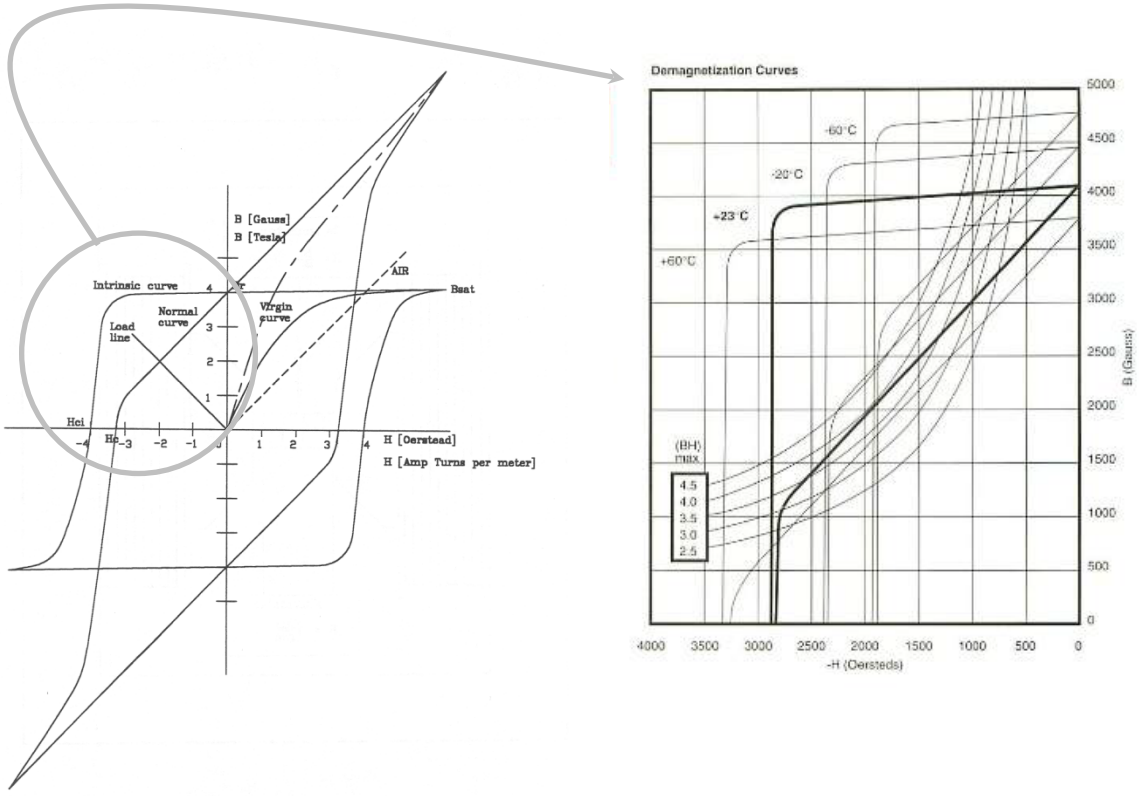
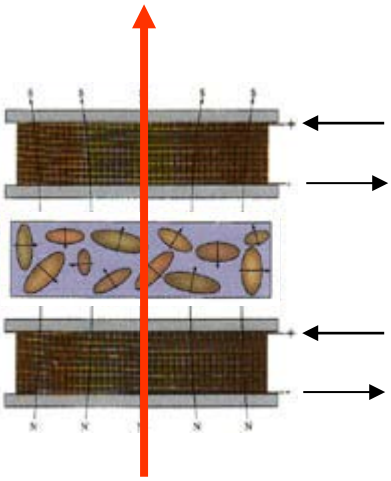
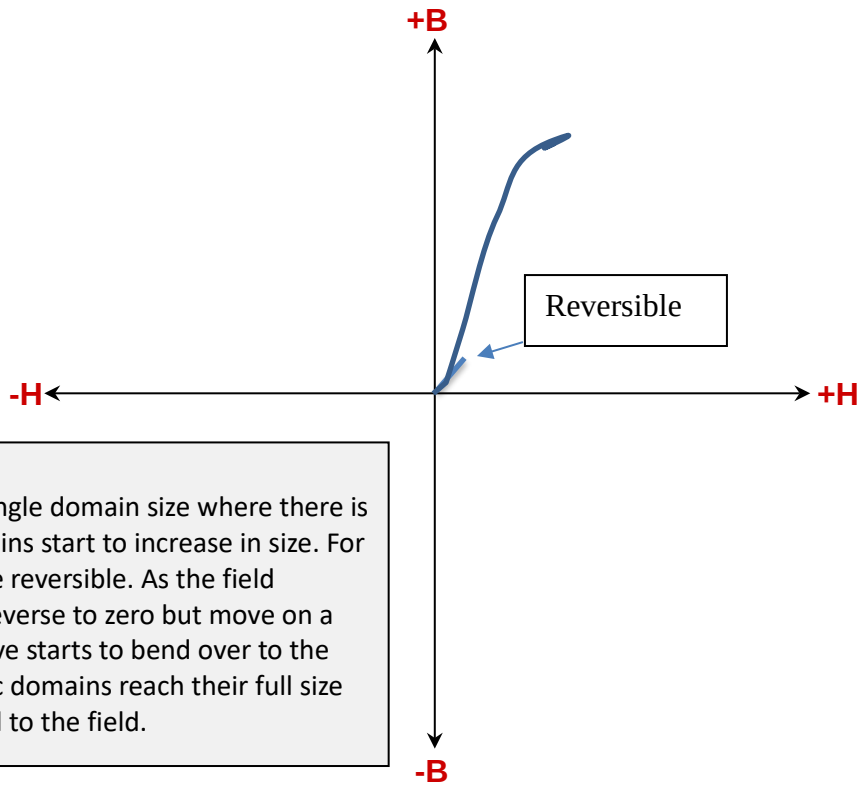
Understanding the Hysteresis (BH) Curve

