

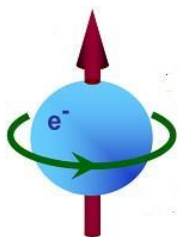
PMAG Visualizer User Manual

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By

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ABSTRACT

MagWeb's new **Visualizers** display the magnetic property curves of any magnetic material. You can visually compare thousands of magnetic property curves of most grades produced around the world – all with a couple of clicks. You can use them to discover the grades that best suits your machines. MagWeb offers two visualizers:

- **SMAG Visualizer** - visualizes the magnetic properties of soft magnetic materials.
- **PMAG Visualizer** – visualizes the magnetic properties of hard materials (permanent magnets).

Both visualizers have several powerful interactive tools such as:

- compare several grades side by side
- Autocomplete - a pull-down chart lists possible grades as you type
- show/hide any curve
- cursor read of magnetic property data
- zoom and pan any area of the plot

These visualization tools are available 24/7 from work, home, or anywhere. You can access them from a phone, laptop, tablet, or any computer. You do not need to download, install or license the software. **MagWeb** respects your privacy. It does not leave any cookies nor access to your computer.

This handbook details the **PMAG Visualizer**. It can visualize the magnetic properties of 5 types of permanent magnets (Neo, Samarium, Bonded, Ferrite, Alnico). It visualizes the demagnetization curves, energy product curves, etc. They are available at several temperatures. Its exclusive feature is a display of the **knee point**. This point demarcates the reversible and irreversible segments of the demagnetization curve. Its usage protects a magnet from harmful irreversible demagnetization. It can also display the temperature-dependency of the following parameters.

- Residual Flux density $B_r(T)$
- Coercivity $H_{cB}(T)$
- Knee Flux Density $B_k(T)$
- Knee Field $H_k(T)$
- Energy Product $BH(T)$

Subscribers can access magnetic property curves of all grades in all categories of magnetic materials. They can download data or compare any number of grades side by side. Other 'Free' users can access only a limited number of grades. They cannot download any data, nor can compare grades side by side. Further, they cannot access the saturation flux density of any grade or core loss models.

The **MagWeb** visualizers are the result of a multi-decade effort to compile hard-to-find magnetic property data. All this data is curated from **open sources** such as scientific journals, technical reports, manuals, books, websites, federal databases, university records, manufacturer's catalogs, etc. MagWeb believes it curated the data accurately and reliably. The intent is to support you in making informed decisions on magnetic materials, so MagWeb disclaims all warranties. MagWeb is not liable for any damages caused by using its database, whether explicitly or implicitly. The sources and curating methods used to digitize/smooth/model the data are confidential and proprietary. Resale of MagWeb's curated data is not permitted. MagWeb reserves the right to change the data without notice. By entering the password, subscribers agree to abide by MagWeb's General Terms and Conditions for the subscription services.

Users are invited to contribute their magnetic properties of magnetic materials by email to rao@magweb.us

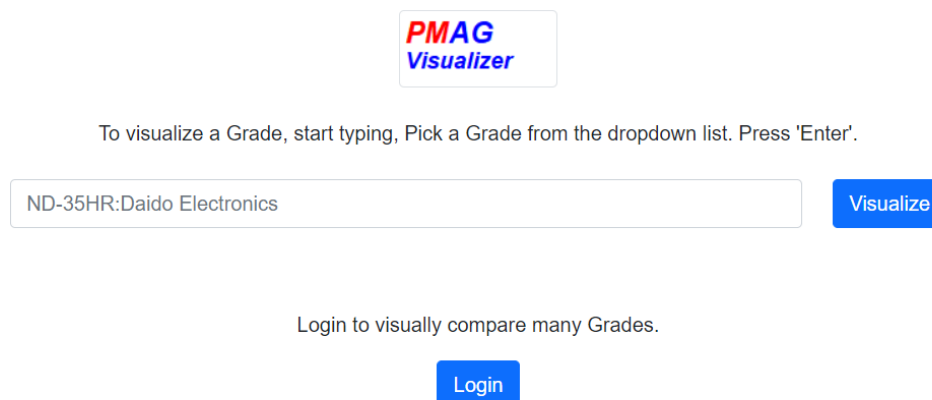
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1. SEARCH PAGE

Fig. 1 shows the Search Page for the **PMAG Visualizer**



To visualize a Grade, start typing, Pick a Grade from the dropdown list. Press 'Enter'.

ND-35HR:Daido Electronics

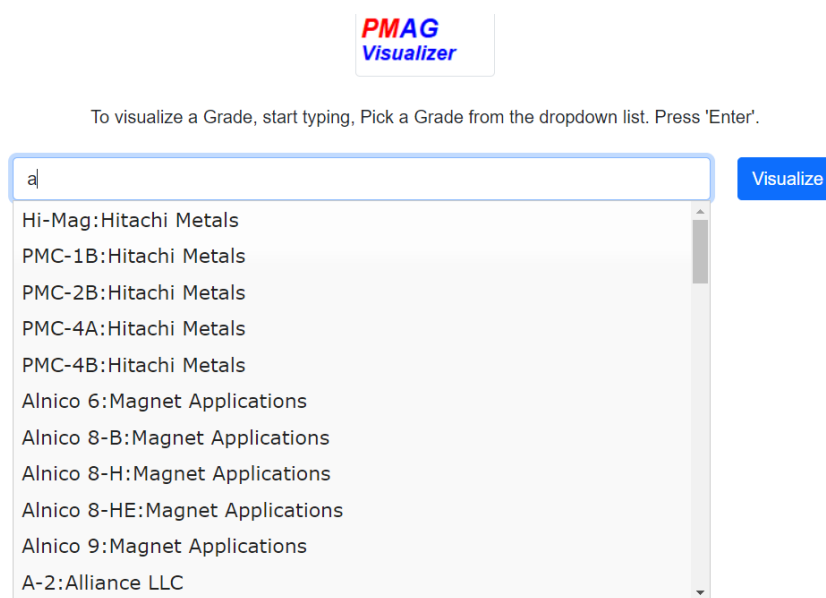
Visualize

Login to visually compare many Grades.

