Mast Parametric Sizing Charts

Telescopic Tube Mast Sizing Charts

Telescopic masts can be made in almost any diameter or length from many materials. Telescopic masts are easily customized to fit customer needs for deployed stiffness and various stowed and deployed lengths. It can be difficult to choose a mast from such a broad range of options so the following method assumes a payload and deployed length for the mast and then determines a mast diameter, stowed size, and mass. These charts are approximate, for other stowed sizes or a more customized solution contact Astro.

The general method to estimate a mast size is as follows:

- Use the mass of your payload and the desired deployed length of the mast and estimate the minimum first mode deployed natural frequency you need. On orbit the guiding factor for most masts is the deployed first mode natural bending frequency rather than strength. Experience has shown that this frequency can be as low as 0.1 Hz, but more typical values are 0.5 Hz, 1.0 Hz, and sometimes higher.
- From these input values determine the required mast stiffness EI (lb-in^2) from the equation given
- Next estimate the stowed length and deployed length and compare these to the values you need and adjust the values if necessary to achieve a solution
- Determine the stowed diameter for the mast for the stowed length you choose
- Determine the mass of the mast based on the material, deployed length, and stowed length

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Telescopic Tube Mast Sizing Charts (cont'd)

To size a mast based on natural frequency, the following equation is used:

$$Fn=0.276*\left(EIg/WL^3\right)^{.5}$$

Where:
Fn is the first mode natural frequency in Hertz (Hz)

EI is the stiffness in lb-in^2

g is the gravity constant 386.4 in/s^2

W is the tip payload mass in lbs

L is the length of the mast in inches

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Telescopic Tube Mast Sizing Charts (cont'd)

Assuming 0.5 Hz is the deployed natural frequency required for a payload of 100 lbs, and knowing that you wish to deploy it 30 ft from your spacecraft, then you can calculate the EI required for your boom. The formula is rearranged as:

$EI=(Fn^2 \, WL^3)/(0.276^2 \, g)$

$EI=(.5^2 \times 100 \times (30 \times 12)^3)/(0.276^2 \times 386.4) = 3.96 \times 10^7$ lb-in^2

Using this number for EI, enter the graph on the left and determine if a mast can meet this requirement. In this case, the chart shows that a graphite epoxy mast with a tip tube 2" in diameter is too small, while the 4" diameter tip tube has a higher EI than required so it will work. Looking at both the 36" and 60" stowed length charts for graphite it shows the EI will work for either stowed length. A 4" aluminum mast will also work.

Note that the "2" and 4" diameter tip tube" refers to the diameter of the smallest tube in the mast. The mast diameter grows by 0.5" for each segment added to the mast, and starting with the smallest tube the mast diameter grows outwards to meet the required deployment length for a given stowed length.

After determining the mast diameter and stowed length, it is useful to know the number of segments in the mast and to minimize this number if possible. The chart on segment lengths gives this information based on mast stowed and deployed length. This data can also be used to calculate the stowed diameter of a mast which has an intermediate stowed length.

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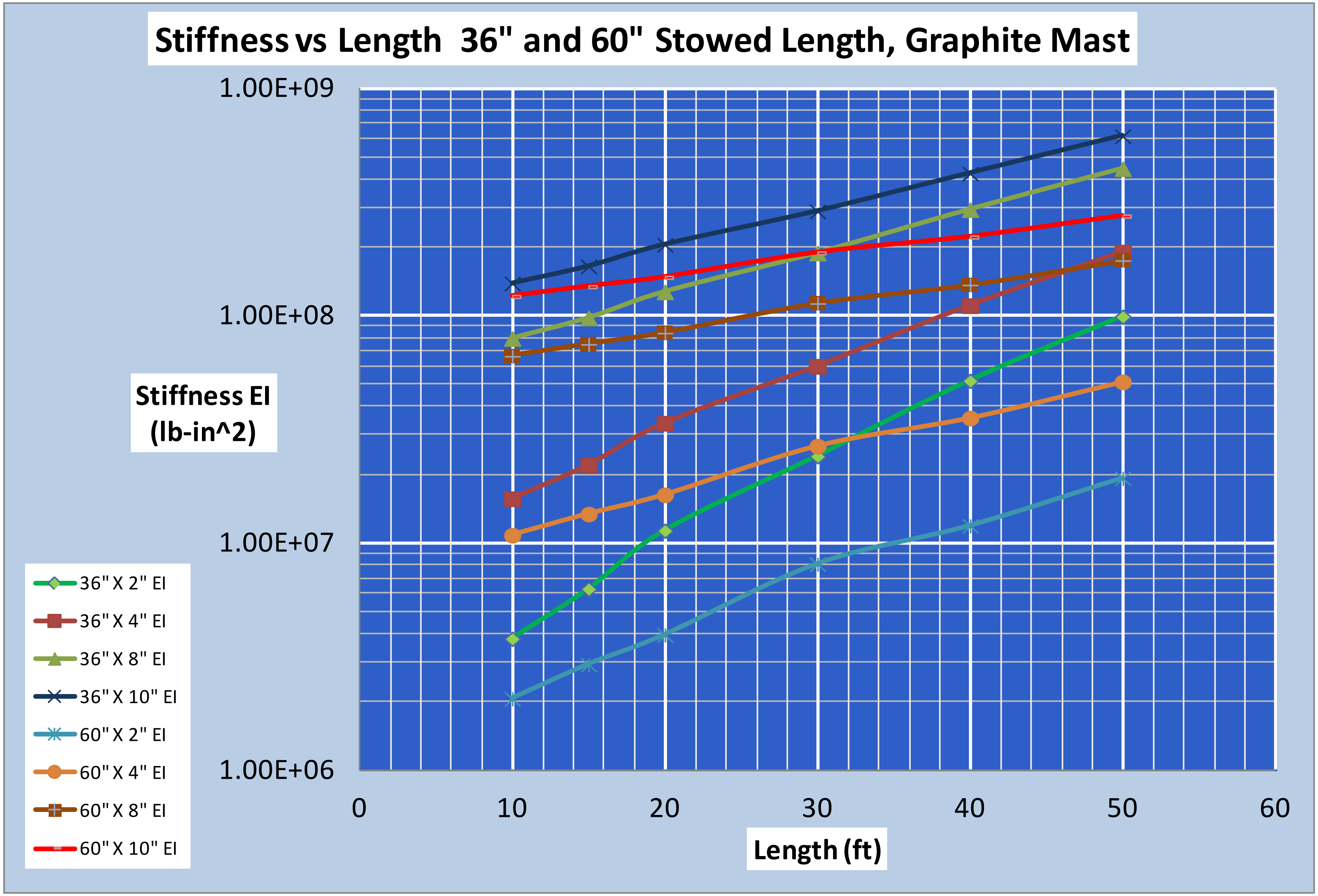

