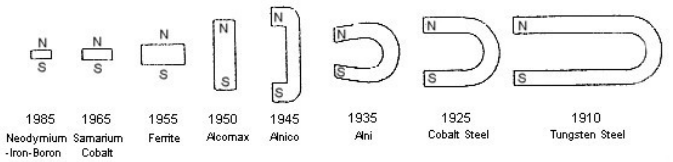
MMG MagDev Limited

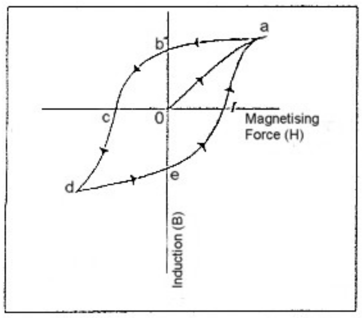
AN INTRODUCTION TO PERMANENT MAGNETS

COMPARATIVE SIZES FOR MAGNETS AS PERFORMANCE STEADILY IMPROVES



1) 80 YEARS OF PERMANENT MAGNET PROGRESS

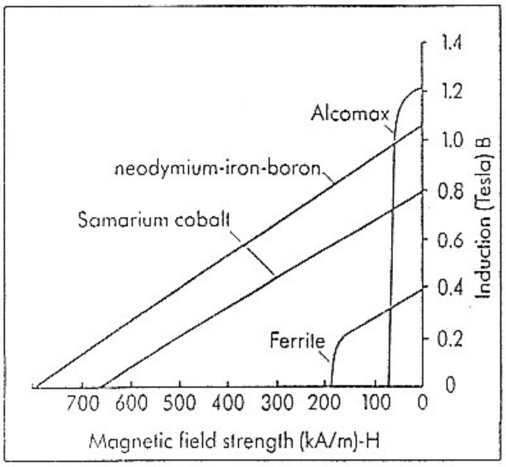
The changing shapes of magnets over the years are shown from the familiar horseshoe shape to the small block or disc as materials improved, so the volume decreased and the much higher coercive forces available reduced the need for long magnetic lengths.



Complete Hysterisis Curve

2) TYPICAL HYSTERESIS CURVE FOR A PERMANENT MAGNET MATERIAL

The second quadrant of the curve (*boc*) is used to demonstrate the demagnetisation characteristics of a permanent magnet material.



Typical 2nd quadrant demagnetisation curves

3) Generally only the last four materials shown in **1)** are still in use today. Typical second quadrant curves for these materials are shown.

4) COMPARING MAGNETIC PERFORMANCES

For convenience it is usual to express the maximum energy product per unit volume. This is the point on the demagnetisation curve where the magnet will provide the most energy for the minimum volume, so:

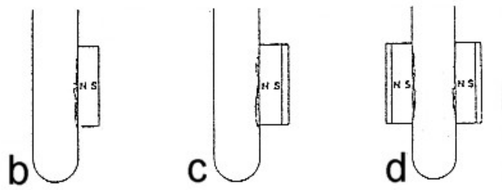
	MGOe	kJm^{-3}
FERRITE	3	24
ALCOMAX	5	40
SAMARIUM COBALT (1:5)	18	144
SAMARIUM COBALT (2:17)	25	200
NEODYMIUM-IRON-BORON	32	256
N.B. MGOe IN CGS UNITS		
kJm^{-3} IN SI UNITS		

5) MAGNETIC ATTRACTION

The attraction between a permanent magnet and a ferrous body is dependent on three main factors:

B = The flux density on the pole face
A = The area of the pole face
μ =the permeability of the material being attracted according to the relation: F= B² Aμ.

B & **A** can be constant for any specific shape of magnet, then the time taken to attract ferromagnetic bodies is controlled by its permeability. Thus, a solid piece of iron will be attracted instantly to a magnet, whereas bodies of low permeability, particularly in a fluid, will take longer.



6) TO OBTAIN THE MAXIMUM FLUX DENSITY (B) IT IS IMPORTANT TO OBSERVE CERTAIN CRITERIA

a) Use the highest grade of material available (usually Samarium Cobalt or Neodymium-Iron-Boron) consistent with environmental conditions.

b) Place the magnet as close as possible to the material being attracted. (The field will reduce proportionally to the square of the distance between the two).

c) Place a ferrous backing plate behind the magnet (at least 2 mm thick) to improve the performance by around 30%.

d) Place magnets with opposite poles facing each other on either side of the test area.

TYPICAL FLUX DENSITY READINGS ON POLE FACES	
ALCOMAX	130 mT
FERRITE	100 mT
SAMARIUM COBALT (1:5)	280 mT
SAMARIUM COBALT (2:17)	320 mT
NEODYMIUM-IRON-BORON	400 mT

7) To achieve the maximum magnetic "throw" when opposite poles are in the same plane, it is necessary to position the poles as far apart as possible in the space available. Although field strengths will be lower, the throw will be much greater, as will the field gradient. A high field gradient is always desirable when attracting very small particles. A high gradient is also achieved when using a single pole.

8) **MAXIMUM WORKING TEMPERATURES**

ALCOMAX	540°C
FERRITE	250°C
SAMARIUM COBALT (1:5)	250°C
SAMARIUM COBALT (2:17)	300°C
NEODYMIUM-IRON-BORON	50°C - 200°C*
* DEPENDENT ON SHAPE AND GRADE	

9) **CORROSION RESISTANCE UNPROTECTED**

ALCOMAX	FAIR
FERRITE	EXCELLENT
SAMARIUM COBALT (1:5)	EXCELLENT
SAMARIUM COBALT (2:17)	EXCELLENT
NEODYMIUM-IRON-BORON	POOR *
* PROTECTIVE COATINGS SUCH AS NICKEL ARE RECOMMENDED	

10) **MAGNETIC STABILITY**

A) Demagnetisation effects caused by exposure to external magnetic fields

ALCOMAX	HIGH
FERRITE	LOW
SAMARIUM COBALT (1:5)	VERY LOW
SAMARIUM COBALT (2:17)	VERY LOW
NEODYMIUM-IRON-BORON	VERY LOW

B) Effect of time on Magnetic Performance

Negligible on any of the above materials and averages a loss of less than 1 x 10^{-5} per annum at 20°C.

C) Reversible Effect of Temperature (20°C - 200°C*)

ALCOMAX	-0.02%°C^{-1}
FERRITE	-0.19%°C^{-1}
SAMARIUM COBALT (1:5)	-0.04%°C^{-1}
SAMARIUM COBALT (2:17)	-0.03%°C^{-1}
NEODYMIUM-IRON-BORON	-0.12%°C^{-1}*
*DEPENDANT ON GRADE (SEE **8)** ABOVE)	

For further information including a booklet on **The Effect Of Temperature Variations On The Magnetic Performance Of Permanent Magnets** contact:

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