Login

Figure 1. Search Page of the PMAG Visualizer

Start typing a grade. Fig. 2 shows the dropdown list on typing 'a' to visualize Alnico. Pick a grade from a specific manufacturer. Subscribers can pick many grades to compare. Then click 'Visualize'.



To visualize a Grade, start typing, Pick a Grade from the dropdown list. Press 'Enter'.

a

Visualize

- Hi-Mag:Hitachi Metals
- PMC-1B:Hitachi Metals
- PMC-2B:Hitachi Metals
- PMC-4A:Hitachi Metals
- PMC-4B:Hitachi Metals
- Alnico 6:Magnet Applications
- Alnico 8-B:Magnet Applications
- Alnico 8-H:Magnet Applications
- Alnico 8-HE:Magnet Applications
- Alnico 9:Magnet Applications
- A-2:Alliance LLC

Figure 2. Start typing a grade. Pick it from the dropdown list.

In MagWeb, a 'grade name' comprises two parts that are separated by a colon.

- The first part contains the name of the grade that is given by the manufacturer.
- The second part contains the name of its manufacturer.

For example 'N40UH: Arnold Magnetics' refers to the N40UH grade that is manufactured by Arnold Magnetics. The name of the manufacturer is included because the properties of grades differ subtly with manufacturers.

2. PLOTS PAGE

Fig. 3 shows the Plots page. Its 8 tabs display 8 types of demagnetization curves. The first column shows the Demagnetization Curve and Energy Product Curve. The next column shows the '**knee point k**' ('Safe Operating Segment' aka linear or reversible segment). The magnet should be operated above the knee point to prevent demagnetization. The rest ($BH(T)$, $B_r(T)$, $B_k(T)$, $H_c(T)$, $H_k(T)$) display temperature-dependency of various parameters. Here BH = Energy Product, B_r = residual flux density, B_k = knee flux density, H_c = coercivity H_{cB} , H_k = knee field.

Demagnetization Curves	Safe Operating Segment	Br(Temperature) Curves	Hc(Temperature) Curves
Energy Product Curves	BH(Temperature) Curves	BK(Temperature) Curves	HK(Temperature) Curves

Figure 3. 8 types of Demagnetization curves visualized by PMAG.

For example, Fig. 4 displays the demagnetization curve of N40UH, produced by Arnold Magnetics. This grade has 8 demagnetization curves at various temperatures. The *Legend* (on the top right side of the plot) lists the *name* of all curves. The name in turn lists the temperature. It toggles between 'show' and 'hide'. To show a curve, click its name. To hide it, click it again.

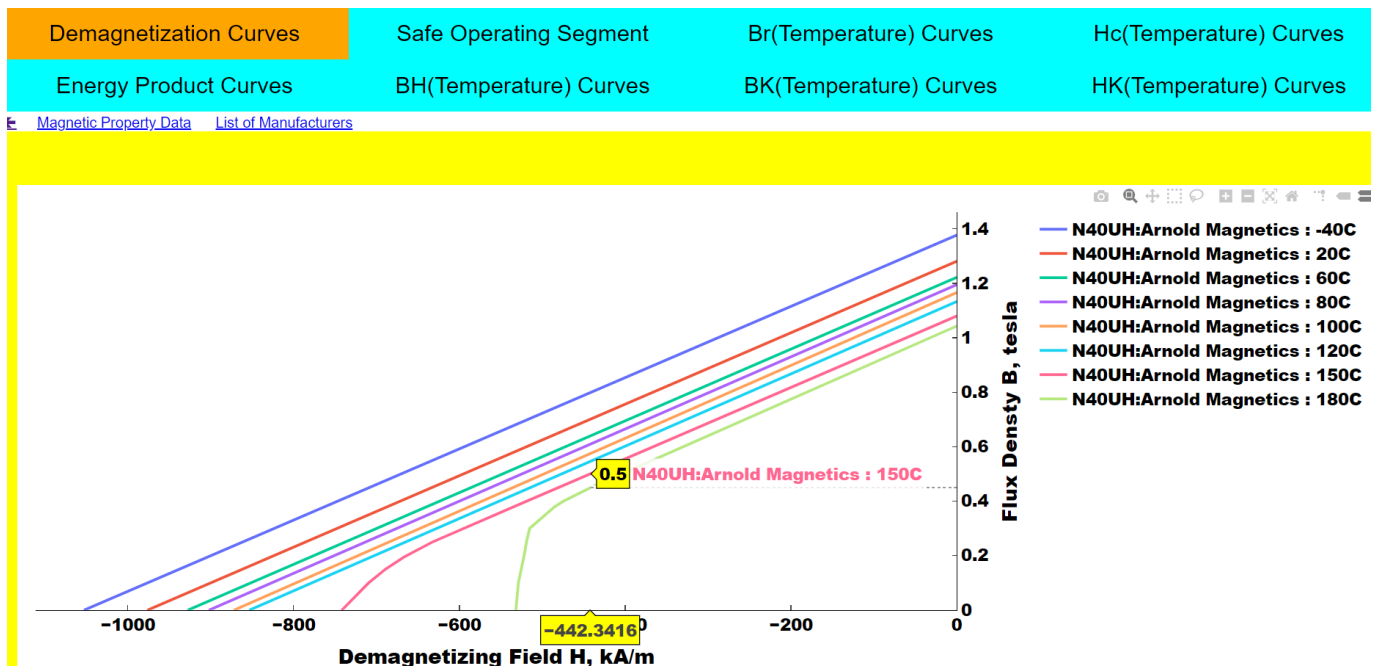


Figure 4. Plots Page displays demagnetization curves of the selected grade

The Plots page shows the demagnetization curves by default. Click different tabs to show different curves (such as Energy Product curves, Safe Operating Segment, etc.) The Plots page also have the following visualization features:

- [DataReader](#)
- Legends
- Visualization tools
- [Subscriber-only](#) links
- Popup Messages

The interactive [DataReader](#) lists the numerical values at a cursor data point. For example, Fig. 4 shows that at 0.5T, 150° C, this grade field is -442 kA/m. The visualization tools (above the legend) help in zooming, panning, box, or lasso selection. The popup messages display any error messages. An appendix describes these features in greater detail.

