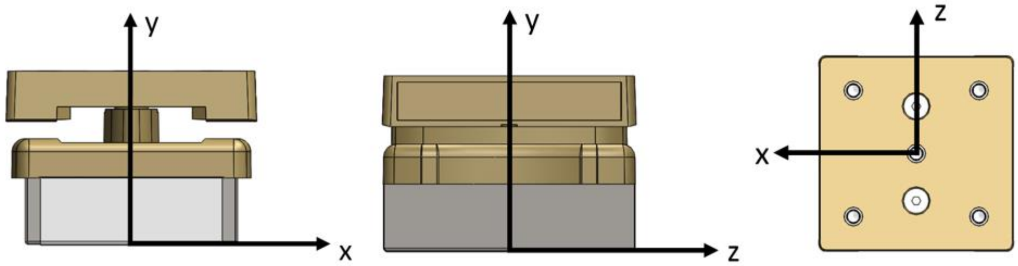

Figure 2: Axis direction and location of origin with respect to the puck.

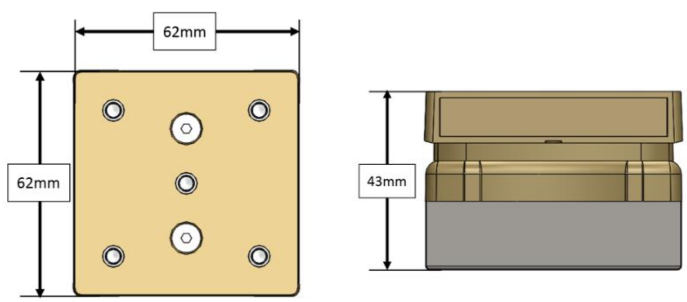

Figure 3: Overall puck dimensions.

It is important to note that due to the design of the puck and magnet array, the x-axis and z-axis measurements are symmetric, but the y-axis is not. Magnetic field magnitude measurements are taken at the following heights:

- Y = 0mm (bottom of magnet array)
- Y = 43mm (top of puck)
- 27.5mm interval above and below puck

for the following conditions while the puck is not on a motor:

1. Measurements taken along direction of travel (along z-axis) and X = 0.
2. Measurements taken along the lateral direction (along x-axis) and Z = 0.
3. Measurements taken above the puck top (x/z = 0mm, 15.5mm, 31mm)

Results

Earth's magnetic field is between 0.3 to 0.6 Gauss. At the test location, the ambient magnetic field is 0.5 Gauss. The following graphs show how the magnetic field falls off to approximately the ambient field as the measurement probe is moved further from the puck. For comparison, Figure 4 and Figure 5 show experimental measurements from two pucks along with data from a FEA model of a puck. Both measurements and the model behave in a similar fashion.

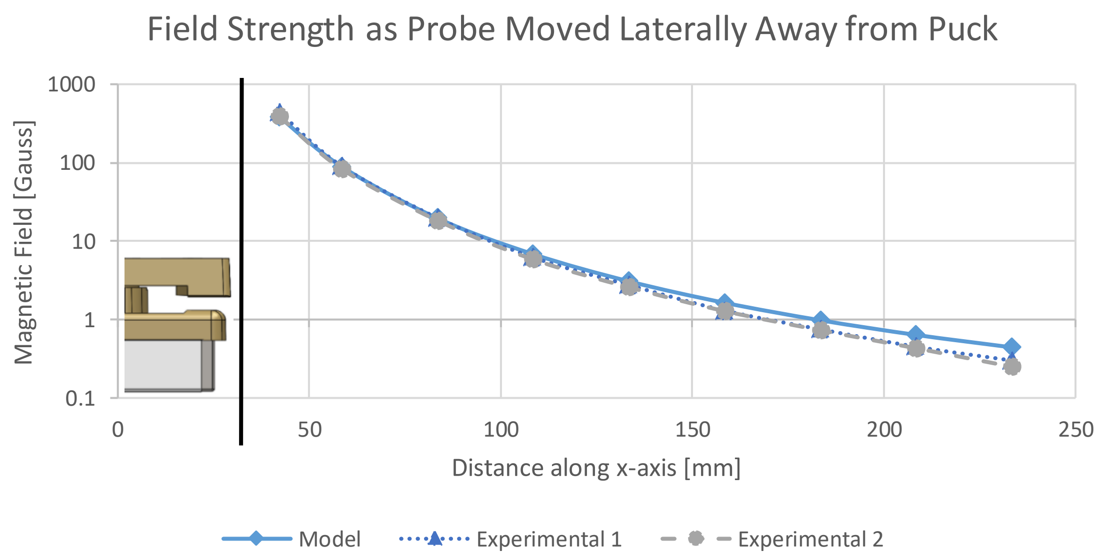

Figure 4: Magnetic field magnitude along the puck's lateral direction – model vs experimental data. Measurements taken along x-axis with Z = 0 and Y = 0.