Hysteresis curves, also called B-H curves, describe the Intrinsic and Normal magnetic properties of a material. The Hysteresis curve is commonly seen in supplier catalogs as a second quadrant curve showing Br, Hc, Hci and $BH_{(max)}$. The test is normally performed by the magnet manufacturer during the initial stage of processing. Because of the lengthy process, it is not practical to perform the test on large numbers of finished parts. Instead, it is common to have one B-H curve supplied with each lot of parts.

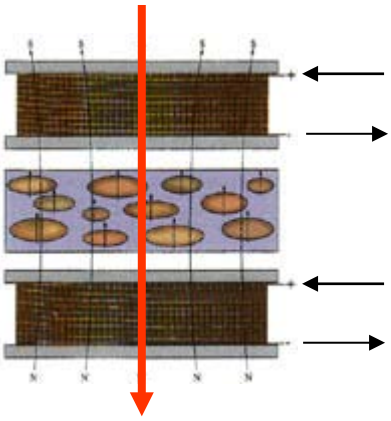


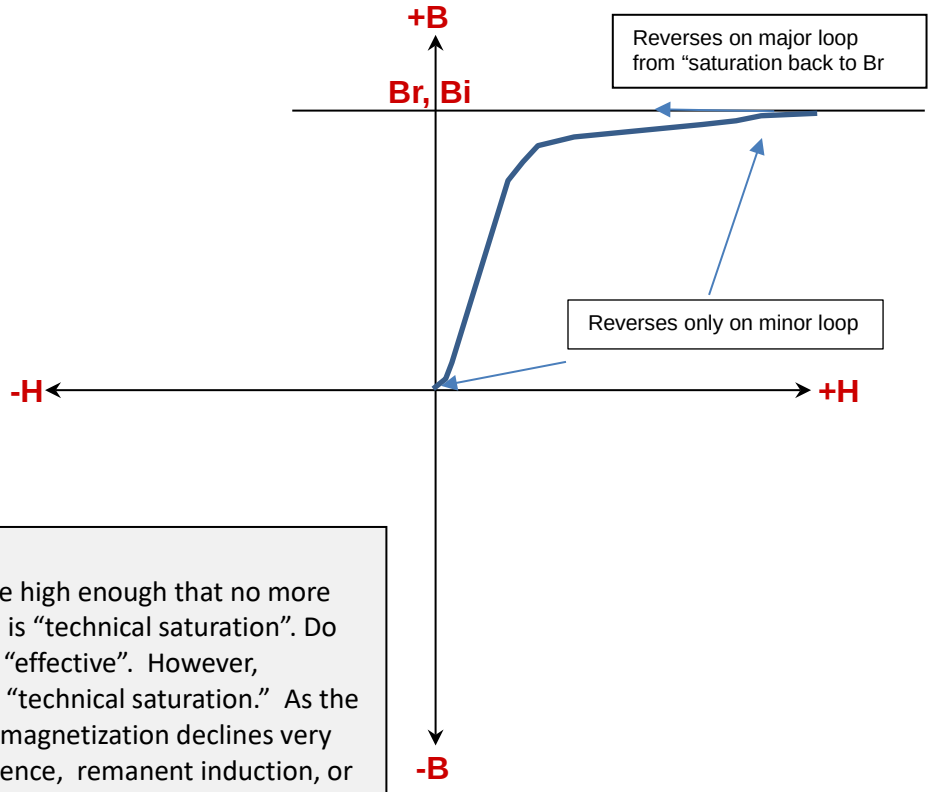
