MATERIALS WEEK EUROPE

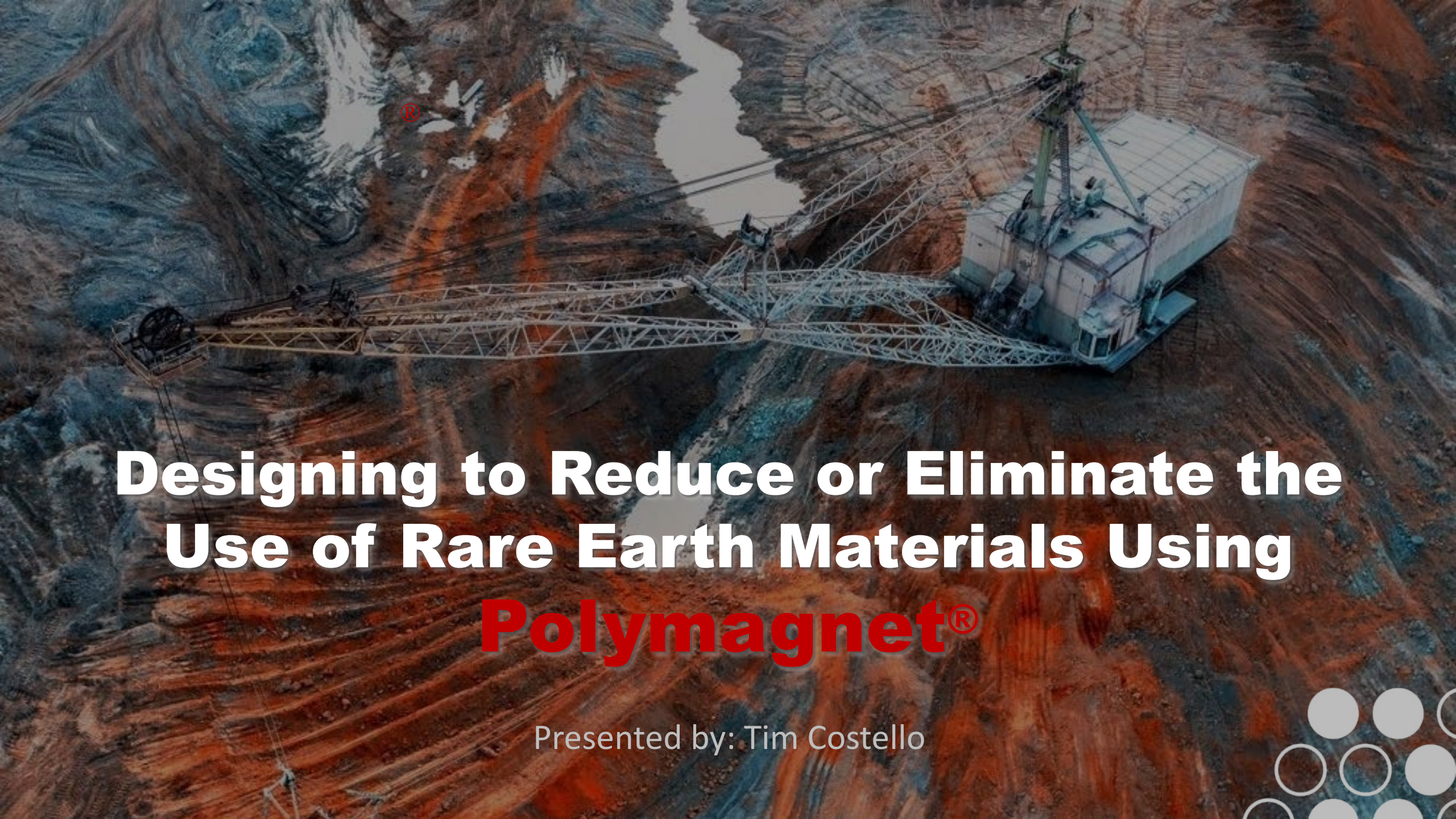
The next speaker is...

Tim Costello
Chief Executive Officer &
Board Chairman
Polymagnet

Polymagnet
CORRELATED MAGNETICS

Designing to Reduce or Eliminate the Use of Rare Earth Materials in Magnetics

Scan below for Conference Agenda



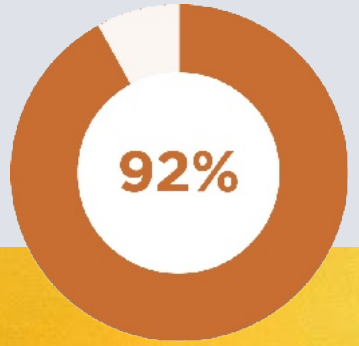
Designing to Reduce or Eliminate the Use of Rare Earth Materials Using Polymagnet®

Presented by: Tim Costello

Problem Statement

China dominates the magnetic supply chain (mining, processing & magnet manufacturing) at a time of rising geopolitical tensions, export controls and tariffs, which creates significant supply chain risk for commercial & defense products

Refining



Magnet Manufacturing

"China has stopped exporting rare earths to everyone, not just the U.S., cutting off critical materials for tech, autos, aerospace, and defense."

Fortune, April 14, 2025

Polymagnet®


Neodymium Rare Earth (CNY/T) 1145000
Nd Price Volatility
makes economic predictability difficult
+400%
+25%
+170%
1600000
1400000
1200000
1000000
785157
600000
400000
2021
2022
2023
2024
2025

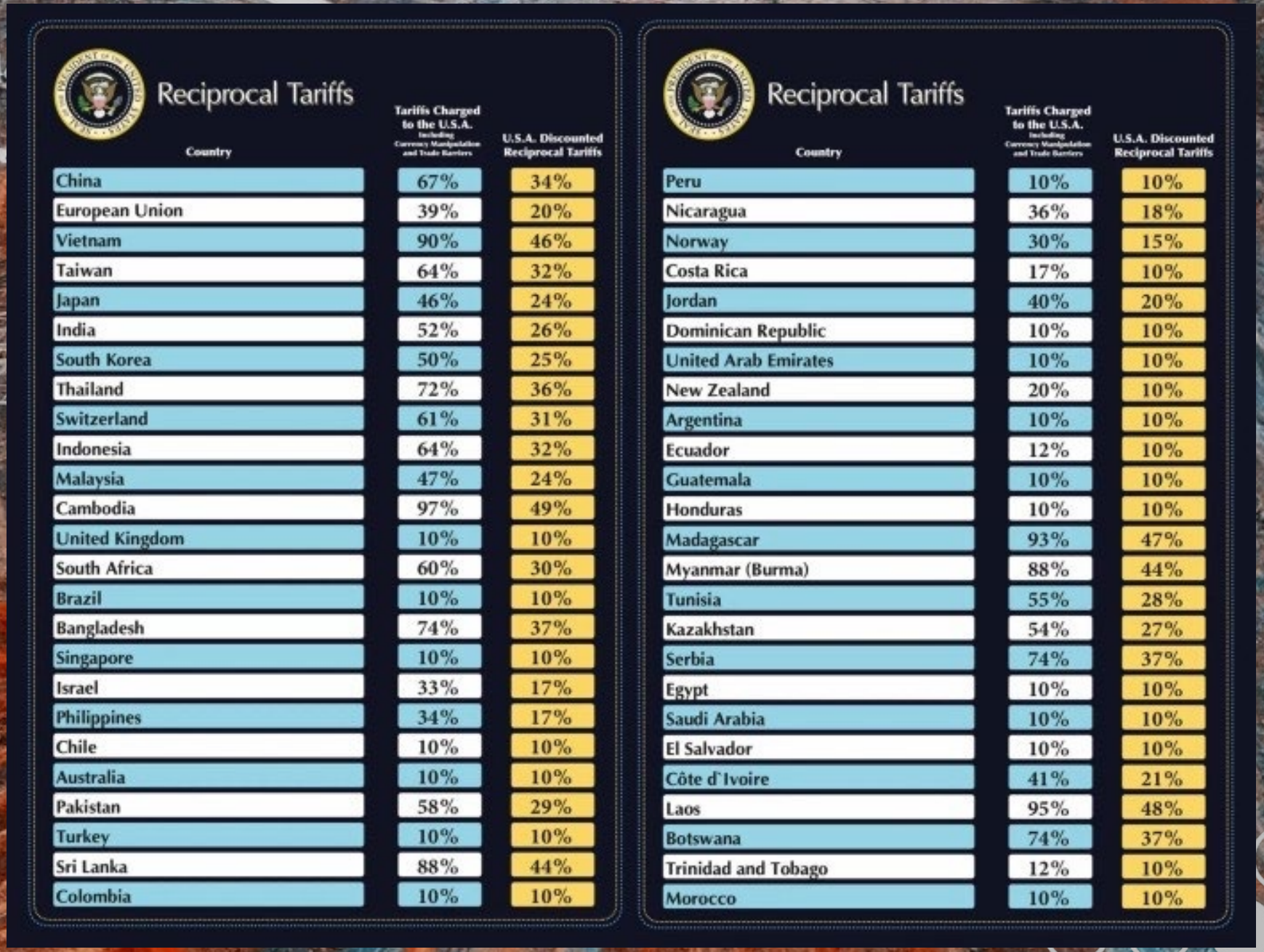
Subject to Political Manipulation

200%

~~125%~~

~~104%~~

~~54%~~ Tariff Rate for China



Reciprocal Tariffs

Country	Tariffs Charged to the U.S.A. Including Currency Manipulation and Trade Barriers	U.S.A. Discounted Reciprocal Tariffs
China	67%	34%
European Union	39%	20%
Vietnam	90%	46%
Taiwan	64%	32%
Japan	46%	24%
India	52%	26%
South Korea	50%	25%
Thailand	72%	36%
Switzerland	61%	31%
Indonesia	64%	32%
Malaysia	47%	24%
Cambodia	97%	49%
United Kingdom	10%	10%
South Africa	60%	30%
Brazil	10%	10%
Bangladesh	74%	37%
Singapore	10%	10%
Israel	33%	17%
Philippines	34%	17%
Chile	10%	10%
Australia	10%	10%
Pakistan	58%	29%
Turkey	10%	10%
Sri Lanka	88%	44%
Colombia	10%	10%

Reciprocal Tariffs

Country	Tariffs Charged to the U.S.A. Including Currency Manipulation and Trade Barriers	U.S.A. Discounted Reciprocal Tariffs
Peru	10%	10%
Nicaragua	36%	18%
Norway	30%	15%
Costa Rica	17%	10%
Jordan	40%	20%
Dominican Republic	10%	10%
United Arab Emirates	10%	10%
New Zealand	20%	10%
Argentina	10%	10%
Ecuador	12%	10%
Guatemala	10%	10%
Honduras	10%	10%
Madagascar	93%	47%
Myanmar (Burma)	88%	44%
Tunisia	55%	28%
Kazakhstan	54%	27%
Serbia	74%	37%
Egypt	10%	10%
Saudi Arabia	10%	10%
El Salvador	10%	10%
Côte d`Ivoire	41%	21%
Laos	95%	48%
Botswana	74%	37%
Trinidad and Tobago	12%	10%
Morocco	10%	10%