3. DEMAGNETIZATION CURVES

A B(H) demagnetization curve plots the flux density B tesla vs demagnetizing field H kA/m. Its intercepts with (H, B) axes define the coercivity H_{cB} and residual flux density B_r . A grade with higher B_r can generally produce higher continuous duty rated torque. A grade with higher H_{cB} generally can produce higher short-duration severe-duty torque. B(H) is the most important property curve of permanent magnets. To convert kA/m to kOe, divide by 79.057. For example, 100 kA/m equals 1.265 kOe.

Subscribers can use PMAG VISUALIZER to resolve many of your thorny questions such as:

- Which firm produces a better N40UH?
- How does a higher grade improve a magnet?

3.1. Which firm produces a better N40UH?

You determined that your machine needs an N40UH magnet. Then you are faced with the daunting task of discovering the right manufacturer. Some manufacturers have gained the reputation that they produce better N40UH grades than others. But how does one verify 'reputation'? All magnets are not created equal!. So you need to discover which firm produces the best N40UH grade. Subscribers can use PMAG Visualizer to quickly solve this puzzle.

Fig. 5 shows a screenshot from the PMAG visualizer. It compares the demagnetization curves of N40UH 150 C from two manufacturers. It shows that one offers a higher residual flux density than the others. By choosing such a manufacturer whose magnet has higher B_r , you can produce higher torque in your machine.

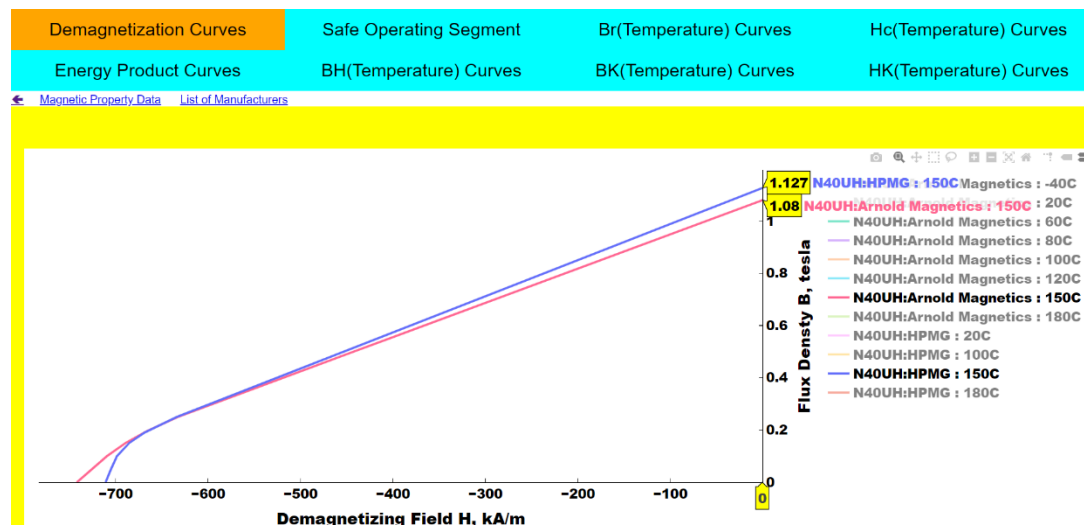


Figure 5. All N40UH grades are not created equal.

3.2. Does a higher grade improve a magnet's performance?

A designer wants to know if switching from N35UH to N40UH improves the performance of a motor operating at 180° C. Subscribers can use PMAG to compare several demagnetization curves side by side. Fig. 7 for example compares N35UH and N40UH. It shows that switching from N35UH to N40UH increases B_r by 8% (from 0.965 to 1.043 T). It also shows that unfortunately, it increases the knee flux density by 18 % (from 0.3192 to 0.3788T).