In the following descriptions we are going to put the magnet in a closed magnetic circuit of infinite permeability and no air gaps. This allows us to avoid the un-necessary inclusion of self-demagnetizing effects.



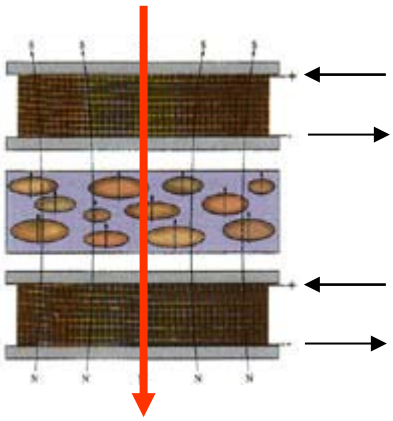


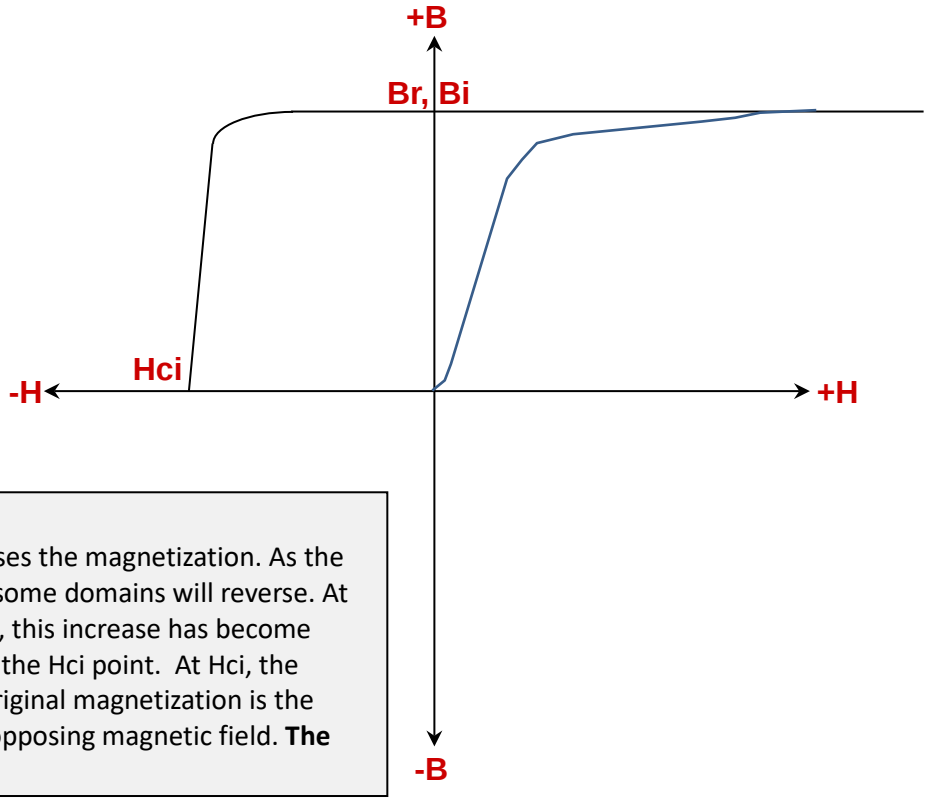
1st Quadrant: Virgin Curve
The domains are very small, below the single domain size where there is resistance to demagnetization. The domains start to increase in size. For a small interval, the magnetization will be reversible. As the field increases, magnetization will no longer reverse to zero but move on a minor hysteresis loop. Eventually the curve starts to bend over to the right, but still increases as more magnetic domains reach their full size and their magnetizations become parallel to the field.