Subject to Political Manipulation: Constrained Availability

New restrictions on China's rare earths will likely disrupt tech and defense industries

The latest measure targets seven rare earth elements, including scandium and dysprosium

By Skye Jacobs April 7, 2025 at 3:49 PM | 23 comments

The Economist

Weekly edition | The world in brief | War in the Middle East | War in Ukraine | United States | The world economy | Business | Arti

Finance & economics | Pit for tat

China has a weapon that could hurt America: rare-earth exports

It has only just begun to use it

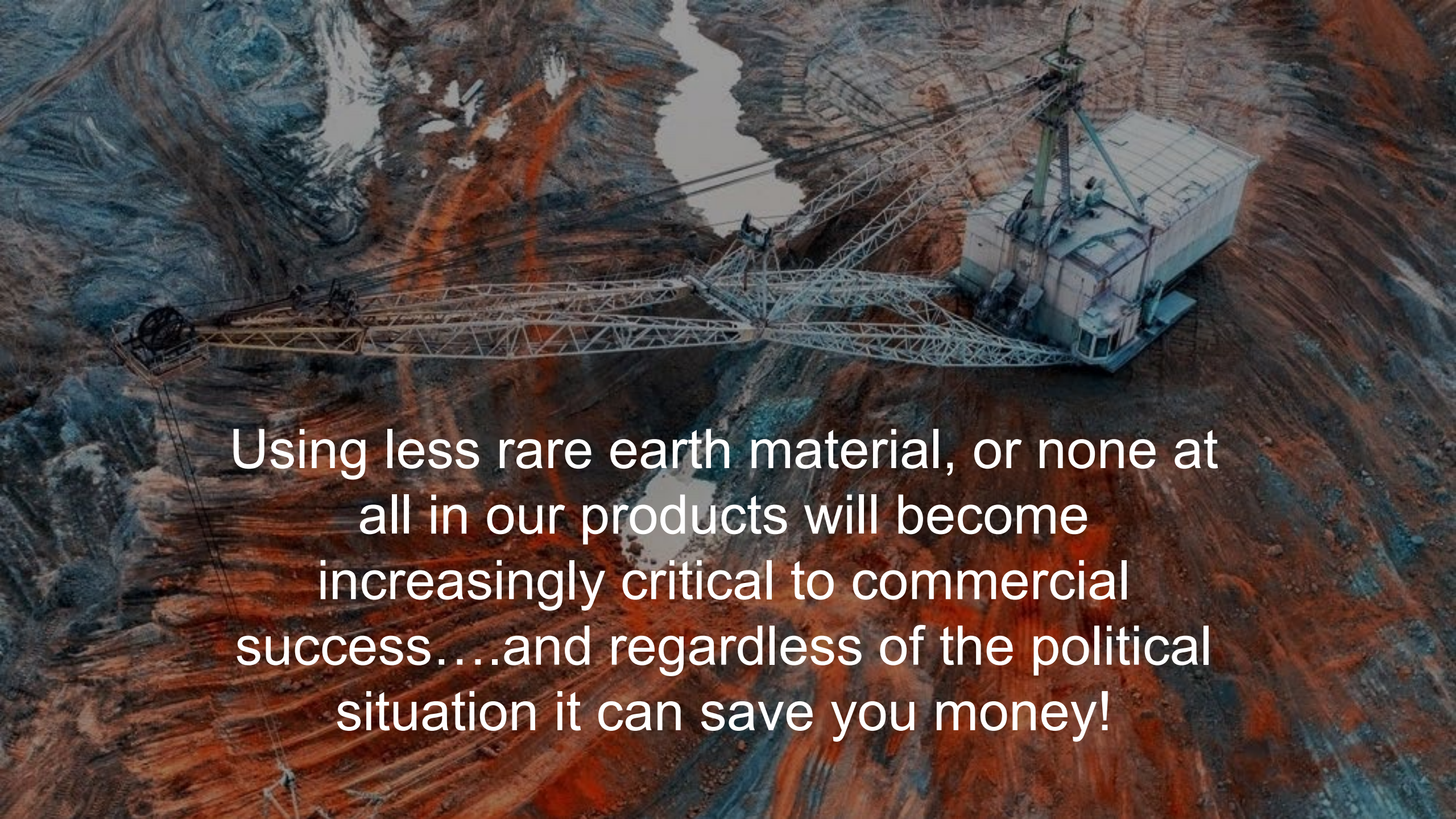
Subject to Political Manipulation: Constrained Availability

$250 inspection fees on every shipment regardless of quantity

To Whom It May Concern

On April 4, 2025, the Ministry of Commerce of China, in conjunction with the General Administration of Customs, issued a public notice to implement **export control measures** on seven categories of medium and heavy rare earth-related items, including samarium, gadolinium, terbium, dysprosium, lutetium, scandium, and yttrium. It covers various forms such as metals, alloys, target materials, permanent magnetic materials, oxides, compounds, and their mixtures. These measures came into effect on the date of issuance.

According to the above regulations, **the exporter must apply for an export license for each shipment of magnet** which includes the above element from the competent department of Ministry of Commerce of China. It will take around 45 working days after receiving all qualified applying documents.



Using less rare earth material, or none at all in our products will become increasingly critical to commercial success….and regardless of the political situation it can save you money!

But we need the strength!

That’s where

Polymagnet®

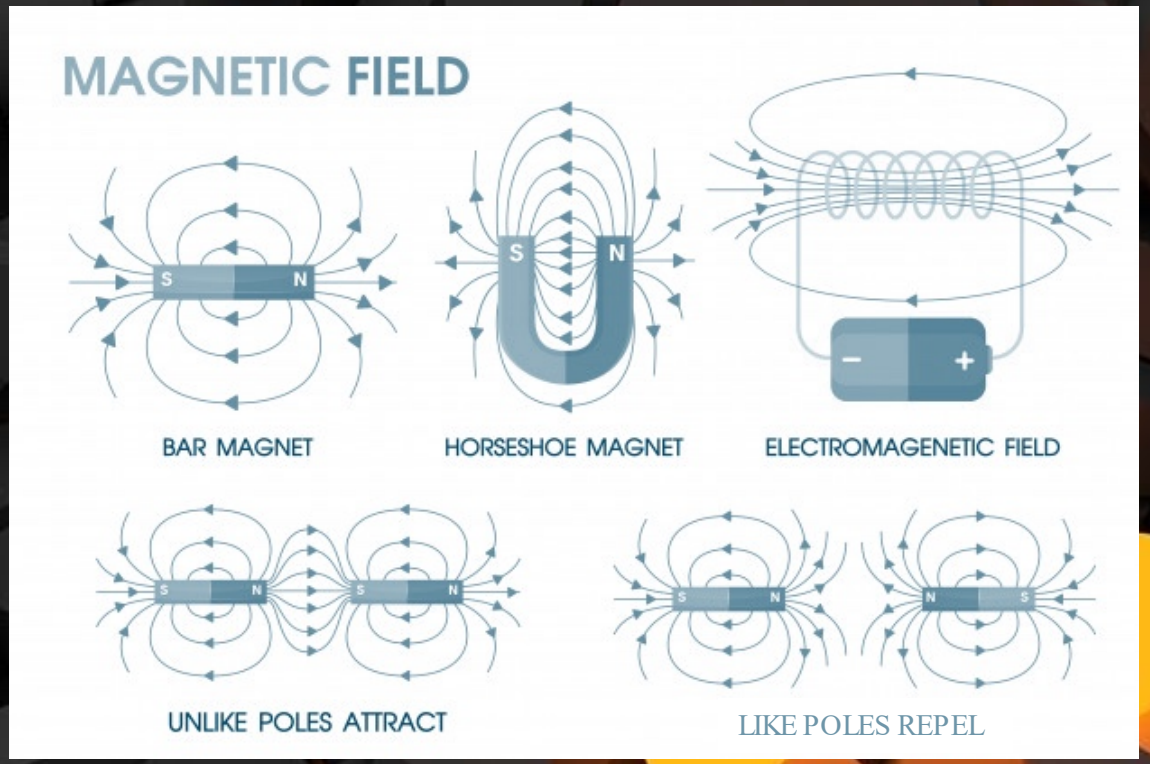
can help

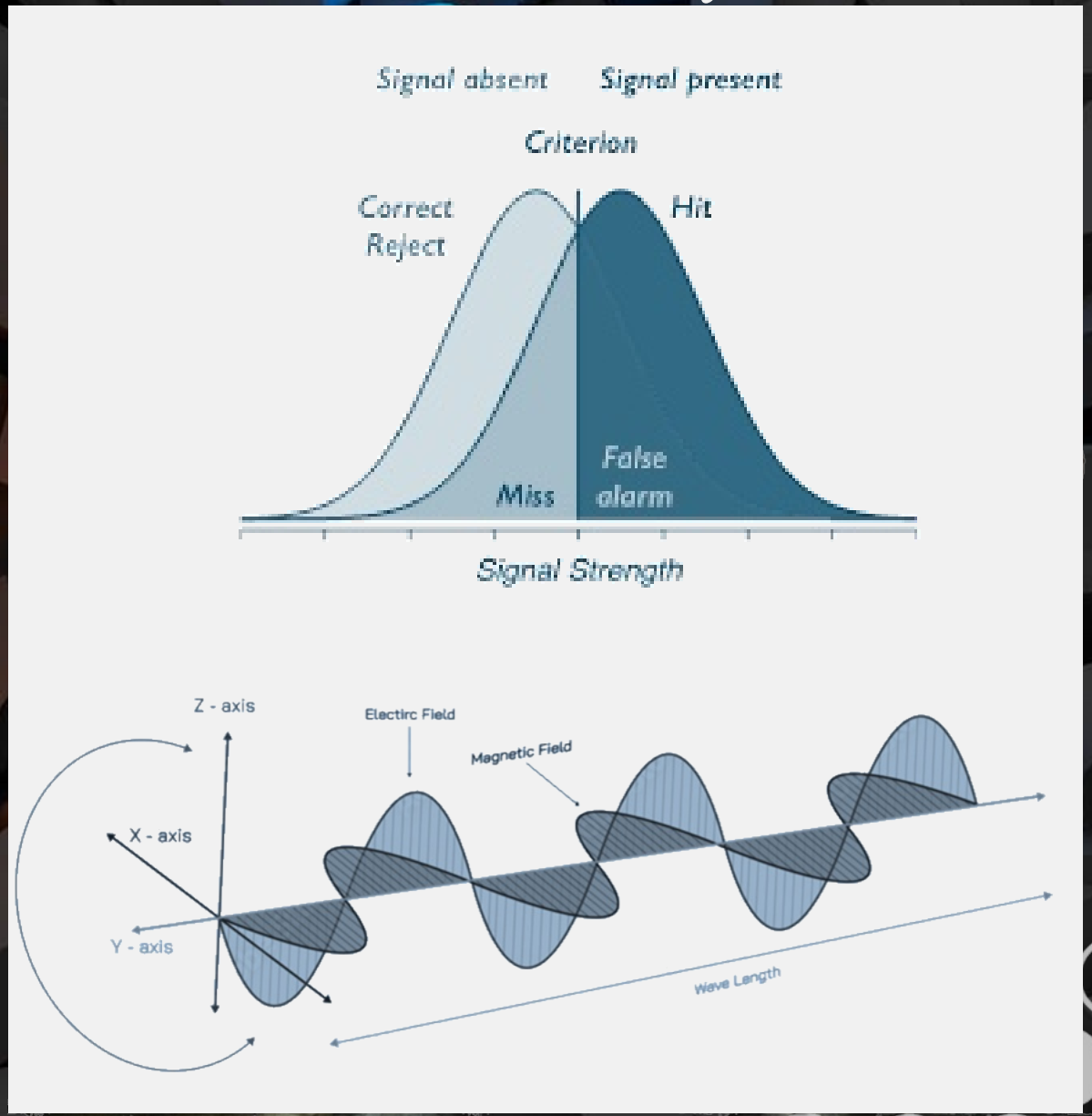
Polymagnet® Mission:

