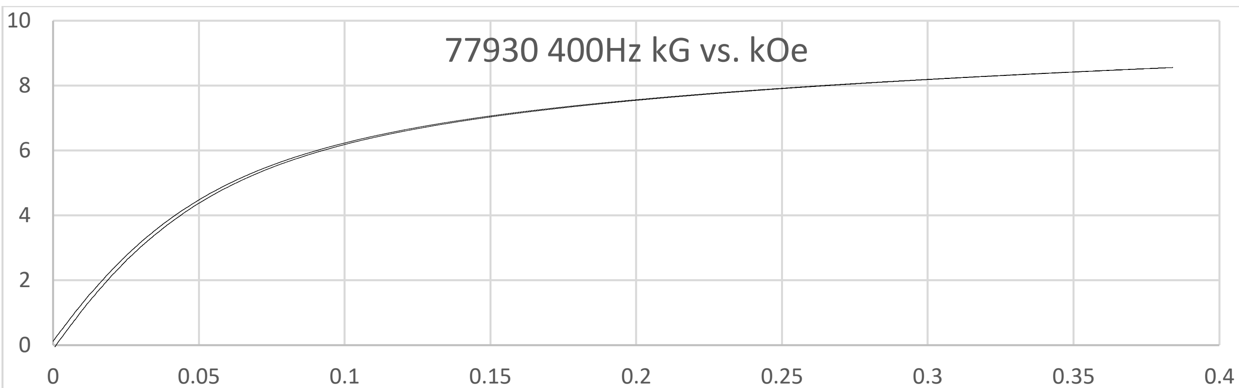
October 2022

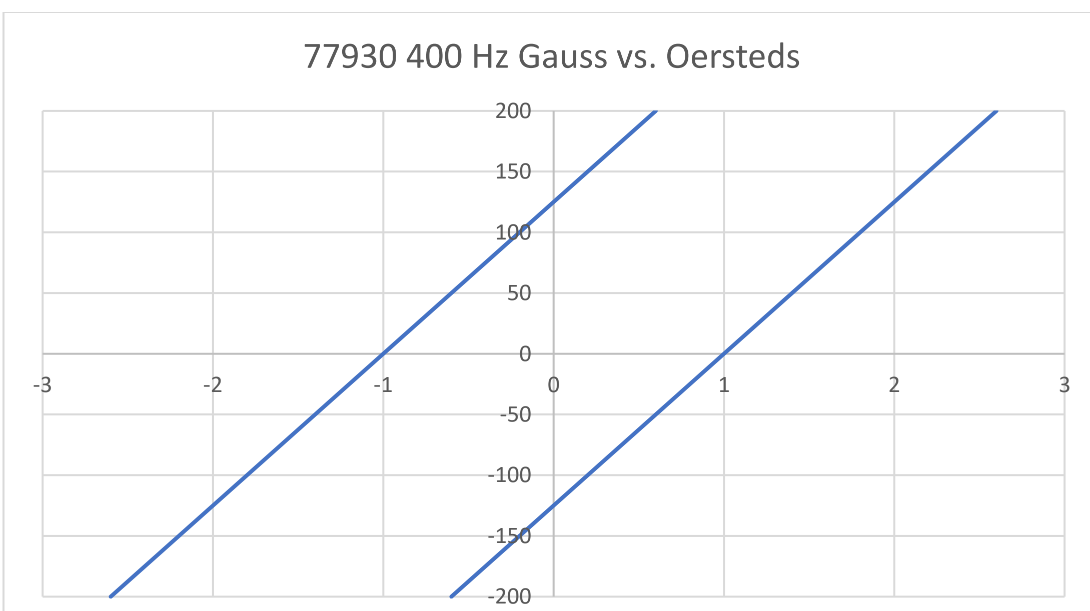
Powder Core Hysteresis Curves

BH loops for powder cores are very narrow and flattened due to the low material permeability and high supported currents. Consequently, the concepts of B_r (remanence) and H_c (coercive force) that are useful for other types of cores are not useful or even easily measured for powder cores. Jiles-Atherton coefficient models of ferrites and tape wound cores depend on BH loop data points that are not applicable in the same way for powder cores.