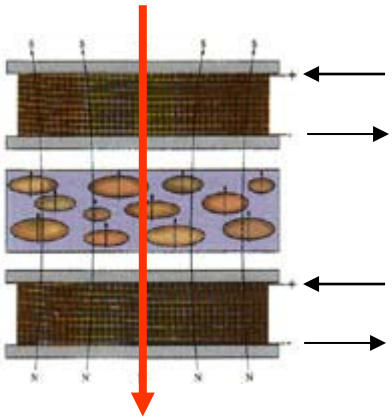


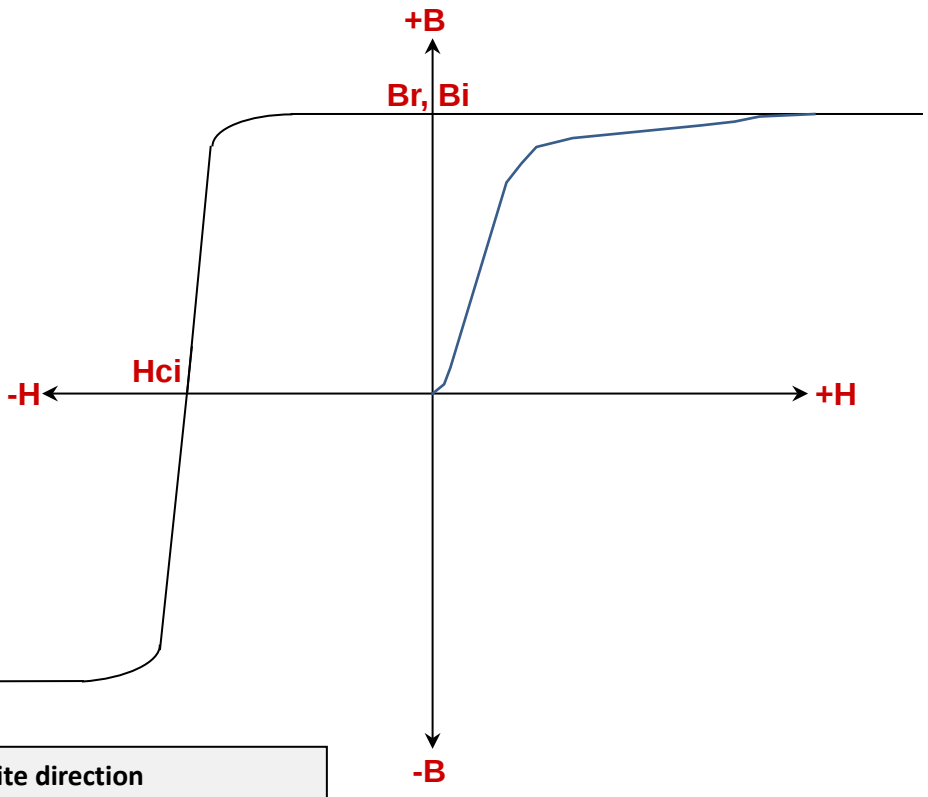
1st Quadrant: Saturation
Eventually the magnetic field will become high enough that no more change in the magnetization occurs. This is "technical saturation". Do not confuse technical with "practical" or "effective". However, technology is sufficient to reach 99+% of "technical saturation." As the field is backed off from "saturation", the magnetization declines very slightly to the Br point. This is the remanence, remanent induction, or residual induction. All of the magnetic energy is now in the magnet and its field.