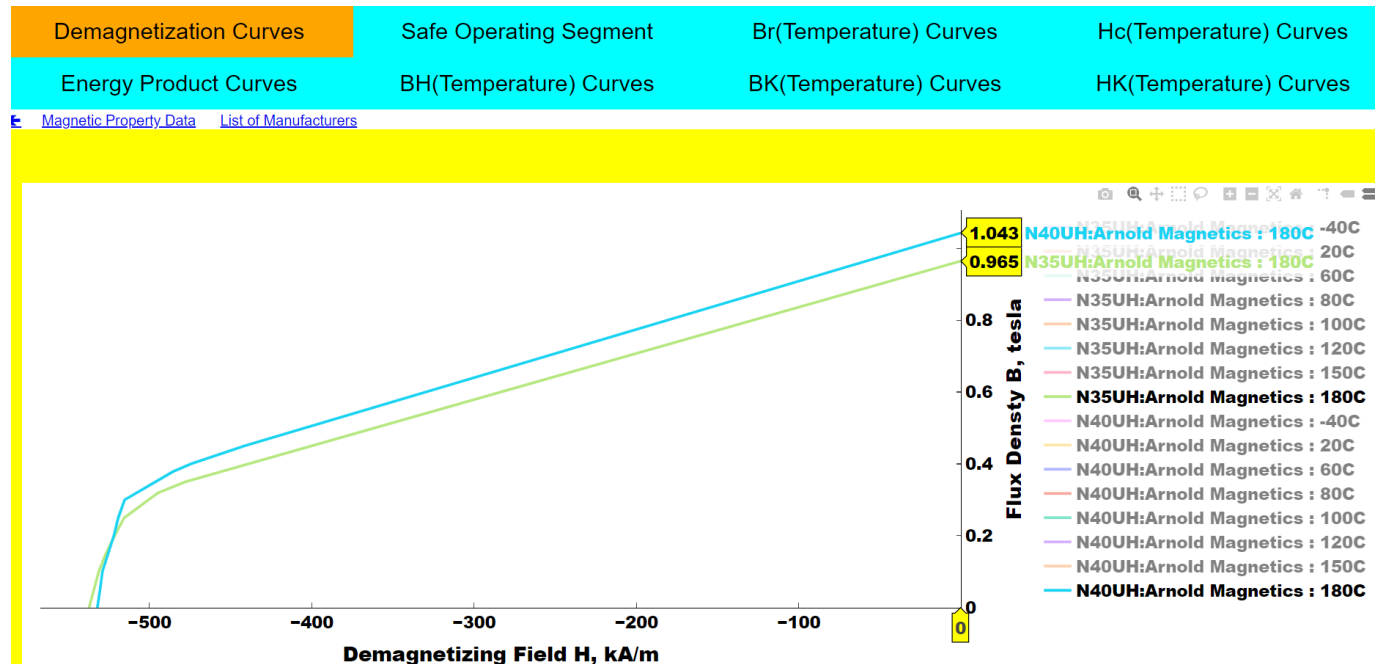


Figure 7. PMAG shows higher grade improves B_r but not B_k .

4. ENERGY PRODUCT CURVES

A BH(B) energy product curve plots the energy product BH MGOe vs. magnetic flux density B tesla. It determines the optimal flux density at which a magnet stores maximum energy. The size and cost of permanent magnets depend on the energy product. Most manufacturers express it as MGOe (B in kG and H in kOe). However, some European manufactures express it in kJ/m³ 1 MGOe = 7.958 kJ/m³. We present below few examples of how to use these curves.

4.1. Which firm's magnets produce the highest energy?

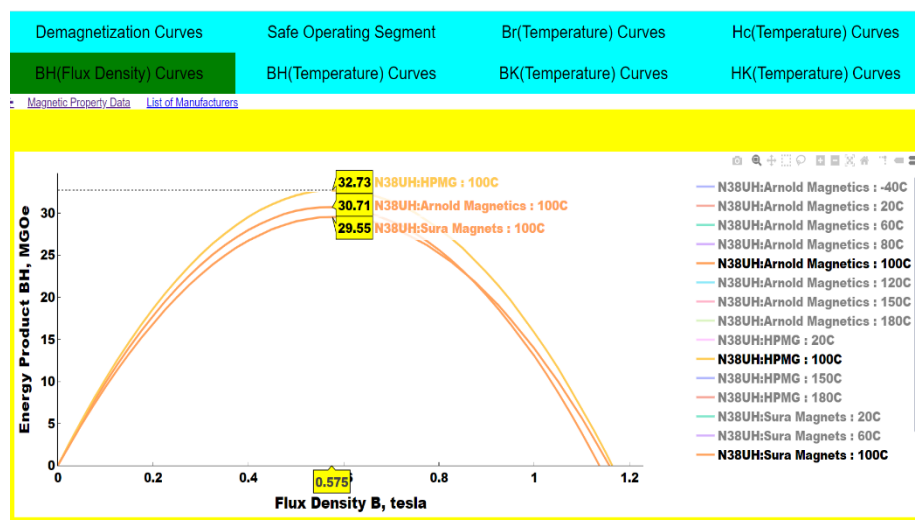


Figure 8. Energy product of a magnet depends on the manufacturer

Your machine needs magnets that store the highest energy at 100° C. Energy produced by a magnet depends on the process and hence on the manufacturer. You want to discover which firm produces the highest energy magnets. Subscribers can use PMAG to compare energy products of different grades.

Fig. 8, for example, compares the energy product of N38UH class magnets that are produced by three different manufacturers. It shows that one firm stores 10% higher energy (32.73 MGOe). Choosing such a firm can save on the cost of magnets. PMAG visualizer can thus help you to quickly locate the manufacturer of high-performance magnets at a lower cost.

4.2. How do energy products vary with grade?

It is well known that the cost of a magnet increases significantly with the grade. You are interested to learn how lowering a grade will affect its energy product. Subscribers can use

PMAG to study such trade. Fig. 9, for example, demonstrates the trade between the grade and its energy product. It shows that, at 120C, the grade N40UH produces a maximum energy product of 30.34 MGOe. Lowering it to N35UH reduces it only by 10.8 % to 27.06 MGOe.