To enable a new, technology differentiated, Western based, magnetic supply chain which supports our national security and the products critical to our economic transition

Signal Processing, Coding, Signal & Wave Theory

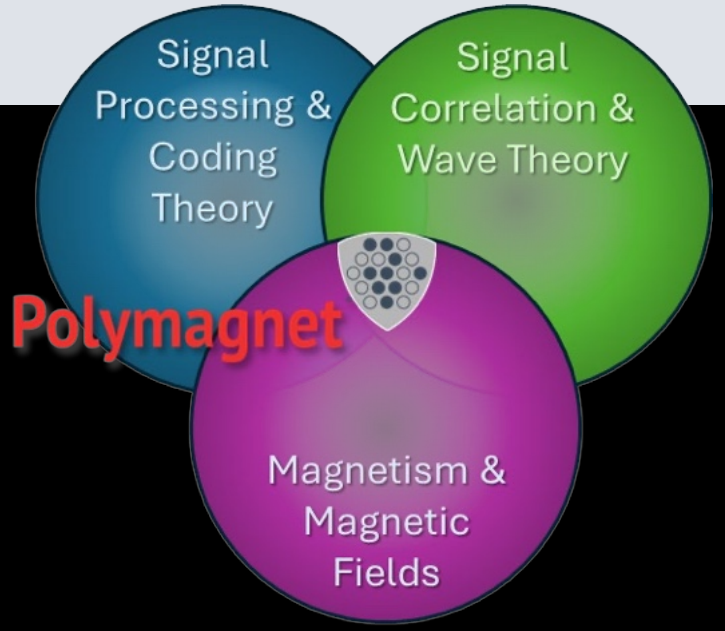
Polymagnet®





Polymagnet®
CORRELATED MAGNETICS

Polymagnet® enables a new era of programable functionality

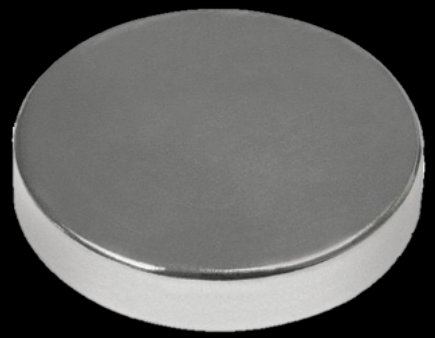


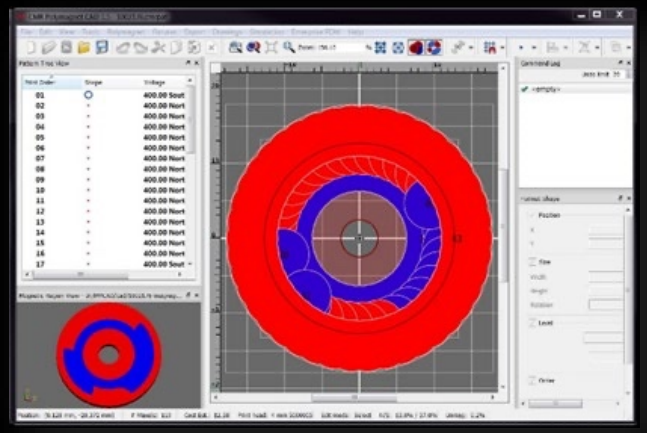
By combining coding, signal processing and wave theory with magnetic fields, Polymagnet® allows designers to optimally design the magnet's magnetic field for their specific application

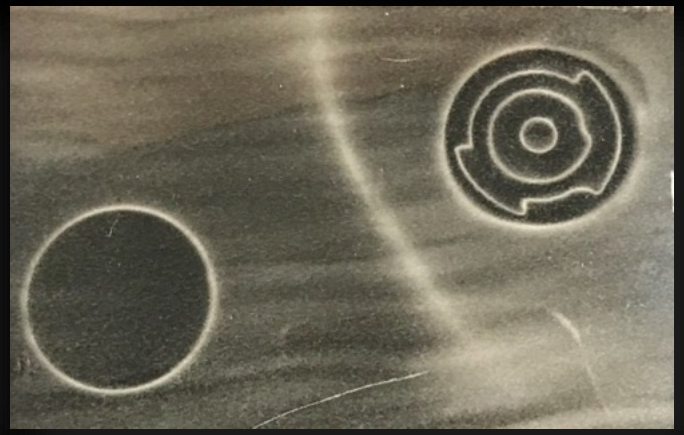
higher forces – lower cost – unique functionality – more secure supply chain – custom flux field geometries – medical & electronic safe….

Polymagnet®

What are Polymagnets®?







…they're just better magnets! *With our end-to-end suite of tools and services, we turn normal Ferrite, Neodymium and Samarium Cobalt magnets into* **Polymagnets®** *which exhibit higher performance, incredible versatility in magnetic field engineering & unique functionality*

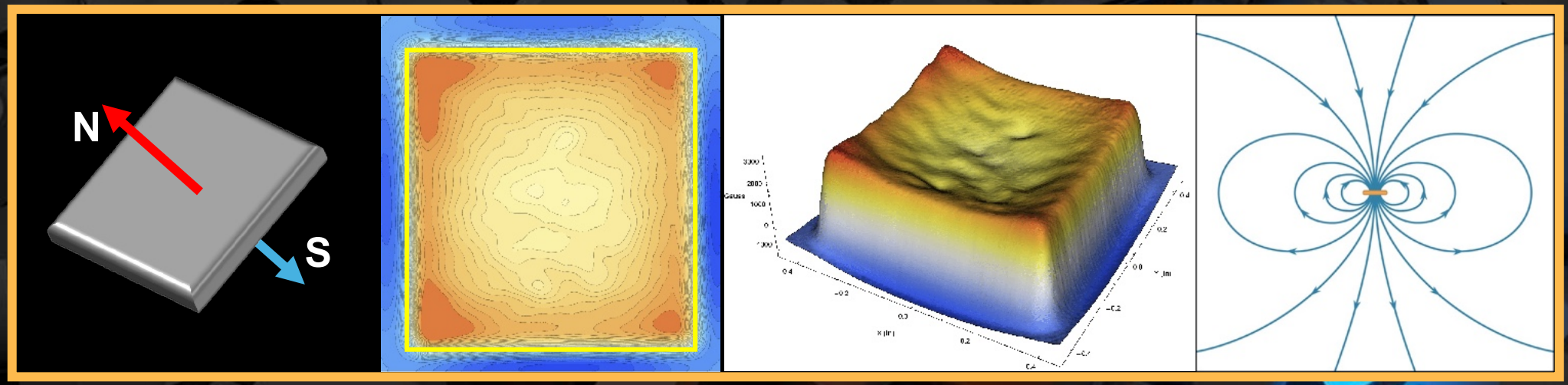
CMR

Magnets Come with Sticky Issues

- Uncontrolled magnetic fields (reach, geometry…)
- Non linear fields
- Poor utilization of potential energy
- Simple north/south functionality
- Unrealistic reference data
- EMI issues
- Challenging supply chains for rare earth materials
- High & unpredictable costs
- Lack of in-house expertise

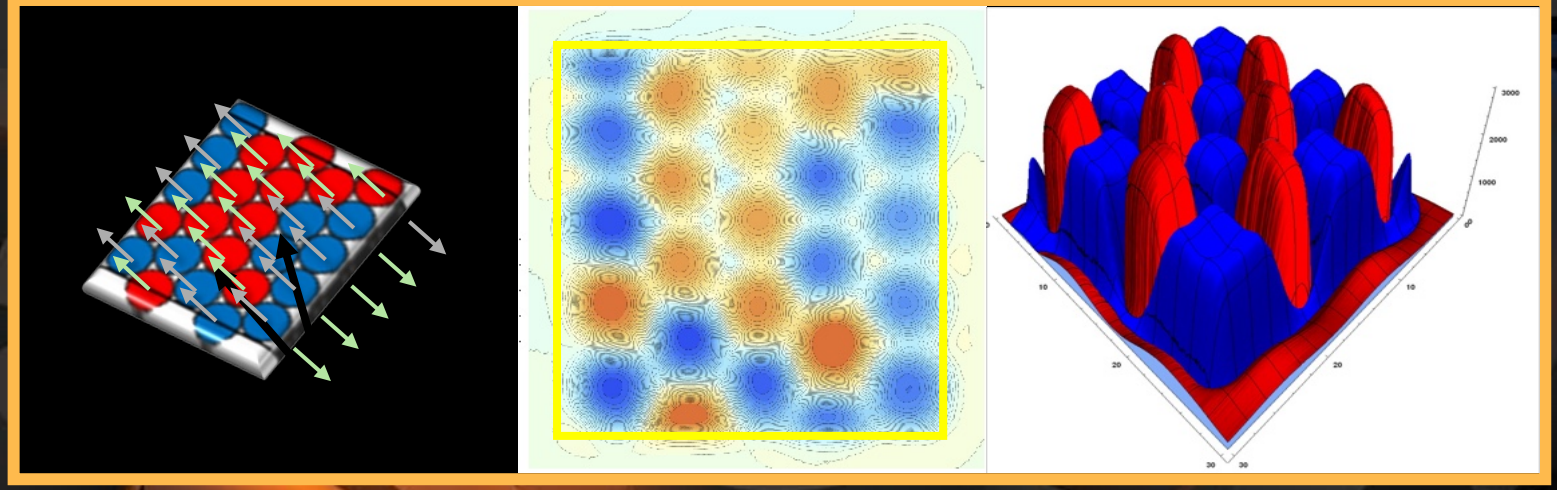
We fix that!