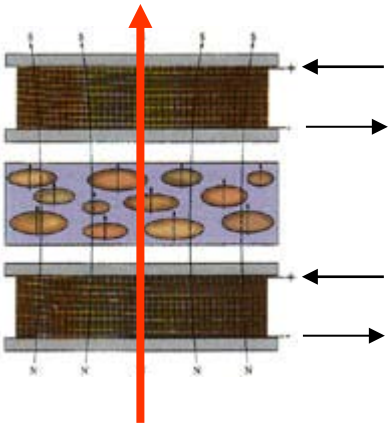


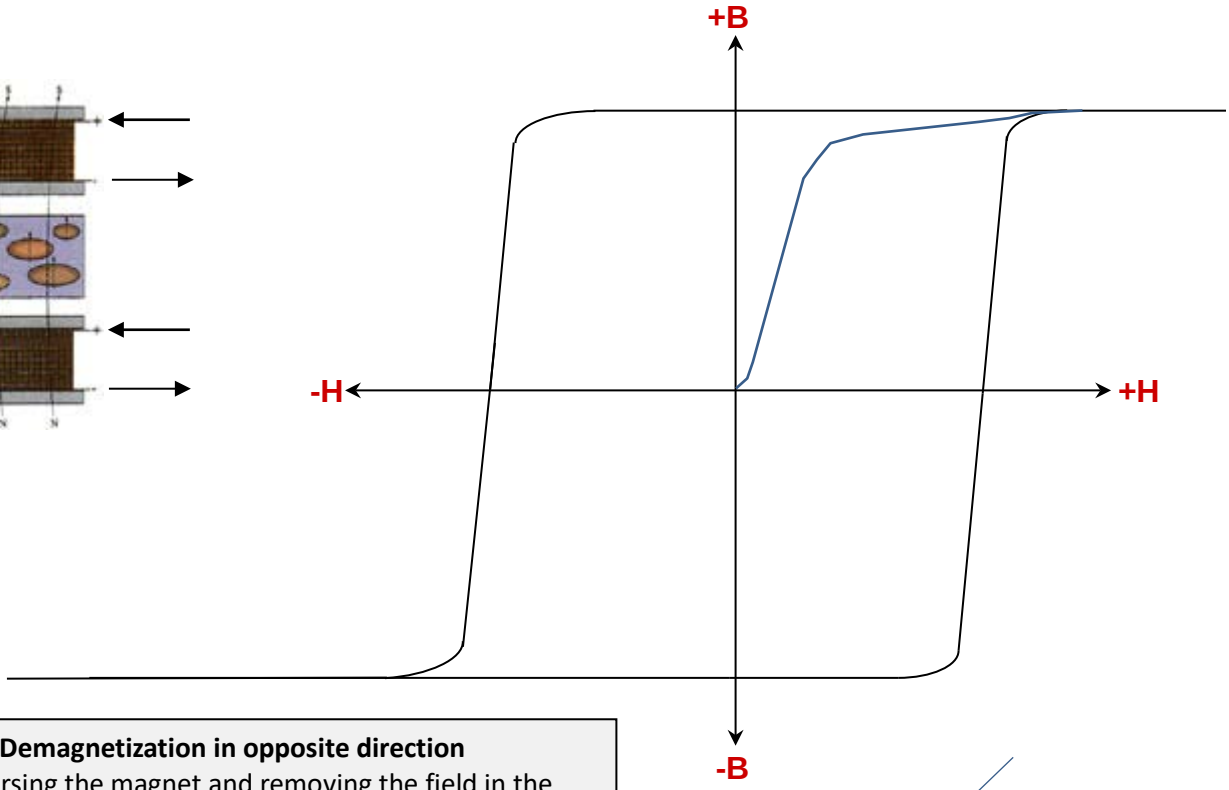
2nd Quadrant Demagnetization
In this quadrant the applied field opposes the magnetization. As the negative field increases in magnitude, some domains will reverse. At the knee of the demagnetization curve, this increase has become rapid and the magnetization will fall to the Hci point. At Hci, the number of domains aligned with the original magnetization is the same as the number aligned with the opposing magnetic field. **The net magnetization is zero**