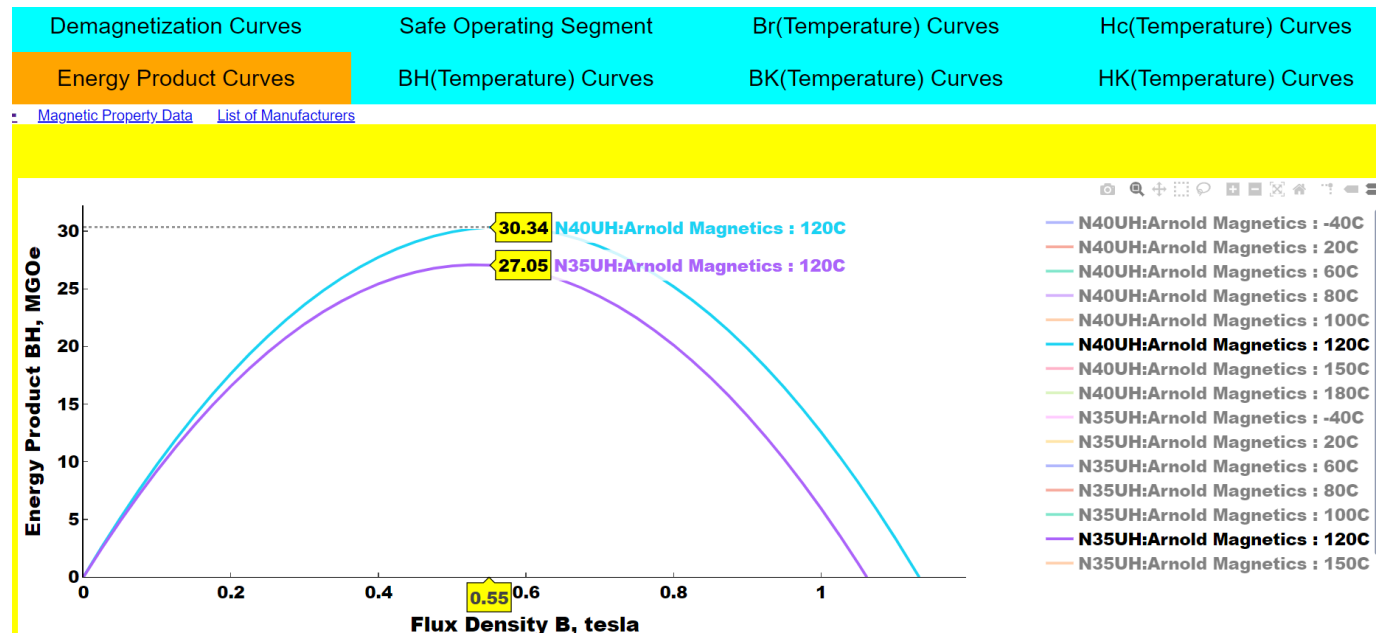


Figure 9. Lowering a grade reduces the energy product marginally.

5. KNEE POINT

The knee point k demarcates the reversible or linear segment of $B(H)$ curves from its nonlinear or irreversible segment. The magnet should always be operated within the reversible segment to prevent demagnetization. The knee point, therefore, defines the demagnetization withstand capacity of a magnet. This in turn defines the overload duty torque of a motor without demagnetization. PMAG has the exclusive feature of defining the coordinates (H_k, B_k) of the knee point k . It identifies the knee point k by a 4-digit valued flux density.

5.1. Show how knee point varies with manufacturer

The demagnetization withstand capacity of a magnet depends on its composition and hence on the manufacturer. Consider a specific magnet N42UH operating 180C. Two competing firms, Arnold Magnetics and Sura Magnet produce this grade. How do you discover which manufacturer offers a better grade? You want to compare the demagnetization withstand capability of their magnets. Subscribers can use PMAG to compare the knee points of their magnets.

Fig. 10, for example, compares the safe operating segments of these magnets. This segment brackets the residual flux density and the knee flux density. It also defines the knee field up to which a magnet can operate. This figure shows that the knee point of Sura Magnets is at $(-453\text{ kA/m}, 0.3498\text{ Tesla})$ while that of Arnold Magnetics is at $(-492\text{ kA/m}, 0.375\text{ tesla})$. It thus shows that magnets from Arnold Magnetics can withstand an 8.6% higher demagnetizing field than that of Sura Magnetics. So obviously usage of this magnet will result in a more robust motor.

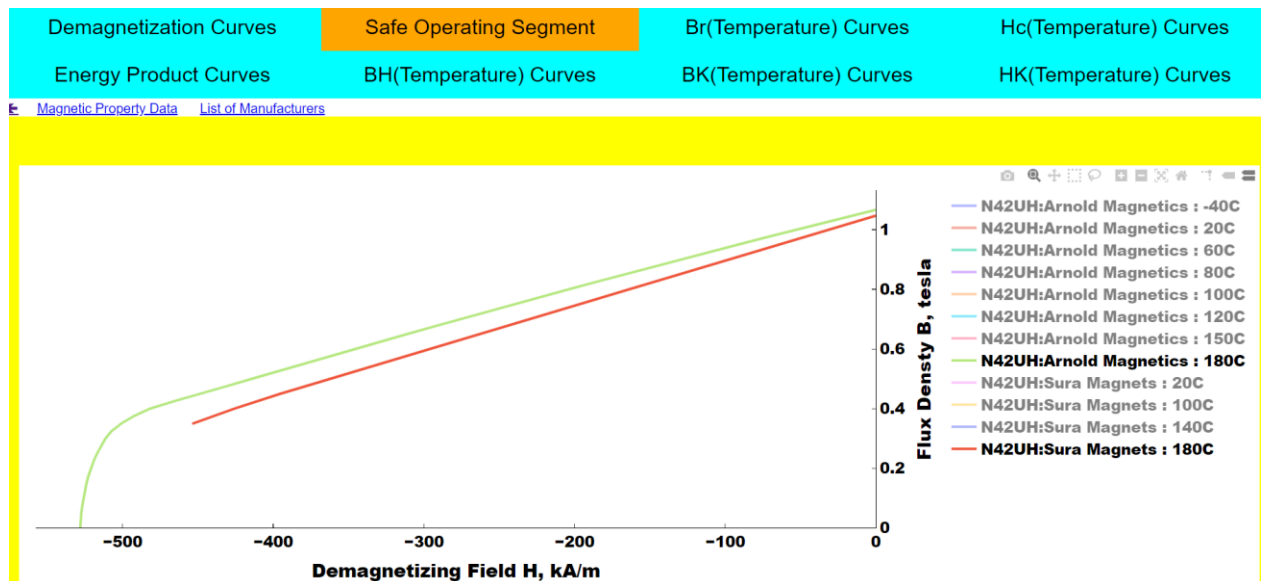


Figure 10. The Knee Point of a grade depends on its manufacturer.

5.2. Show how knee point varies with Grade

Suppose you want to know how replacing an expensive N40UH magnet with a less expensive N40H magnet (both operating at 150C) impacts the demagnetization withstand capability. Subscribers can use PMAG to compare how both magnets impact this parameter. Fig. 11 compares both grades. It shows both have the same residual flux density, so will produce the same rated torque. But it shows for N40UH, the knee point is at (-666.7 kA/m, 0.1945 tesla). But that at N40H is at (-339.6 kA/m, 0.8116 T). Thus degrading from N40UH to N40H reduces the knee field by nearly 50%. Such drastic reduction is not advisable.