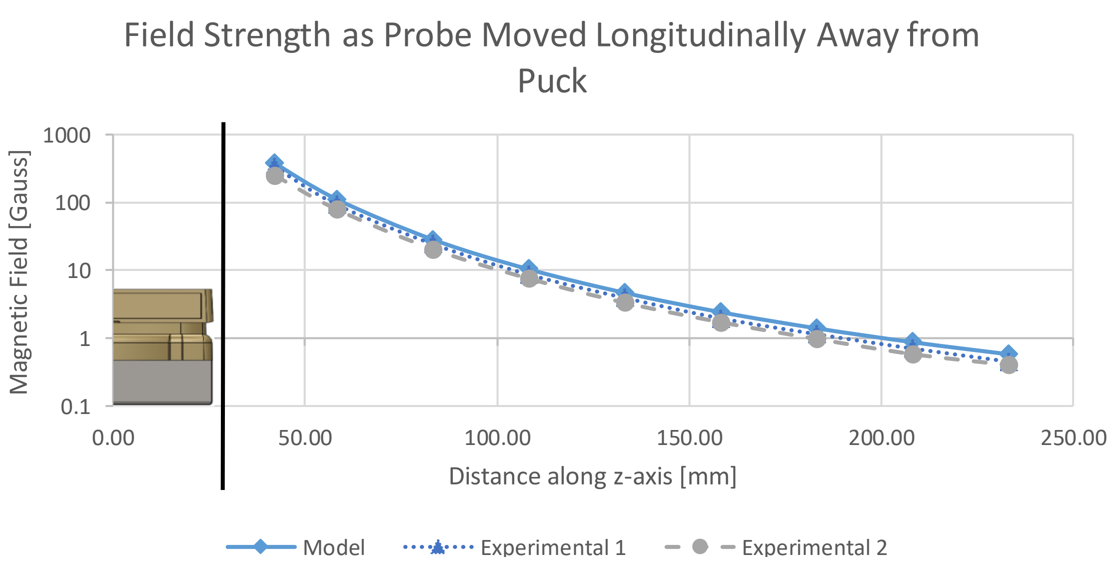

Figure 5: Magnetic field magnitude on the puck's longitudinal direction – model vs experimental data. Measurements taken along z-axis with X = 0 and Y = 0.

Figure 6 and Figure 7 show the magnetic field magnitude above the puck, while Figure 8 and Figure 9 show the magnetic field magnitude below the magnet array. As the magnetic field magnitude drops to below 1G, it is considered to reach ambient fields.