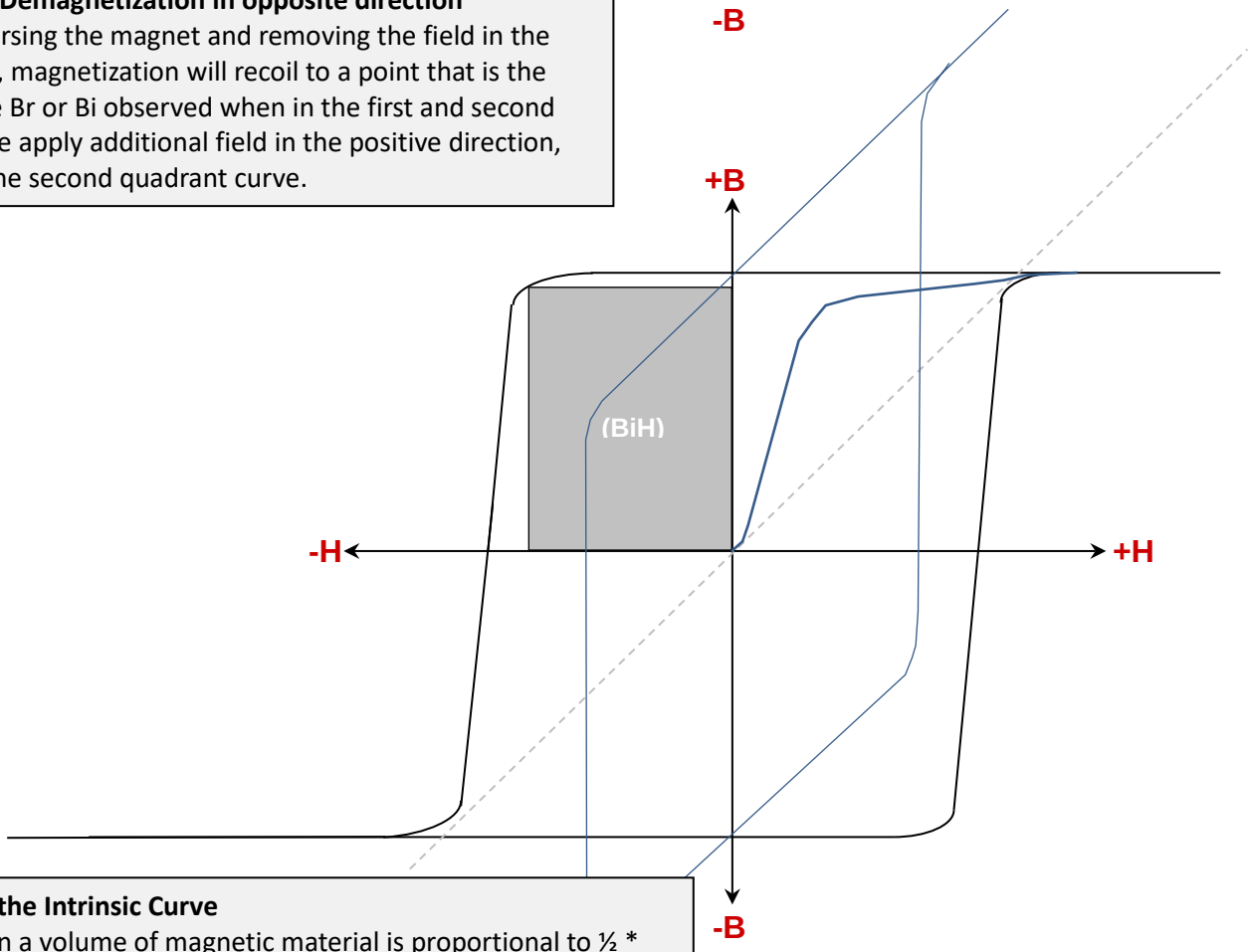


3st Quadrant: Remagnetization in opposite direction
In the third quadrant, **the total magnetization of the part will be reversed.** If we go far enough, magnetization will reach the saturation level in the negative direction.