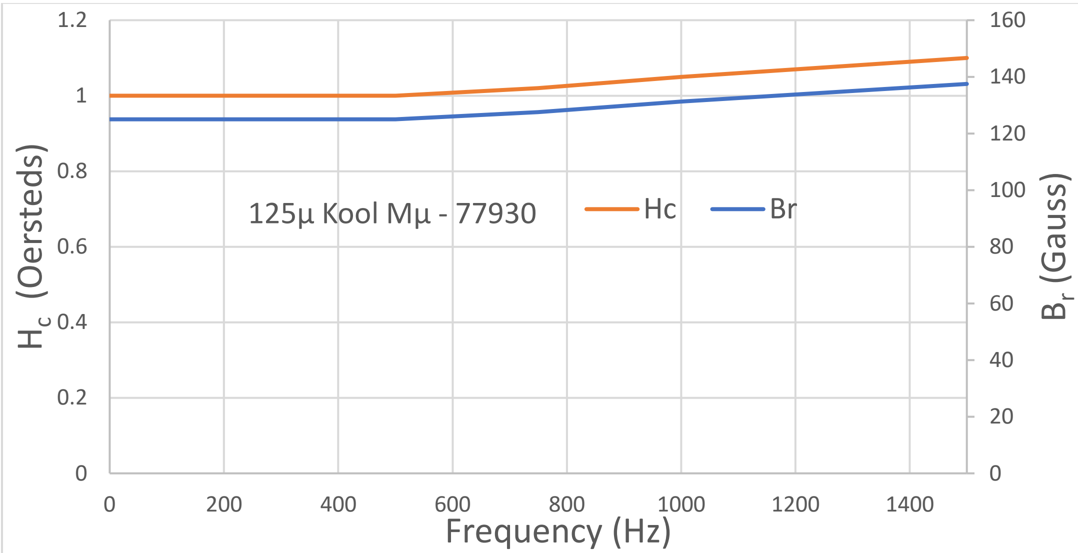
To illustrate, Magnetics plotted the BH curve for a standard 125µ Kool Mµ core, 77930-A7. The drive frequency for this curve is 400 Hz, since that is the lowest frequency that resulted in stable readings.



Zooming in on the area close to the origin, the remanence for this core is seen to be about 125 G (12.5 mT) and the measured coercive force is about 1 Oersted. Other Kool Mµ cores will be in a similar range, with B_r roughly proportional with permeability, since the width of the loop does not change much for different permeabilities. Note that the exact value of B_r will have no practical impact on the permeability of the material, nor to its response to DC bias current. A difference among B_r values of, for example, 0 G, 125 G, and 500 G, would be indistinguishable in cores' impedance, load response, or AC losses.



As noted above, tracing a true DC BH loop plot is not simple to do. Nor is it necessary for a high frequency powder core material. To demonstrate that the 400 Hz BH loop is essentially the same as a DC loop, hysteresis curves were plotted from 400 Hz to 1500 Hz, with the result that the width of the hysteresis varies only slightly and can be extrapolated to a nearly flat curve from 400 Hz to 0 Hz.



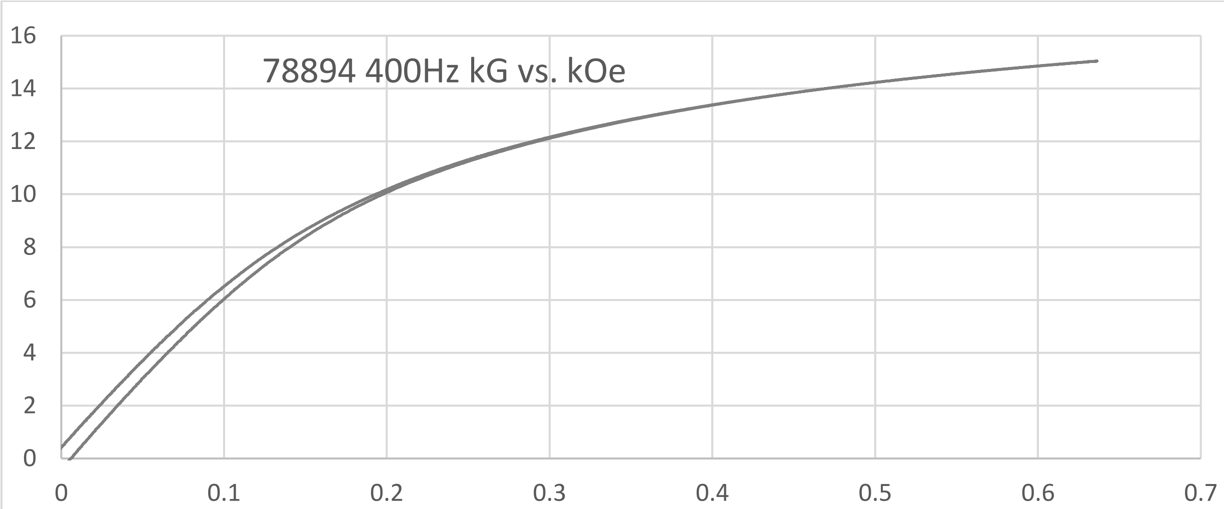
To show the similarity with other powder core materials, Magnetics generated the same plots for a standard 60µ XFlux core, 78894-A7. Those are shown below.