Polymagnet®



Non-linear – Edge Effects – High Propensity for "shorts/eddies" – Single Function

Polymagnet®



Force – Reach – Shape - Combined Function

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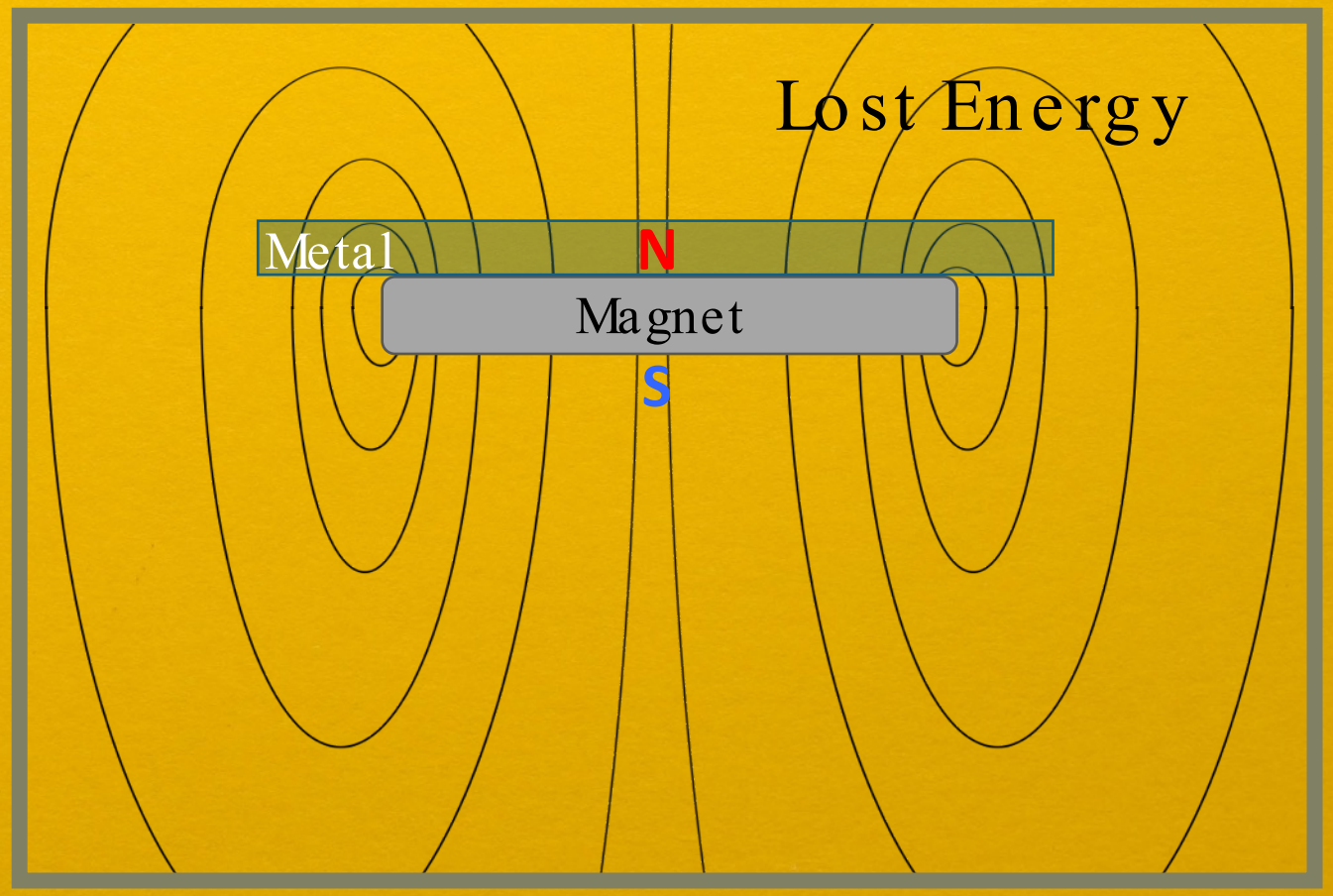
The Box We Design Within



Design Tools:

- **Bigger**
- **Thicker**
- **Higher Grade**

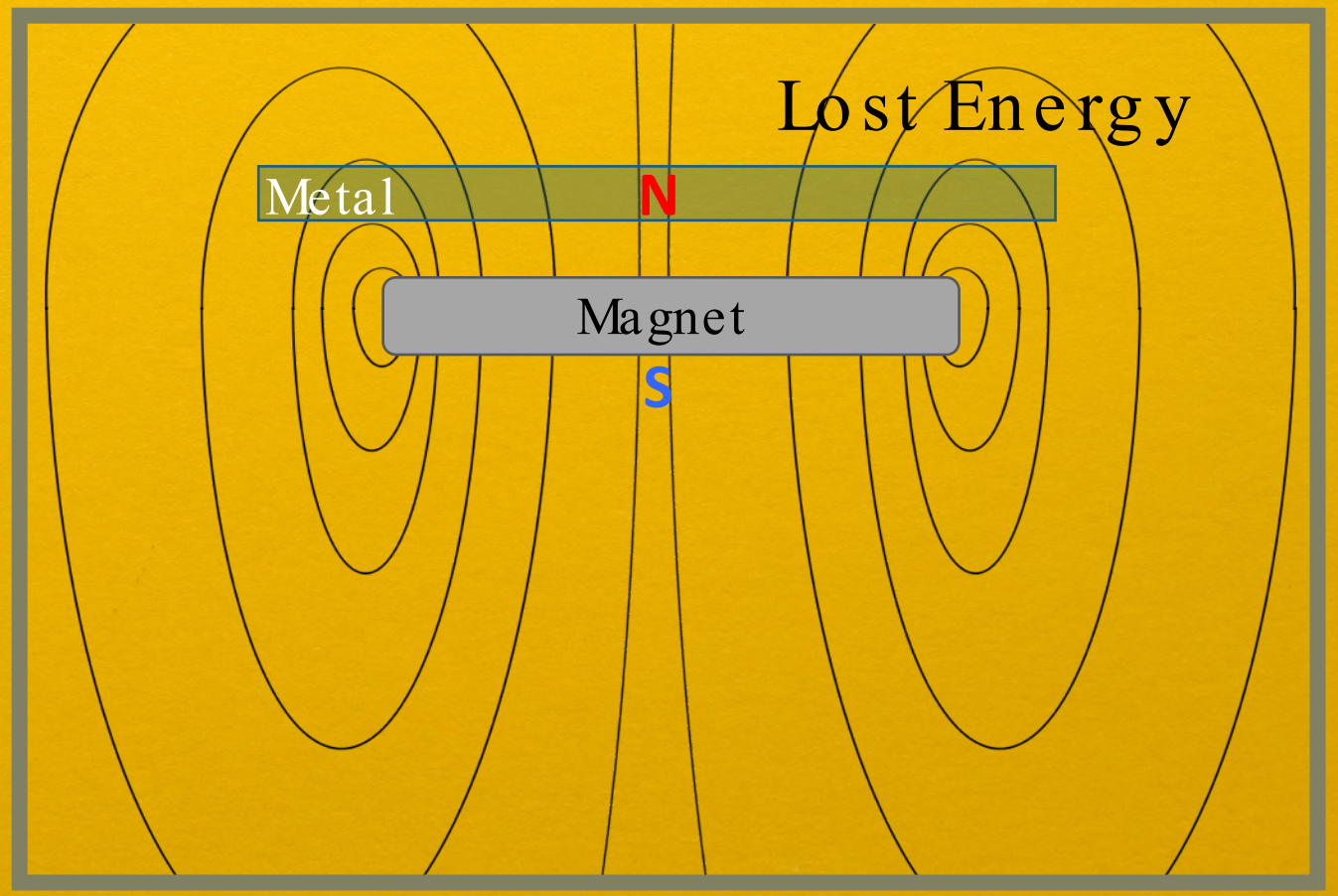
Pour Use of Potential Energy – Eddy Current Activation
EMI Issues – Poor Shear & Torsion Performance

Polymagnet®
CORRELATED MAGNETICS

The Box We Design Within

Design Tools:

- **Bigger**
- **Thicker**
- **Higher Grade**



Poor Use of Potential Energy – Eddy Current Activation
EMI Issues – Poor Shear & Torsion Performance

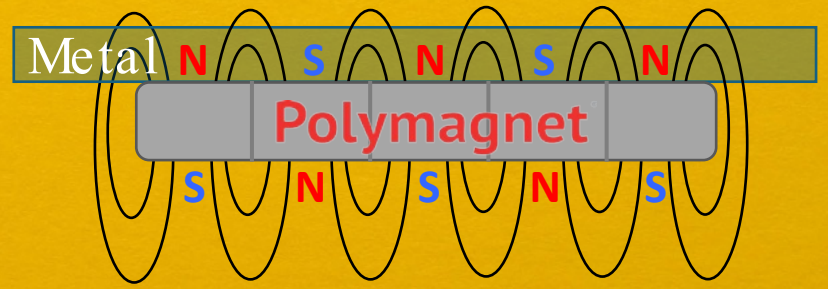
Polymagnet®
CORRELATED MAGNETICS

The Box We Design Within

Design Tools:

- **Field Shape**
- **Field Depth**
- **Muti-Function**

Focused Fields to Optimize Function



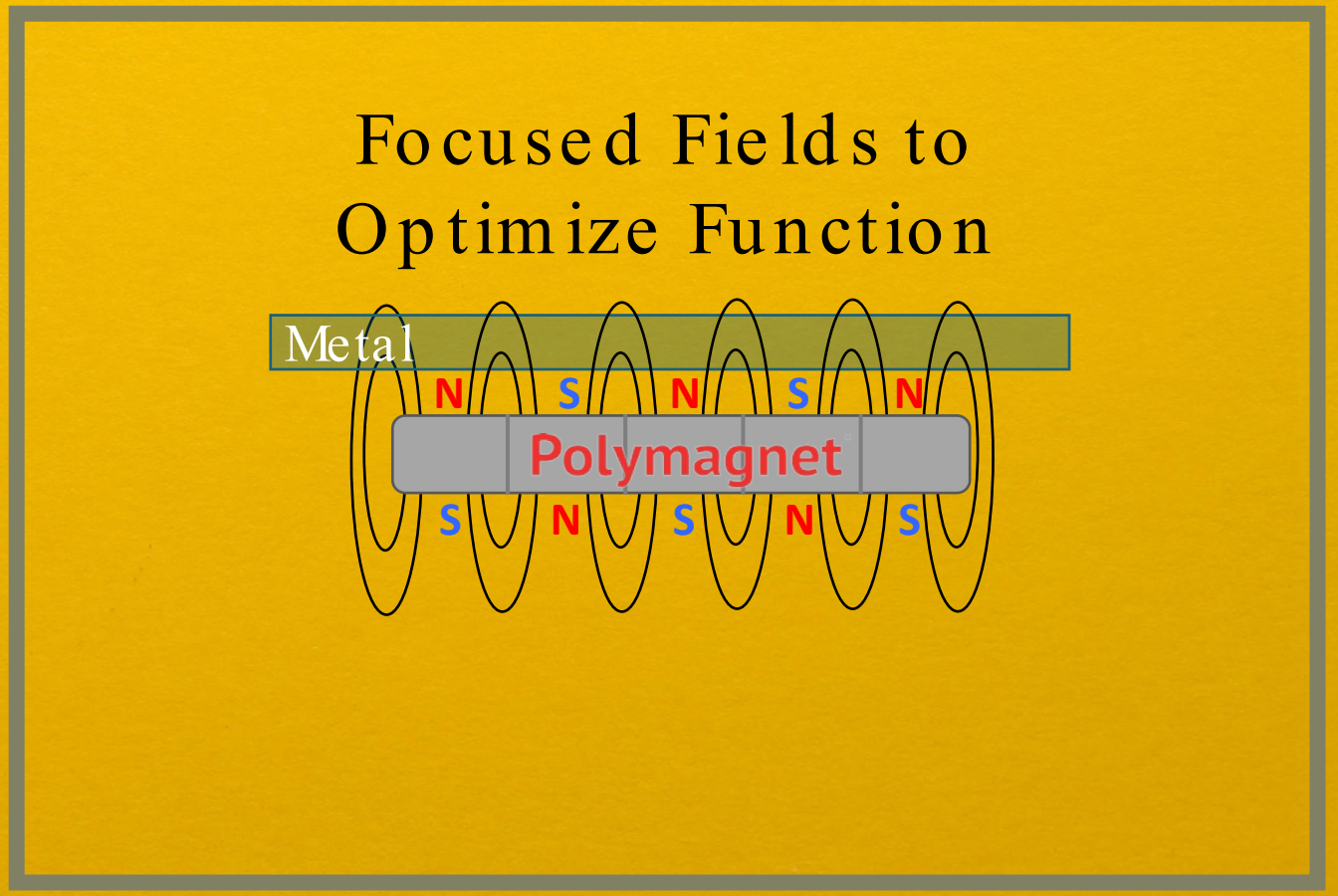
Reduced Flux Waste – Minimize Eddy Currents
Eliminate EMI Issues – Improved Attachment,
Shear & Torsion Forces