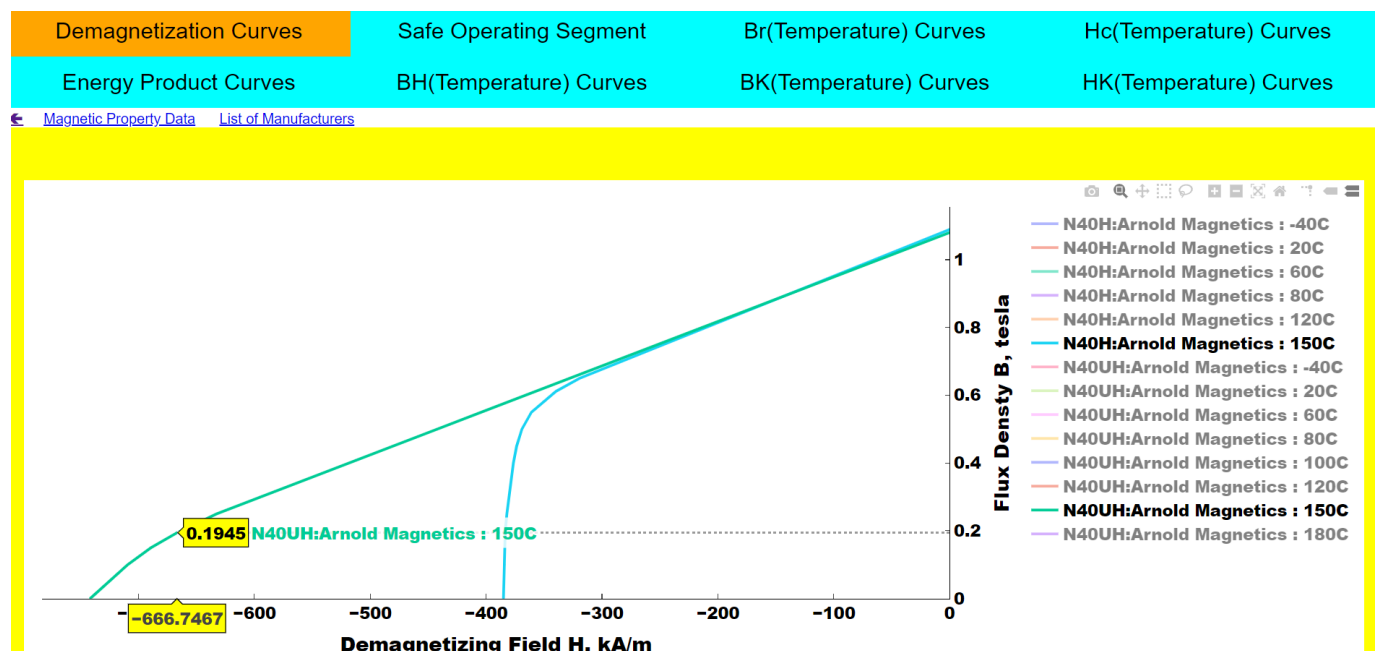


Figure 11. Downgrading a magnet significantly reduces its demagnetization withstand.

6. TEMPERATURE DEPENDENCY

All characteristics of magnets vary significantly with temperature. The temperature-wise plots of $B_r(T)$, $H_c(T)$, $B_k(T)$, $H_k(T)$ display how they vary with temperature. Some of them vary almost linearly while others vary nonlinearly. Cooler magnets have a longer life and produce more torque. You can use these plots to analyze how temperature impacts these parameters.

6.1. Show how B_r varies with temperature?

You want to know the temperature coefficient of N40UH for residual flux density. Fig. 12, derived from the PMAG visualizer, displays how B_r varies with temperature. This plot shows that for this grade, the residual flux density reduces linearly with temperature. One can easily compute the temperature coefficient from this plot.