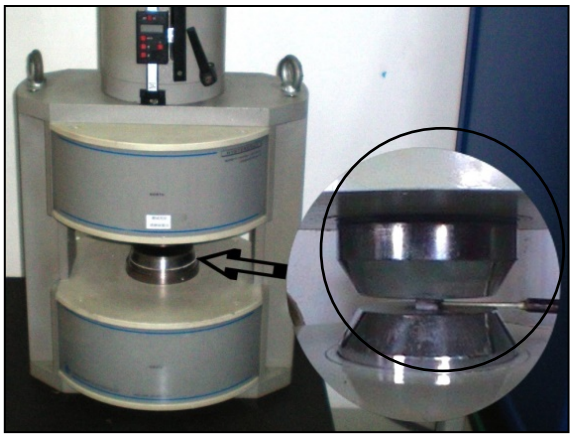
4th Quadrant: Demagnetization in opposite direction
After fully reversing the magnet and removing the field in the third quadrant, magnetization will recoil to a point that is the negative of the Br or Bi observed when in the first and second quadrant. If we apply additional field in the positive direction, we duplicate the second quadrant curve.



BHmax and the Intrinsic Curve
The energy in a volume of magnetic material is proportional to ½ * B*H or ½ * M*H. We show two energies: the transparent rectangle is the maximum intrinsic energy and the solid rectangle is the energy associated it the normal curve, covered in a following section. The intrinsic energy is useful for materials manufacturers. The normal curve is used in designing magnetic circuits.

Instrument for developing a BH Curve (Permeameter)

This test can be performed at various temperatures. The equipment is comprised of a DC Magnetizer and a Fluxmeter connected to a Search Coil. Of the various tests for magnetic materials, this is one of the most expensive because the sample material must be machined to a precise dimension, usually a cube, and a search coil is then wound around the sample. The sample is then placed between two large pole pieces which create a closed loop system (pic. 3). A DC magnetizer cycles the sample from origin to saturation, to complete demagnetization, to saturation in the opposite direction, and finally back to the original saturation level. The fluxmeter continuously records B and H and, via special software, provides a B-H or Hysteresis Curve (fig. 2). This data is commonly seen in supplier catalogs as a second quadrant curve showing Br, Hc, Hci and $BH_{(max)}$. The test is normally performed by the magnet manufacturer during the initial stage of processing. Because of the lengthy process, it is not practical to perform the test on large numbers of finished parts. Instead, it is common to have one B-H curve supplied with each lot of parts.



Pic. 3

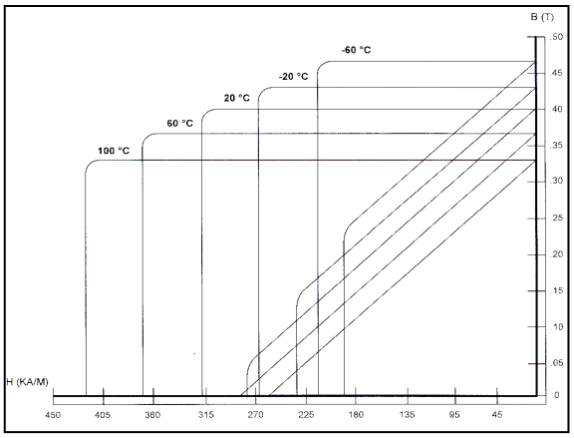


Fig. 2

If you have any questions regarding the BH Curve or the equipment please feel free to call or customer support team at 219-548-3799 or engineering@allianceorg.com