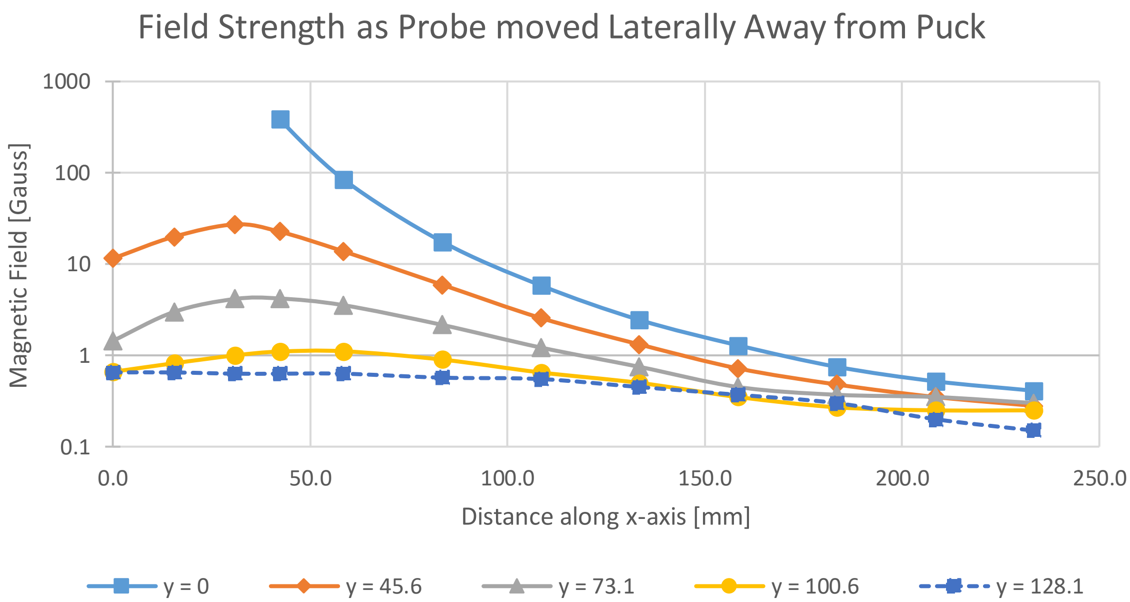

Figure 6: Magnetic Field Magnitude along lateral axis at different heights. Measurements were taken at a given Y, along the X axis, and Z = 0

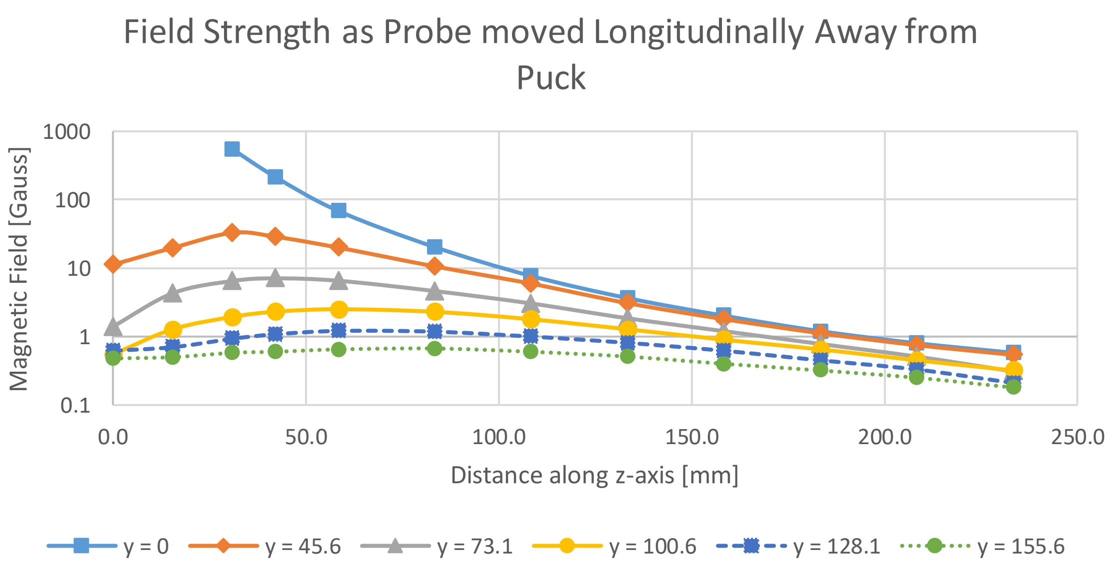

Figure 7: Magnetic field magnitude along travel axis at different heights. Measurements were taken at a given Y, along the Z axis, and X = 0