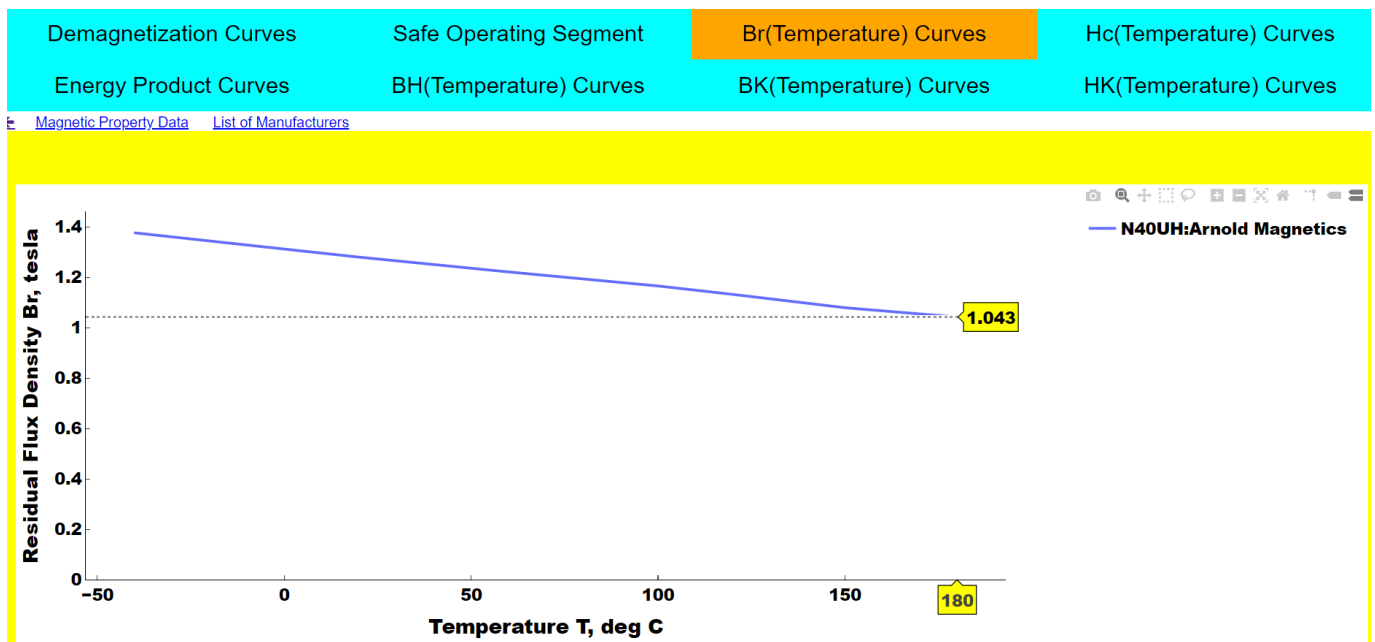


Figure 12. For this grade, B_r reduces linearly with temperature.

6.2. Show how H_c varies with temperature

Alternately, you want to know the temperature coefficient of N40UH for coercivity. Fig. 13, derived from the PMAG visualizer, displays how H_c varies with temperature. This plot shows that for this grade, the coercivity reduces nonlinearly with temperature. It shows that using the linear temperature coefficients that are usually supplied by the manufacturer, is ineffective.

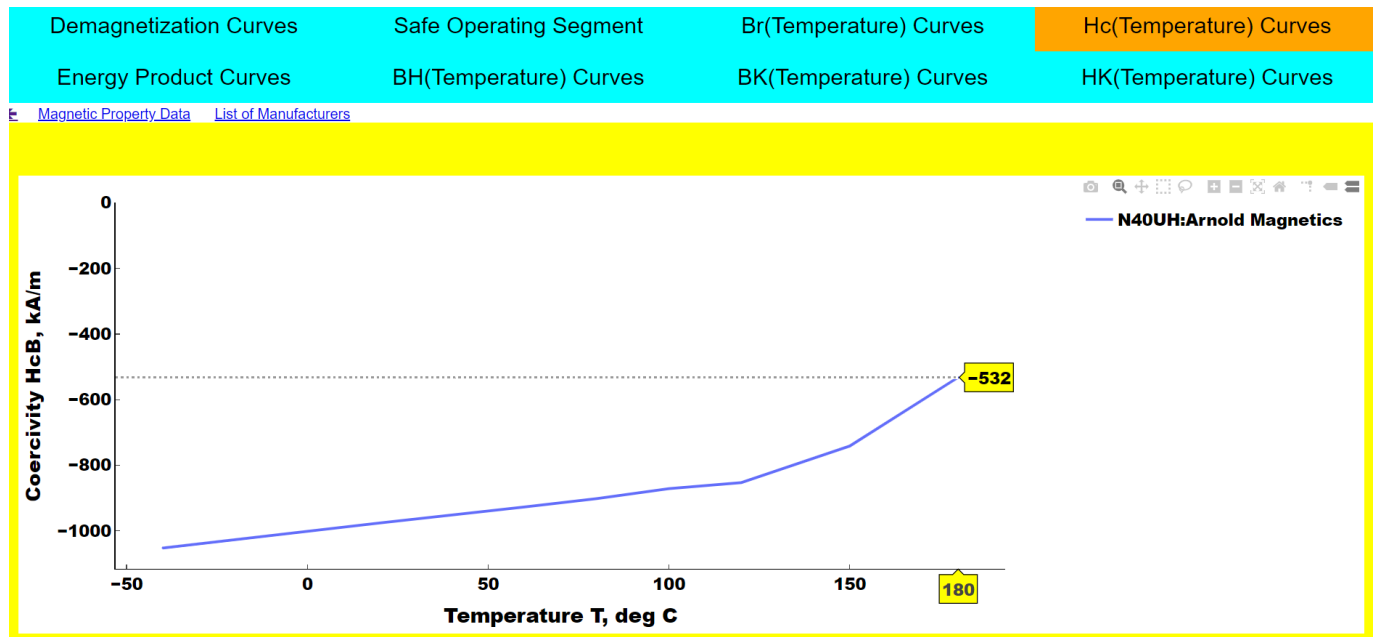


Figure 13. Coercivity H_c varies nonlinearly with temperature

6.3. Show how knee point increases with temperature

Traditionally, coercivity has been used to characterize the demagnetization withstand capacity of magnets. But most motor designers use knee flux density as a marker to indicate the fraction of magnet volume that is demagnetized. The value of B_k reflects a magnet's vulnerability to demagnetization as temperature increases. Higher the B_k , the poorer the demagnetization resistance. PMAG visualizer can thus be used to understand how temperature affects this parameter.

Fig. 14 plots the knee flux density B_k as a function of temperature for N40UH. It shows that B_k increases linearly with temperature. One can thus define and use a temperature coefficient for the knee flux density to project the knee flux density at any temperature.

Demagnetization Curves

Safe Operating Segment

Br(Temperature) Curves

Hc(Temperature) Curves

Energy Product Curves

BH(Temperature) Curves

BK(Temperature) Curves

HK(Temperature) Curves

[Magnetic Property Data](#) [List of Manufacturers](#)