Polymagnet®
CORRELATED MAGNETICS

The Box We Design Within

Design Tools:

- **Field Shape**
- **Field Depth**
- **Muti-Function**



Reduced Flux Waste – Minimize Eddy Currents
Eliminate EMI Issues – Improved Attachment,
Shear & Torsion Forces

Polymagnet®
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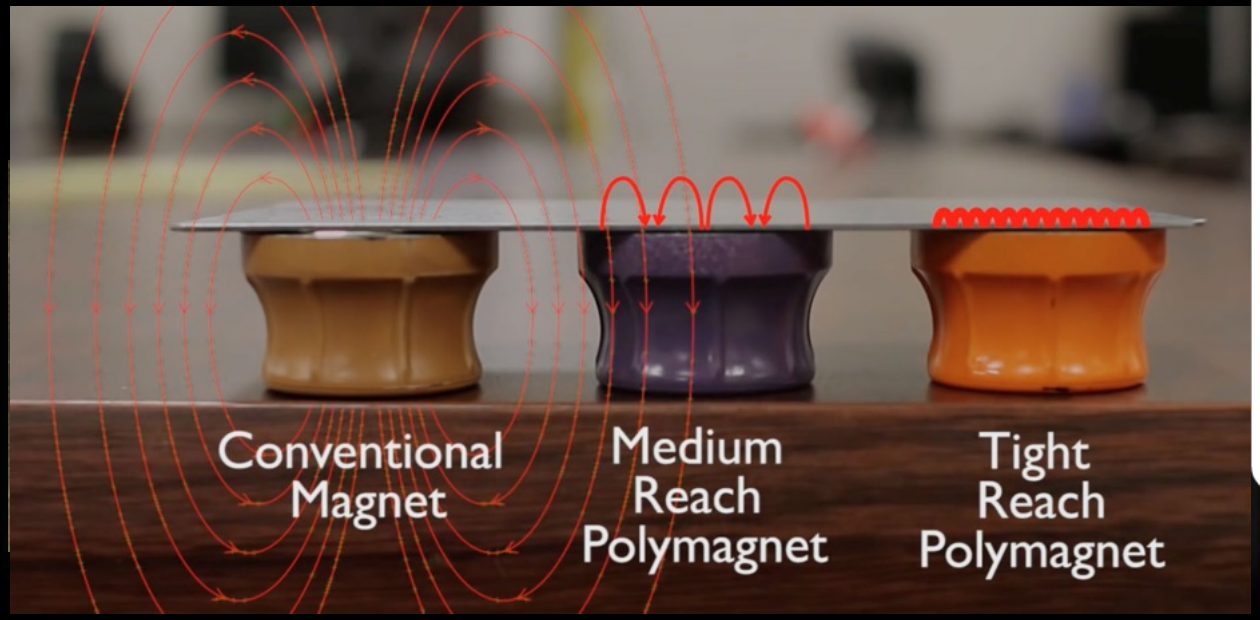
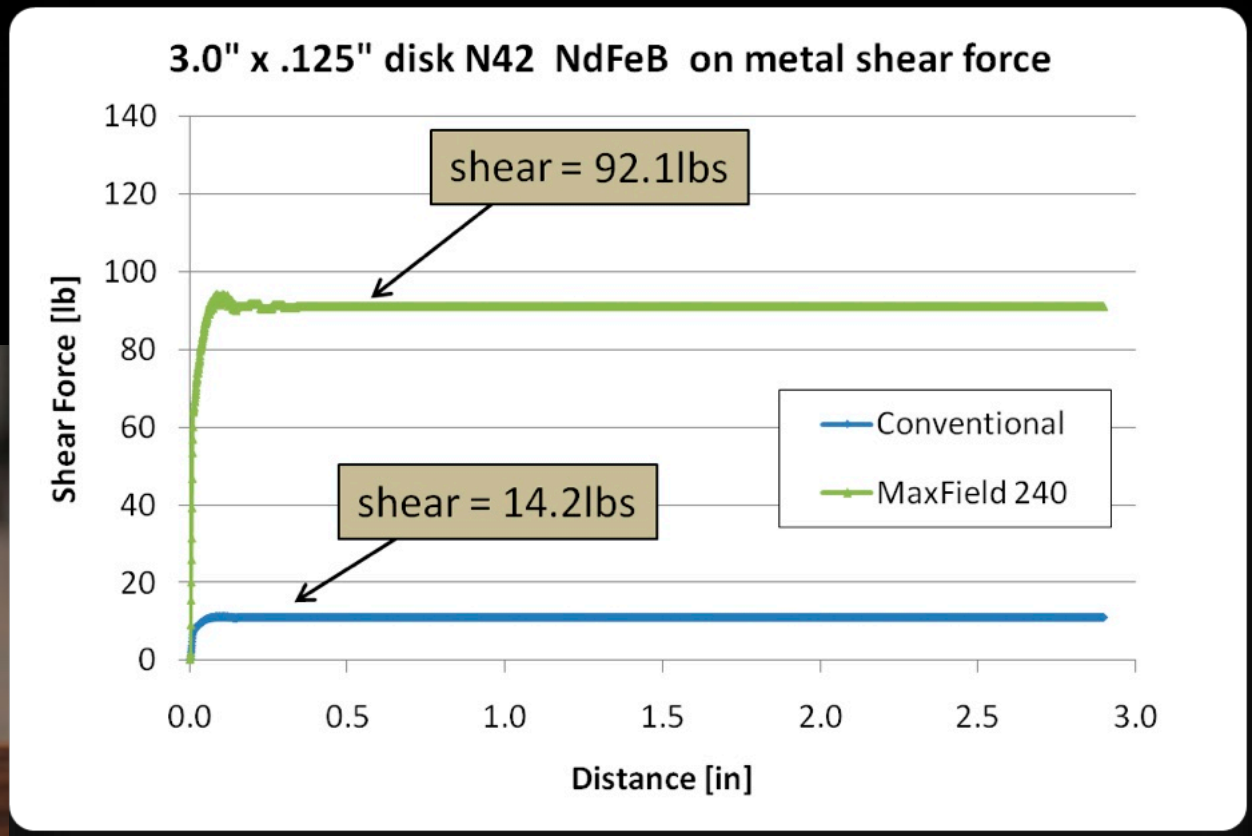
Force and Field Control





Polymagnet® *pattern design optimizes force, field, and experience*

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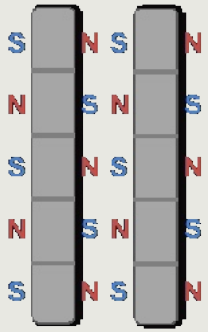
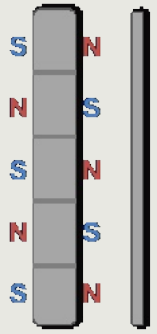
Increased Shear Resistance