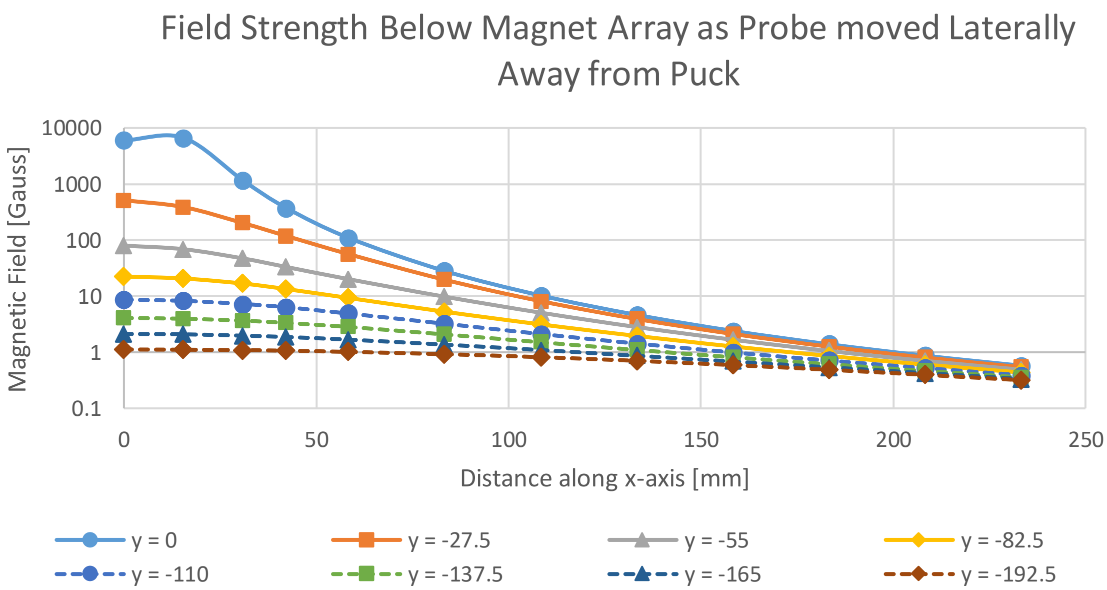

Figure 8: Magnetic field magnitude below magnet array along lateral axis at different heights. Measurements were taken at a given Y, along the X-axis, and Z = 0

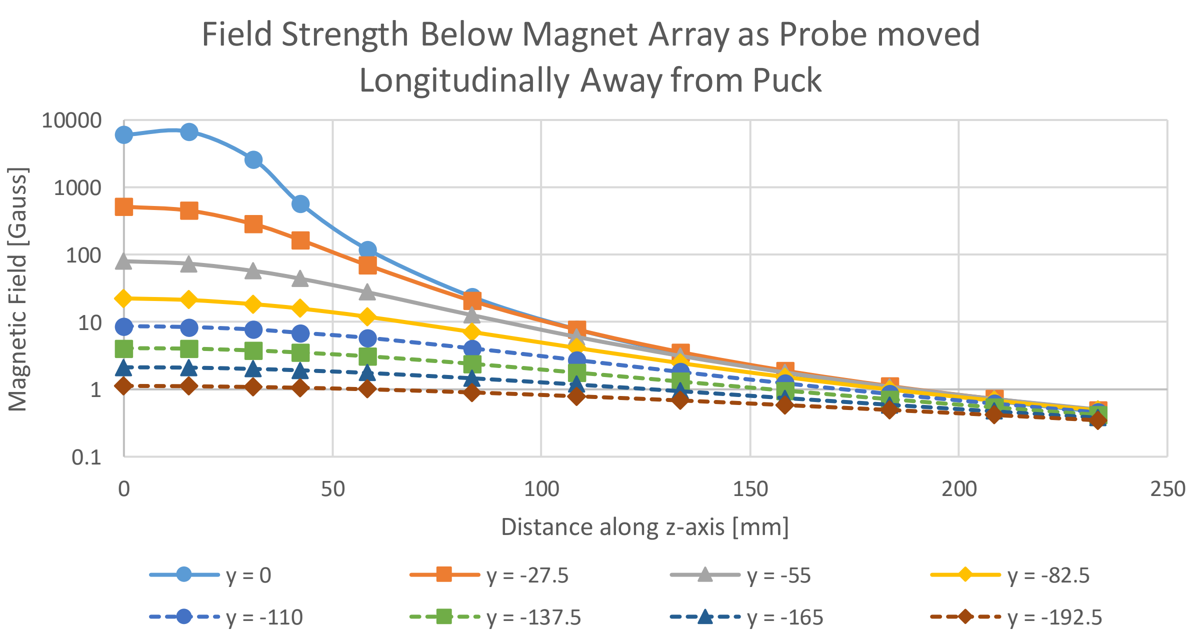

Figure 9: Magnetic field magnitude below magnet array along longitudinal axis at different heights. Measurements were taken at a given Y, along the Z-axis, and X = 0

As some materials being transported by a puck might be sensitive to magnetic fields, Figure 10 and Figure 11 show the field strength above the puck top.