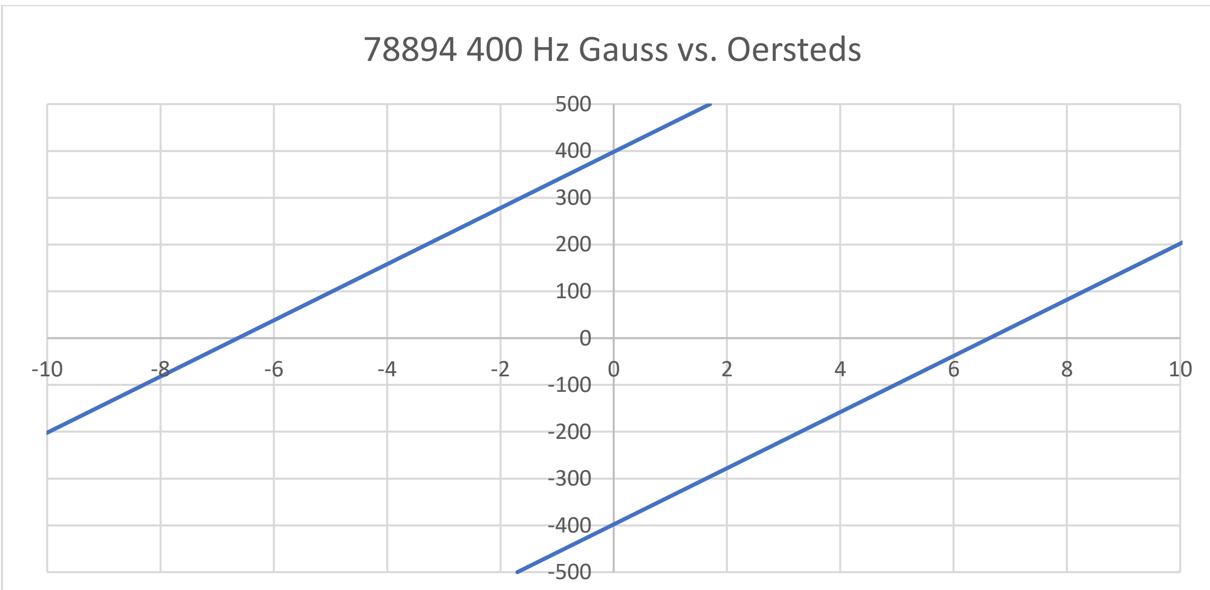
Comparing 77930-A7 (125µ Kool Mµ) with 78894-A7 (60µ XFlux), several differences are apparent.

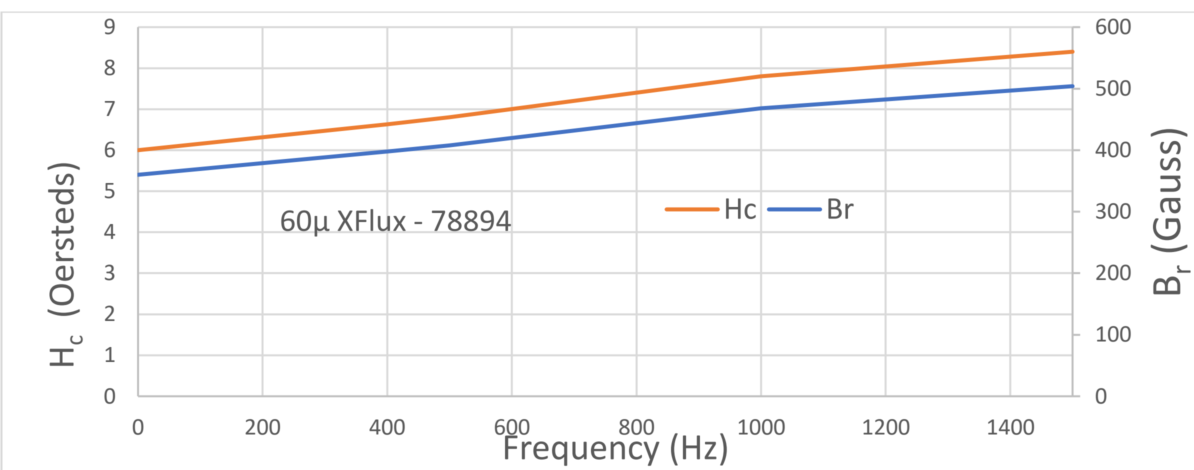
- The 77930-A7 BH loop is narrower, which is consistent with Kool Mµ exhibiting lower AC losses than XFlux.
- 78894-A7 reaches higher levels of flux density, which is consistent with XFlux exhibiting better DC Bias performance than Kool Mµ.
- The slope of the 77930-A7 curve near the origin is steeper than the slope for 78894-A7, because 77930-A7 has higher material permeability. The 60µ Kool Mµ equivalent size part is 77894-A7. The curve for 77894-A7 would show the same slope as for 78894-A7 since both have the same initial permeability. And 77894-A7 has a loop width similar with 77930-A7 since both are Kool Mµ. Therefore, B_r for 77894-A7 is lower than for either 78894-A7 or 77930-A7 (because B_r is determined by H_c and the slope of the curve.)

The differences between the 77930-A7 and 78894-A7 curves are very small indeed if compared with the curves for ferrite or other higher permeability materials. All powder cores exhibit BH curves that are quite narrow and flat, so that predicting performance at high drive levels from B_r or H_c is not realistic.

The data for the curves shown here is available by contacting Magnetics.


78894 400Hz kG vs. kOe
16
14
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7


78894 400 Hz Gauss vs. Oersteds
500
400
300
200
100
0
-100
-200
-300
-400
-500
-10
-8
-6
-4
-2
0
2
4
6
8
10


Hc (Oersteds)
Br (Gauss)
60µ XFlux - 78894
Hc
Br
Frequency (Hz)
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
600
0
200
400
600
800
1000
1200
1400