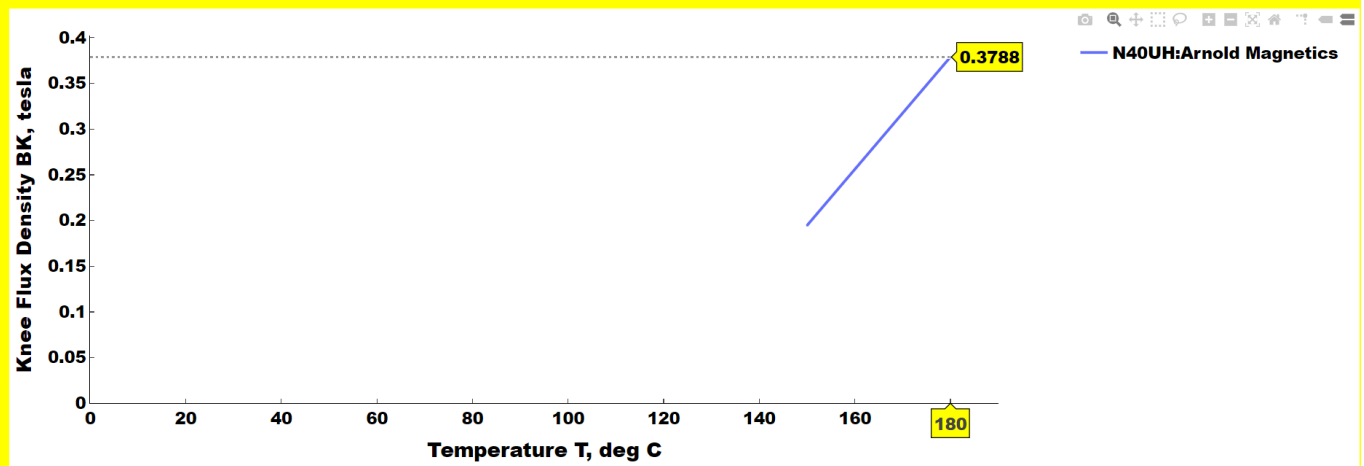


Figure 14. Knee Flux Density increases with temperature linearly

7. APPENDIX. VISUALIZER FEATURES

PMAG Visualizer provides several features, e.g.

- Legend
- **DataReader**
- Visualization tools
- Messages
- Links

7.1. Legend

It is located on the top right of the plot. It lists the names of all curves; the name also contains temperature information. Click a name to show or hide a curve.

7.2. DataReader

The interactive **DataReader** displays the (x, y) coordinates at the cursor point on all curves. The cursor identifies the position of the point. As you hover the cursor over a plot, it instantaneously updates the coordinates to the cursor point. You can use it to read Flux Density, Demagnetizing field, Energy Product, Temperature, Coercivity, etc. It is also visible in zoom mode.

For example, Fig. 15 shows the Demagnetization curve of N40UH Grades. The **DataReader** reads the core loss value as shown.

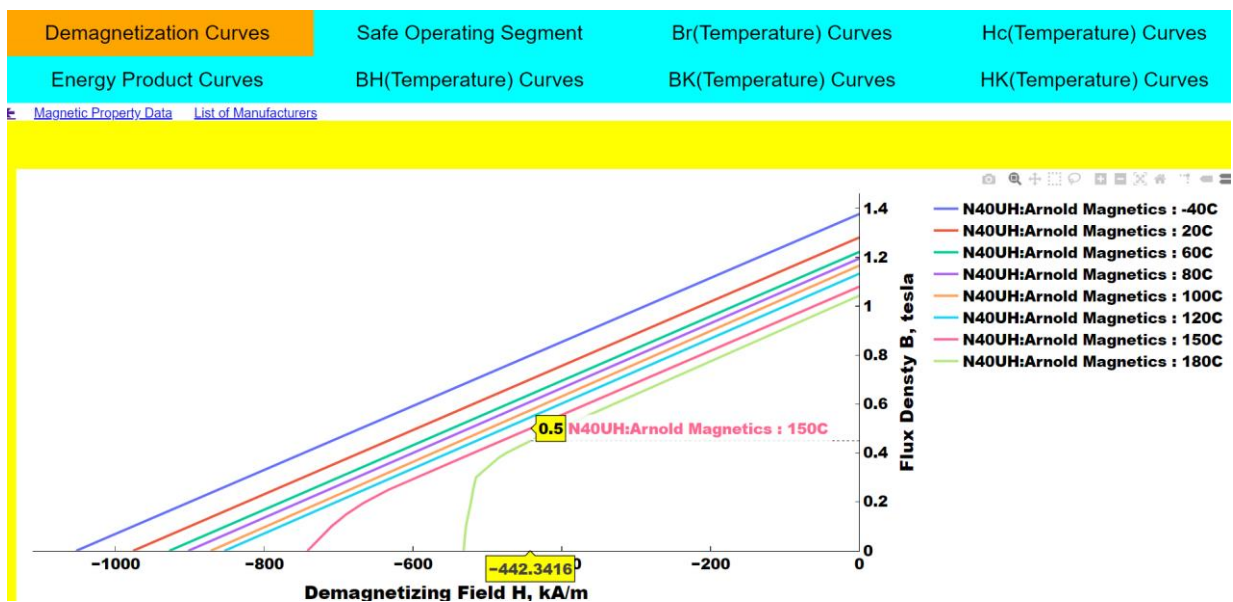


Figure 15. **DataReader** reads the (x,y) coordinates of data points

7.3. Navigation tools

Fig. 16 shows the visualization tools that are available with SMAG and PMAG. It comprises 12 buttons. These buttons allow you to visualize the property curves in a variety of modes. Following is a brief description of these buttons.



Figure 16. Buttons in a Navigation Toolbar. They enhance the data visualization

Save (Camera) Button. Click this button to launch a file save dialog. You can save files in the following formats: png, eps, SVG.



Pan Button: To pan, click this button. Move the mouse over a curve, press the left mouse button, and hold it to pan the figure, dragging it to a new position. When you release it, the data under the point where you clicked will be moved to the point where you released it.



Zoom Button, Click the right mouse button to zoom, dragging it to a new position. **Zoom to Rectangle Mode.** Move your mouse over the chart and press the mouse button. Define a rectangular region by dragging the mouse while holding the button to a new location. When using the left mouse button, the plot view limits will be zoomed to the defined region.

Home Button. Brings the plot back to normal view and position

7.4. Links

Subscribers can access the following additional features, located under the tabs.

- [← return](#) – returns to the Search Page
- [magnetic property data](#) – download magnetic properties (you specify the folder)
- [List of manufacturers](#) – access the list of manufacturers
- [equivalent grades](#) – access the equivalent grades