Best System

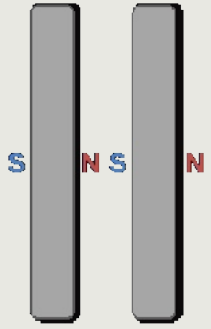
Active shear resistance

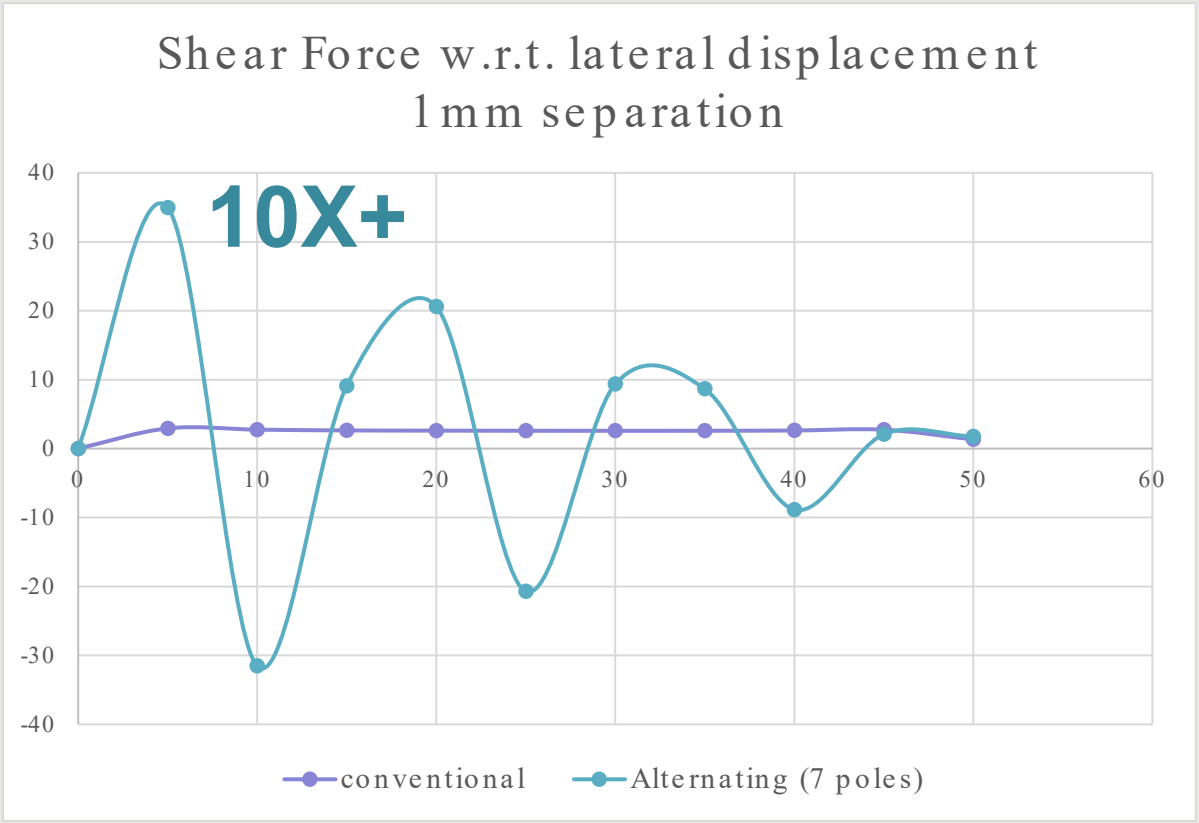


Good System
Strong holding force against friction

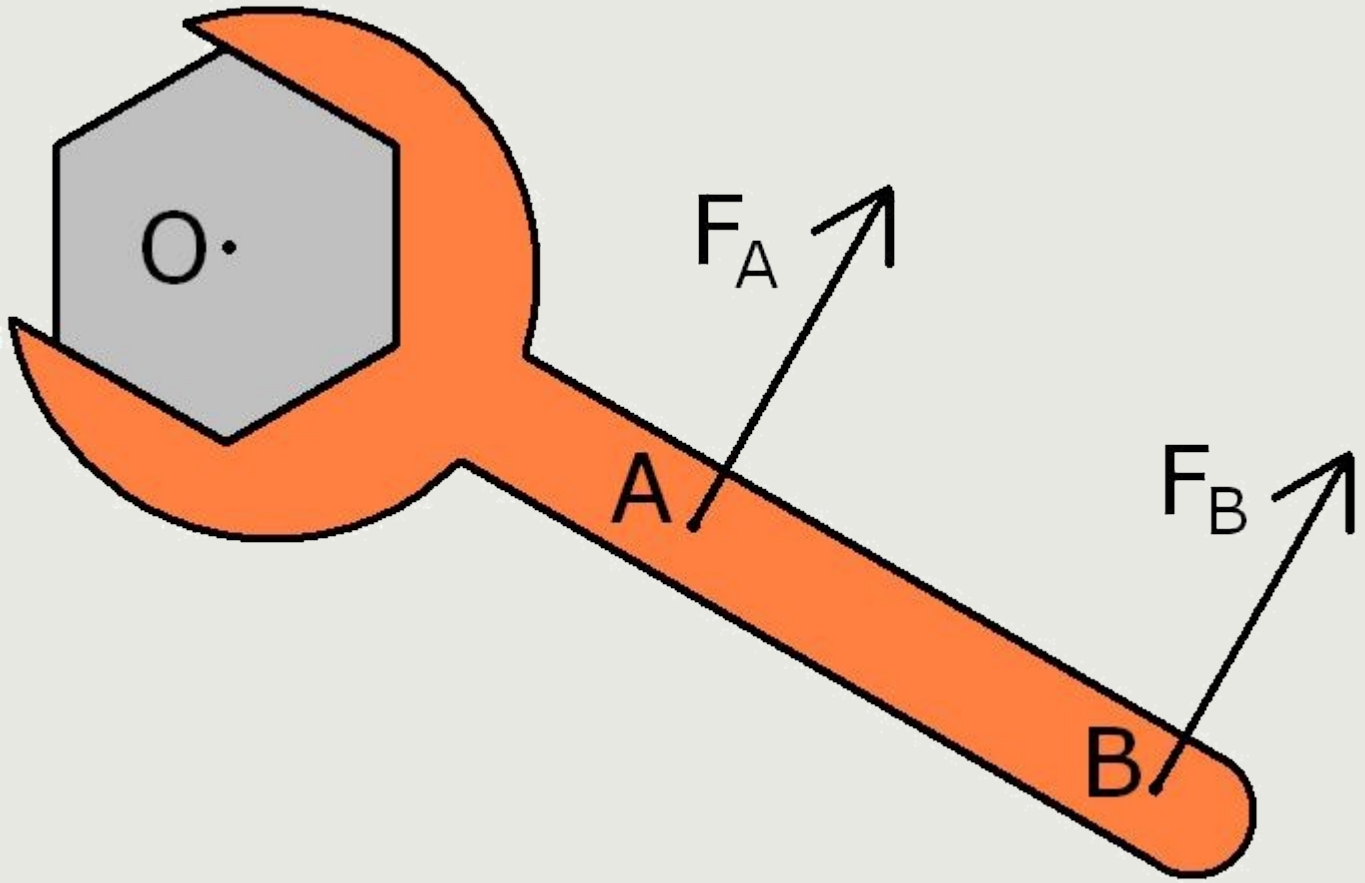


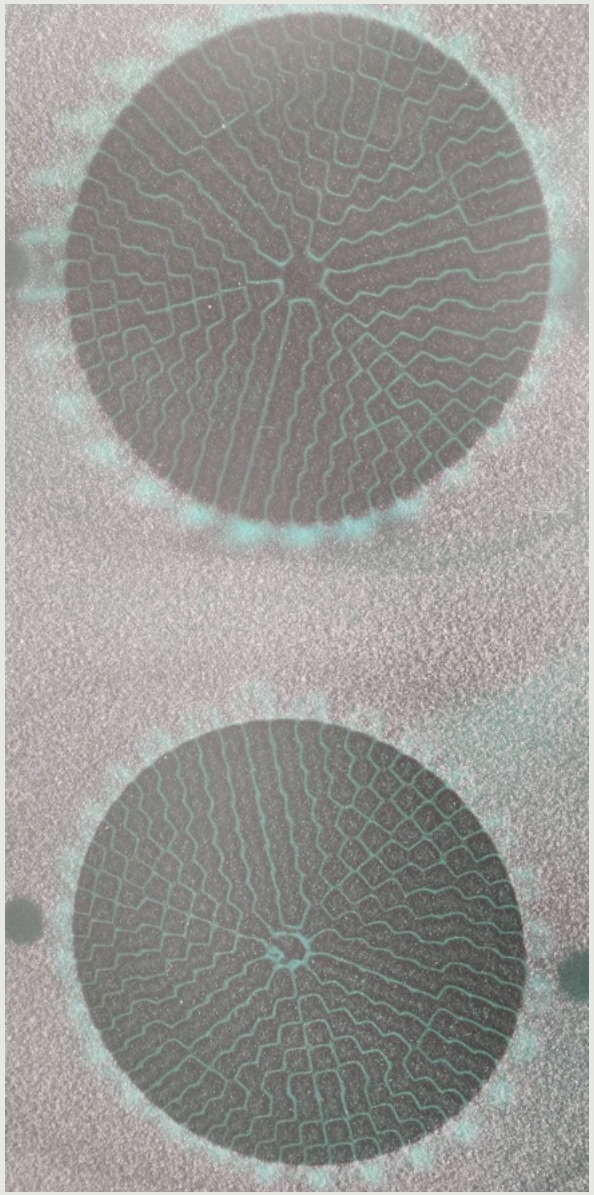
Poor System
Strongest at circumference



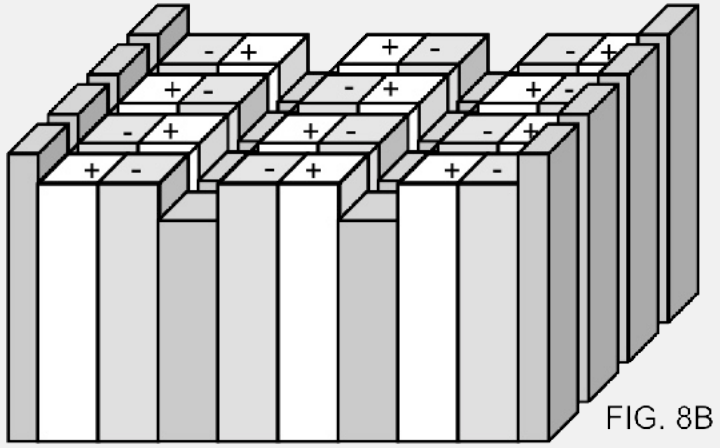


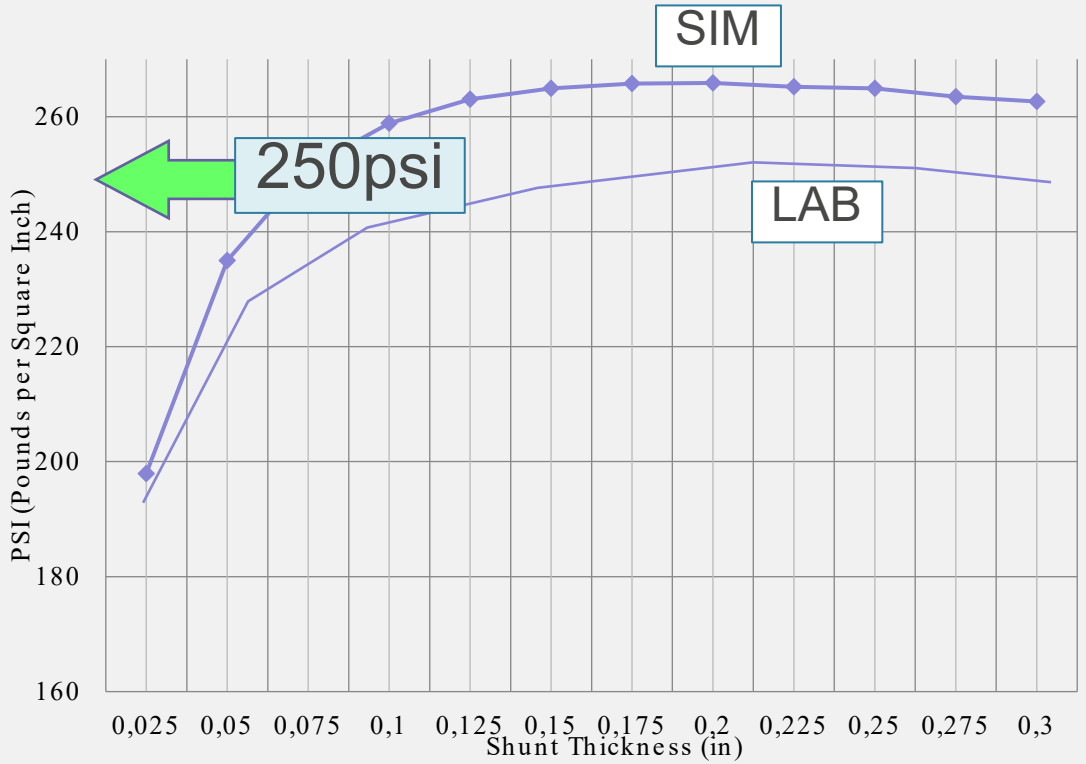
Designing for Torque

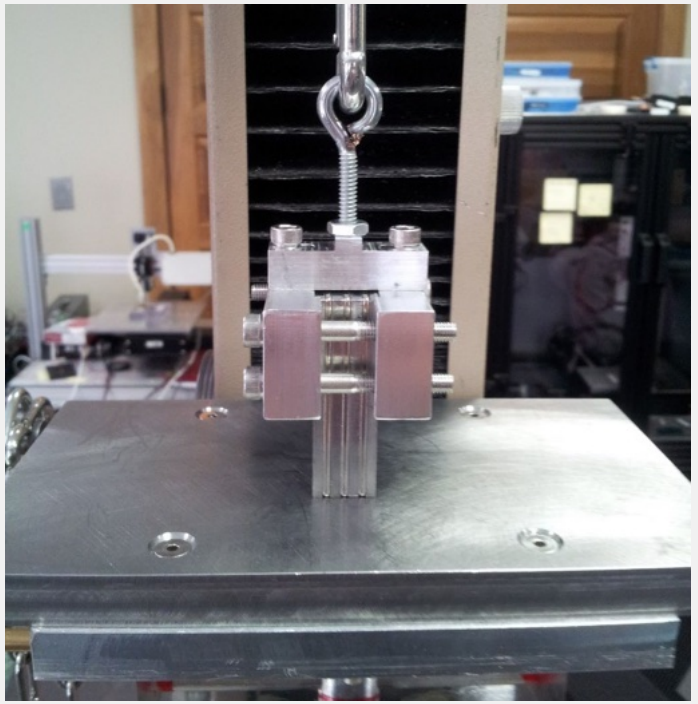




Polymagnet® - Lateral Magnet™







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Time for Some Case Studies

Photo by Mika Baumeister on Unsplash

55N

46N

23N

16N

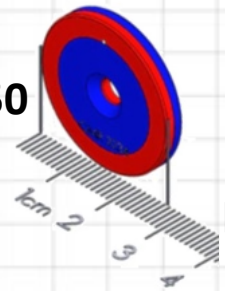
Attachment Force: Magnets vs 0.010" Thick Steel