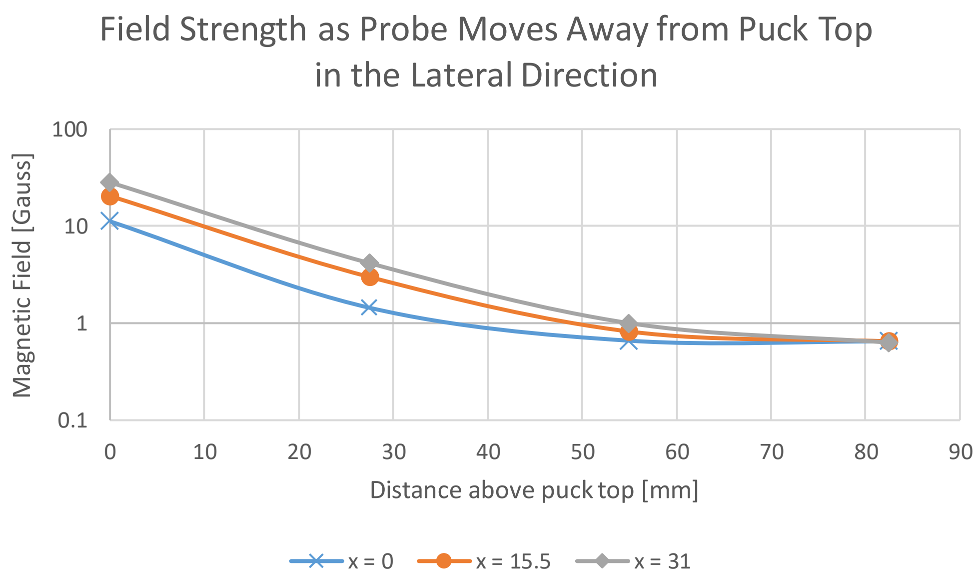

Figure 10: Magnitude of magnetic field measured at three locations above the puck top (Z = 0)

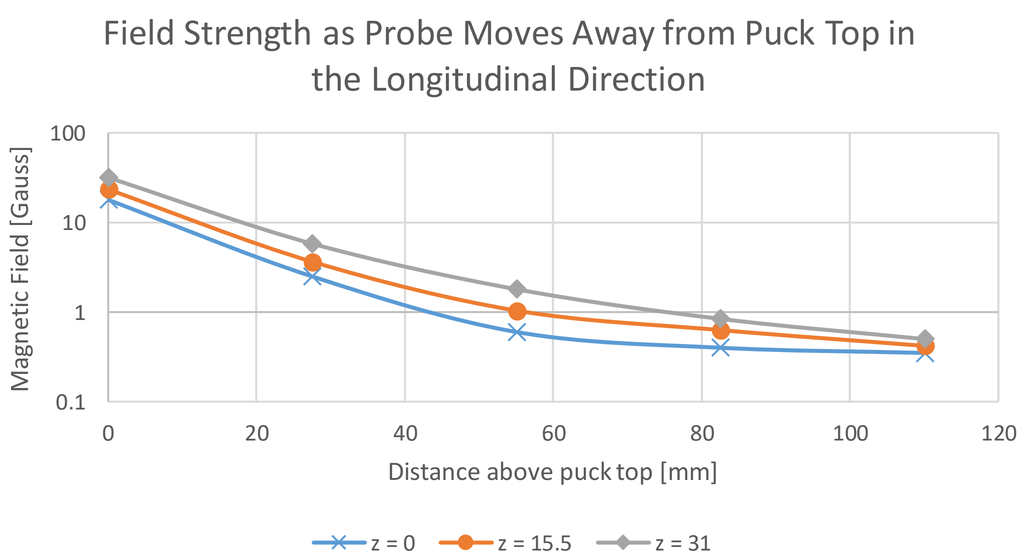

Figure 11: Magnitude of magnetic field measured at three locations above the puck top (X = 0)

Shielding

The puck's magnetic field can be shielded by the addition of ferromagnetic metal. Metals such as iron, nickel or cobalt can work as a shield.

Permeability is the ability to re-direct magnetic flux, in effect providing a short circuit path to steer the flux away from the area one is trying to shield. Higher permeability materials are better than lower permeability materials. But one must also consider the saturation point of the material – the point at which the material loses the ability to steer additional magnetic flux – as well as the thickness of the material. Thinner materials will saturate at a lower flux density than thicker ones. Once the material saturates, the shielding effect diminishes. If saturation is an issue, multiple layers of material can be used.