Reduction in Nd Material Volume or Grade

(or both)

Polymagnet® 1” N50

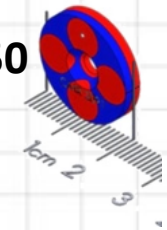
3.5X+



Alternative patterns could increase this to 6-9X, this pattern was for demonstration purposes only

Polymagnet® .75” N50

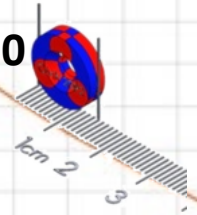
3.0X



42% material volume reduction

Polymagnet® .5” N50

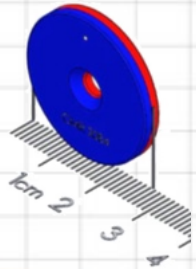
1.4X



75% material volume reduction

Polymagnet® .5” N35

75% material volume reduction & lower cost material



Conventional 1” N50

Polymagnet® excels at thin metal attachment

-	1000320	Square	1"	1"	1/16"	121.99	N40

Polymagnet

Part Number: 1000320

Pairs with: 1000335

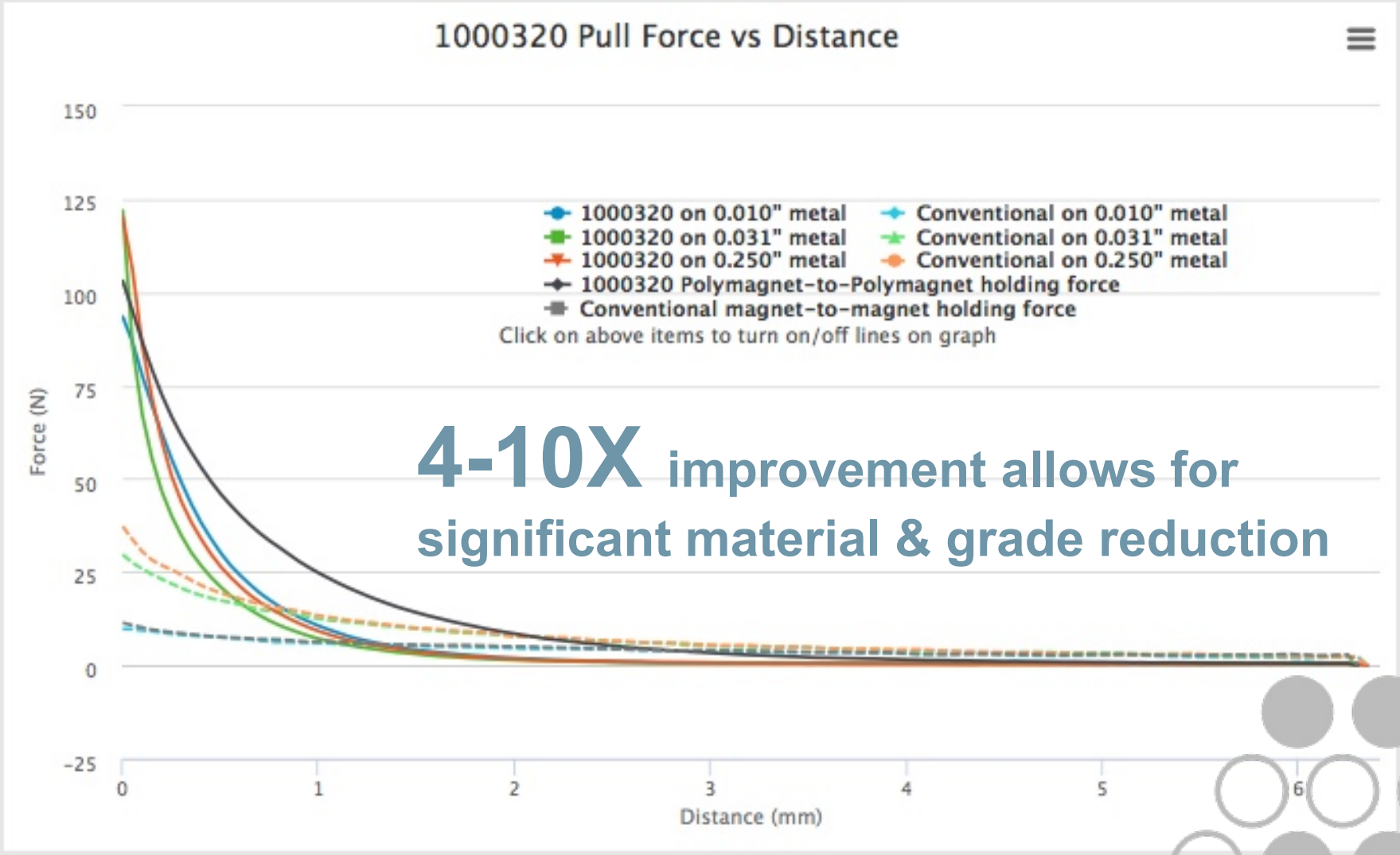
Material Properties

Material: NdFeB

Coating: Ni-Cu-Ni

Maximum Operating Temperature: 80.0° C

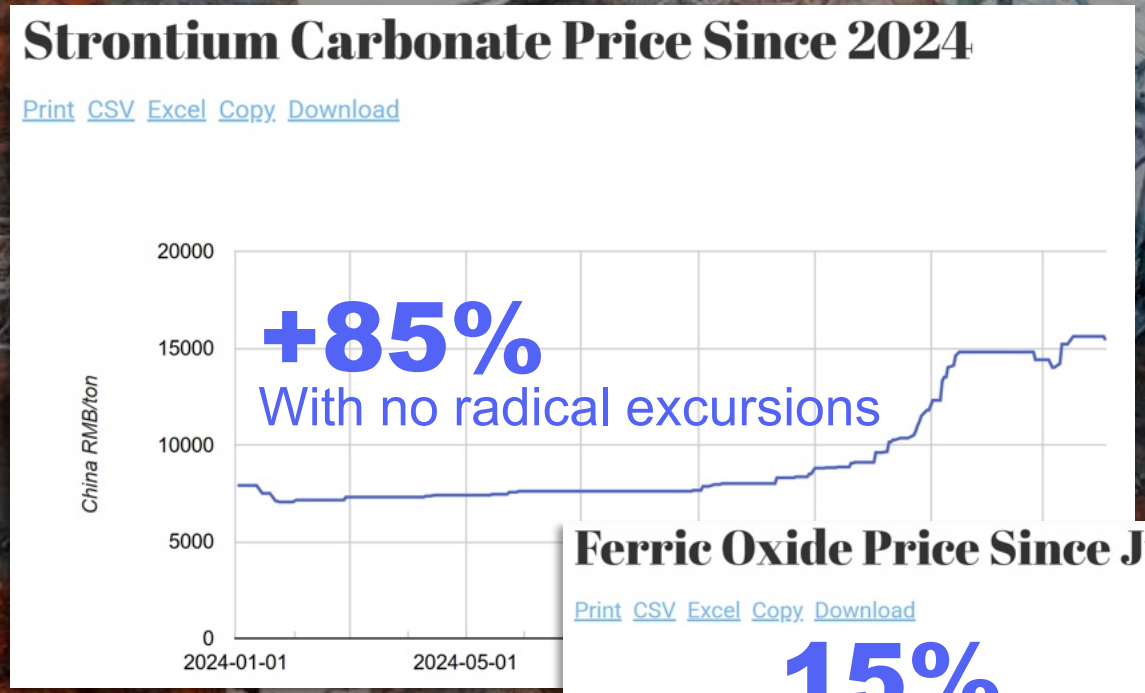
View Details



4-10X improvement allows for significant material & grade reduction

Rare Earth Materials are Significantly More Expensive & Volatile than Ferrite

Nd Magnets are 10X the Price of Ferrite



...and Ferrite exhibits superior mechanical properties as well as being naturally more temperature & corrosion resistant

Polymagnet® Combined with Sizing Allow Ferrite to Compete

Ferrite Grades

Br		Hcb		Hcj		(BH)max		Japan Material Grade	
mT	Gs	KA/m	Oe	KA/m	Oe	KJ/m3	MGOe	Grade	
430-450	4300-4500	247-271	3100-3400	251-275	3150-3450	33.4-36.6	4.2-4.6	6	FB6N (Y36)
390-410	3900-4100	287-310	3600-3900	347-370	4350-4650	28.7-31.8	3.6-4.0	7	FB6H YBM-6BF
420-440	4200-4400	294-326	3700-4100	386-410	4850-5150	33.4-36.6	4.2-4.6	9	FB9H YBM-9BF
440-460	4400-4600	318-350	4000-4400	347-370	4350-4650	36.6-39.8	4.6-5.0	9	FB9B YBM-9BE
450-470	4500-4700	290-267	3350-3650	298-275	3450-3750	38.8-42	4.9-5.3	9	FB9N
450-470	4500-4700	330-360	4150-4450	415-445	5250-5550	39.8-43.0	5.2-5.4	12	
460-480	4600-4800	328-352	4150-4400	368-392	4650-4950	41.5-44.7	5.2-5.6	12	