Steel is commonly used because it is inexpensive and widely available. It saturates around 22 kG, and has a permeability between 1000 and 3000 times μ_0 (the permeability of free space). Steel is a good shielding material for applications involving large, powerful neodymium magnets due to the higher saturation point of steel. In these cases, steel provides good attenuation and a much higher saturation threshold.

Figure 12 shows the magnetic field with and without shielding placed on the puck top, with the probe at various distances above the puck. The shield is a galvanized, low carbon steel measuring 15.5cm x 9cm (6.1in x 3.5in) with a thickness of 1/32in.

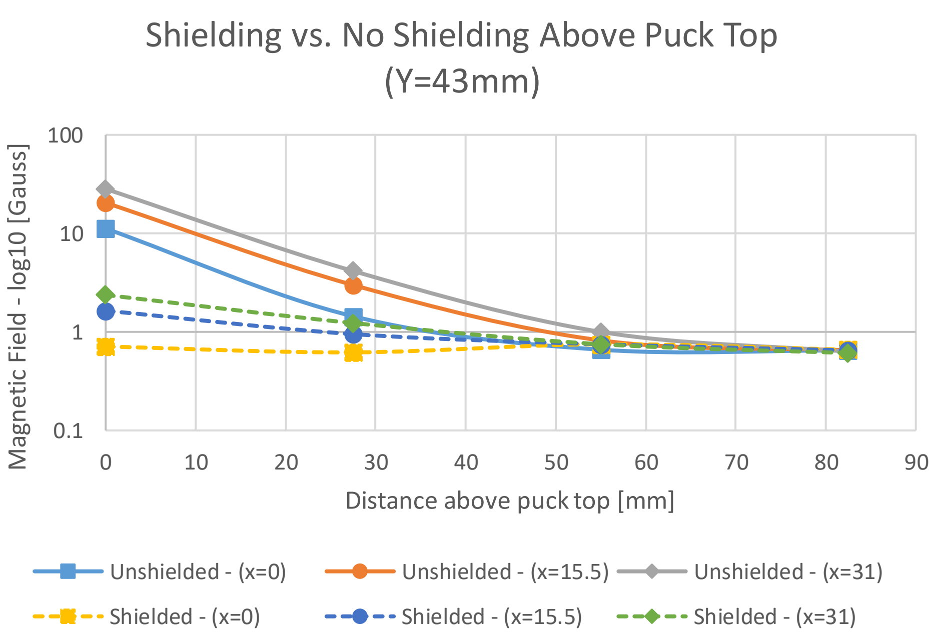

Figure 12: Comparison of Shielded vs. Unshielded Magnetic Field Magnitude above puck top

Safety and Handling

The MagneMover LITE transport systems use high-strength Neodymium Iron Boron (NdFeB) magnets in the magnet arrays attached to the vehicles (pucks). Proper precautions must be observed when using high-strength magnets.

- People with pacemakers and other medical electronic implants should not handle the magnet arrays.
- Handle only one vehicle (puck) or magnet array at a time.
- Do not place any body parts (e.g. fingers) between a magnet array and any ferrous material or another magnet array to avoid injury.
- Vehicles or magnet arrays not being used should be secured individually in isolated packaging.
- Keep watches, instruments, electronics, and magnetic media (memory disks/chips, credit cards, and tapes) away from the magnet arrays

Summary

The magnetic field is largest below the face of the magnet array, where it interacts with the motor for propulsion. Due to the orientation of the magnet array, the longitudinal direction fields are stronger than the lateral direction. Table 1 shows a summary of the distance required to reduce magnetic fields to below 1G in the different scenarios.

Table 1: Distance to Reduce Magnetic Field to Below 1G

Orientation	Distance [mm]
Lateral axis (y = 0, z = 0)	170
Longitudinal axis (x = 0, y = 0)	200
Above puck (x = 31, z = 0)	55
Below puck (x = 0, z = 0)	200

Adding shielding material, such as a steel sheet, reduces the distance at which the magnetic field dissipates to ambient levels. In this measurement setup, a 1/32” thick steel sheet reduced the distance at which the field drops to ambient levels to about 37.5mm above the pallet for x = 31mm and z = 0. Factors that affect shield performance are the shape, size, and thickness of the shield and distance from the shield to the array.

More Information

MagneMotion Website: www.magnemotion.com

Questions & Comments: www.magnemotion.com/about-magnemotion/contact.cfm

Revision History

Rev.	Change Description
A	Initial release