Ferrite is 90% less expensive

N35 →

N35 is 6:1 Ferrite

N57 is 10:1 Ferrite

N57 →

Polymagnet
CORRELATED MAGNETICS

Magnetic properties of sintered Nd-Fe-B magnets

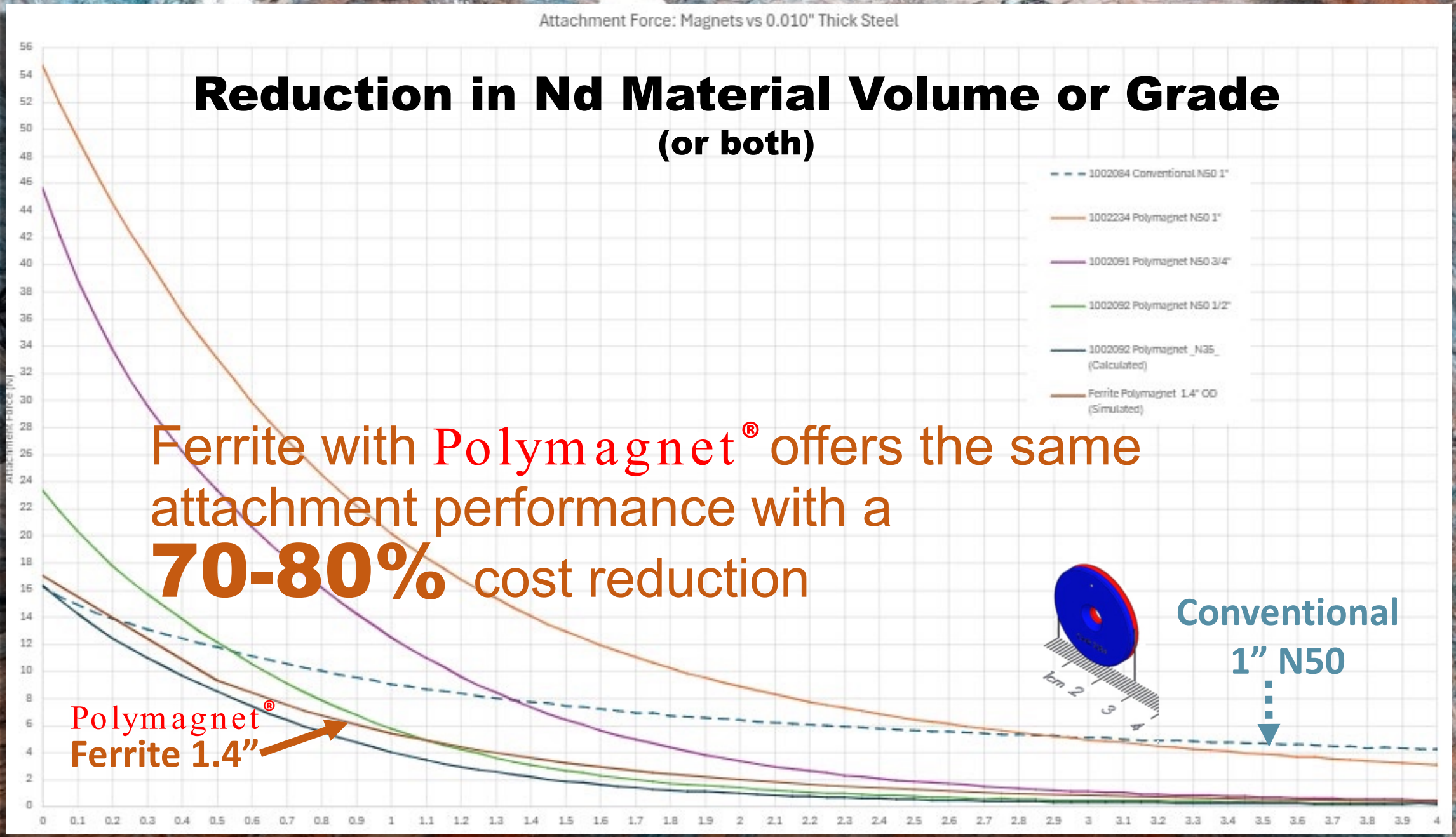
Series	Grade	Remanence Br				Coercivity Hcb		Intrinsic coercivity Hcj		Maximum energy product (BH)max				TemperatureCoefficient %/℃				Hk/Hcj	ρ	Max. operating temperature Tw ℃
Unit		kGs		T		kOe	kA/m	kOe	kA/m	MGOe		kJ/m³		20-100℃		20-150℃		%	g/cm³	
		Max	Min	Max	Min					Max	Min	Max	Min	α (Br)	β(Hcj)	α (Br)	β(Hcj)	Min	typical	L/D=0.7
N	N35	12.20	11.80	1.22	1.18	≥10.8	≥860	≥12	≥955	36	33	287	263	-0.12	-0.78			95	7.5	80
	N38	12.70	12.20	1.27	1.22	≥10.8	≥860	≥12	≥955	39	36	310	287	-0.12	-0.78			95	7.5	80
	N40	13.00	12.60	1.30	1.26	≥10.8	≥860	≥12	≥955	41	38	326	302	-0.12	-0.78			95	7.5	80
	N42	13.40	12.90	1.34	1.29	≥ 10.8	≥860	≥12	≥955	43	40	342	318	-0.12	-0.78			95	7.5	80
	N45	13.80	13.30	1.38	1.33	≥10.8	≥860	≥12	≥955	46	43	366	342	-0.12	-0.78			95	7.55	80
	N48	14.20	13.80	1.42	1.38	≥10.8	≥860	≥12	≥955	49	46	390	366	-0.12	-0.78			95	7.55	80
	N50	14.50	14.00	1.45	1.40	≥10.8	≥860	≥12	≥955	51	47	406	374	-0.12	-0.78			95	7.55	80
	N52	14.70	14.20	1.47	1.42	≥10.8	≥860	≥12	≥955	53	49	422	390	-0.12	-0.78			95	7.55	80
	N55	15.00	14.60	1.50	1.46	≥10.8	≥860	≥12	≥955	55	51	438	406	-0.12	-0.78			95	7.55	80
	N57	15.20	14.80	1.52	1.48	≥10.5	≥836	≥11	≥875	57	53	454	422	-0.12	-0.78			95	7.55	80

55N

46N

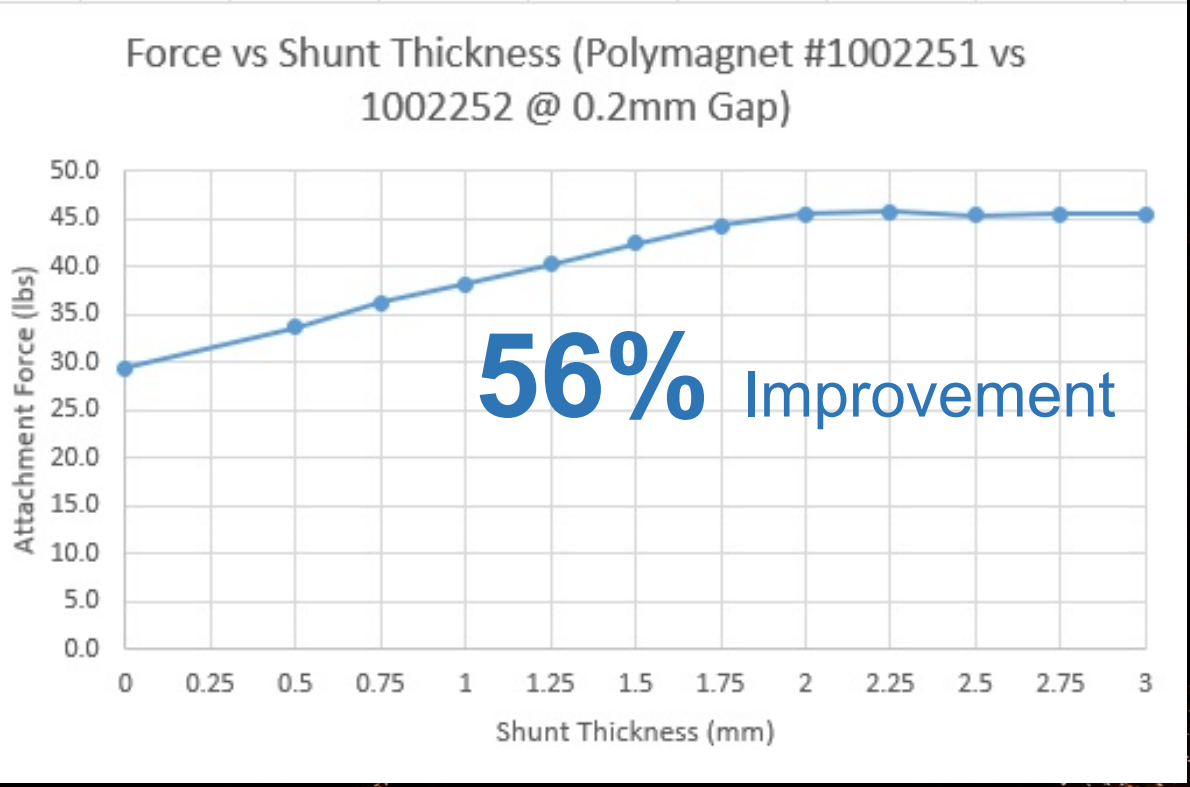
23N

16N



Reducing Magnetic Material Volume with Steel

ShuntThk [mm]	Attachment Force (N)	Attachment Force (lbs)
0	130.8	29.4
0.5	150.0	33.7
0.75	160.9	36.2
1	169.6	38.1
1.25	179.0	40.2
1.5	188.9	42.5
1.75	197.0	44.3
2	202.3	45.5
2.25	203.5	45.8
2.5	202.0	45.4
2.75	202.4	45.5
3	202.3	45.5

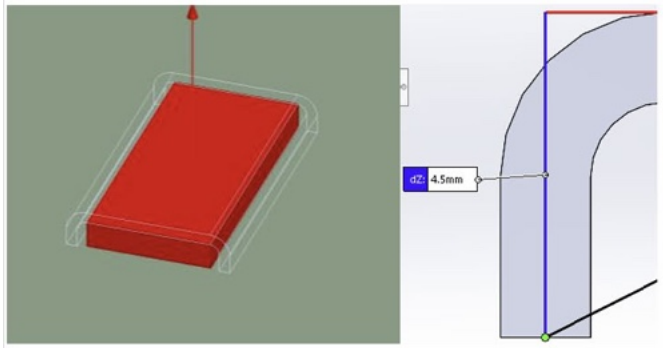


Automotive Application: Substitute Ferrite for Nd, 20lbf (89N) attach force to 1m steel

Uchannel 30.5mmL x 1.25mmT Conventional

	dz [um]	Force_z [newton] Setup1 : LastAdaptive
1	0.000000	122.857000
2	50.000000	89.348150
3	100.000000	70.650590
4	200.000000	49.621790
5	300.000000	37.826610
6	400.000000	30.219080
7	500.000000	24.931620

Uchannel 30.5mm L x 19mm W x 4.5mm T w/ 30.5mm L x 14.428mm W x 3.15mm T Ferrite Magnet



- The magnetizer weighs a few hundred pound
- Requires no gas, water or special facilities installation
- It can run on household voltage and current
- It can operate in a very small footprint and magnetize millions of magnets a year

Polymagnet can be Easily & Quickly Moved to Optimize Your Supply Chain

Polymagnet® can:

- Reduce the amount of magnetic material used by up to 80%
- Design with lower grades of Nd
- Use recycled materials
- Substitute Ferrite for Nd which is 90% less expensive and widely available
- Design & produce novel and unique magnetic functionality providing product differentiation
- Fully saturate magnetic materials yielding higher performance
- Accelerate the design & production cycle by enabling rapid iterative design & prototyping
- Quickly and effortlessly move production to optimize the supply chain
- **Polymagnet®** is your solution to the challenges of today's complex & volatile business environment

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