Note: 36” x 2” is a mast with a 2”dia innermost segment and 36” stowed length

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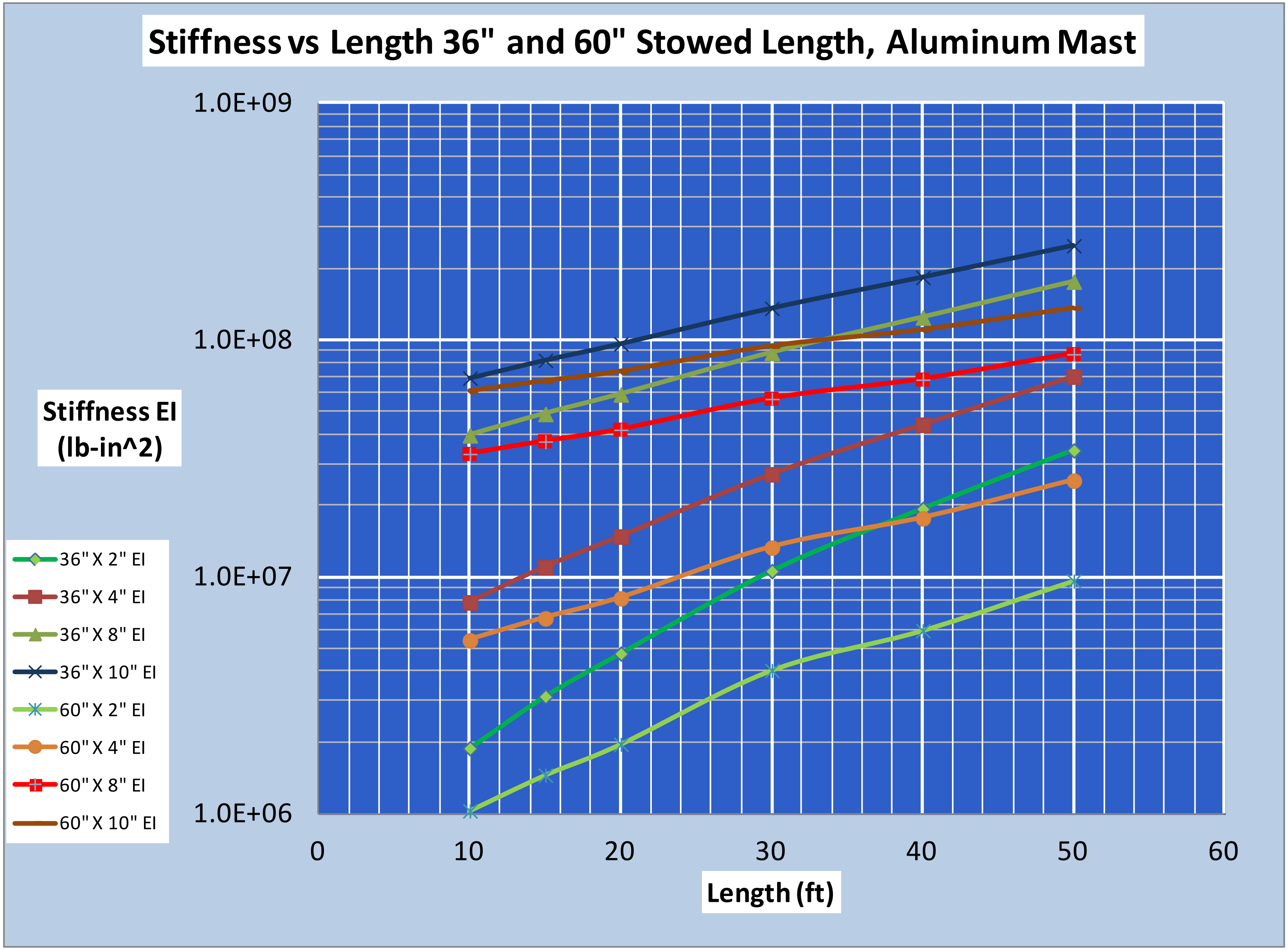


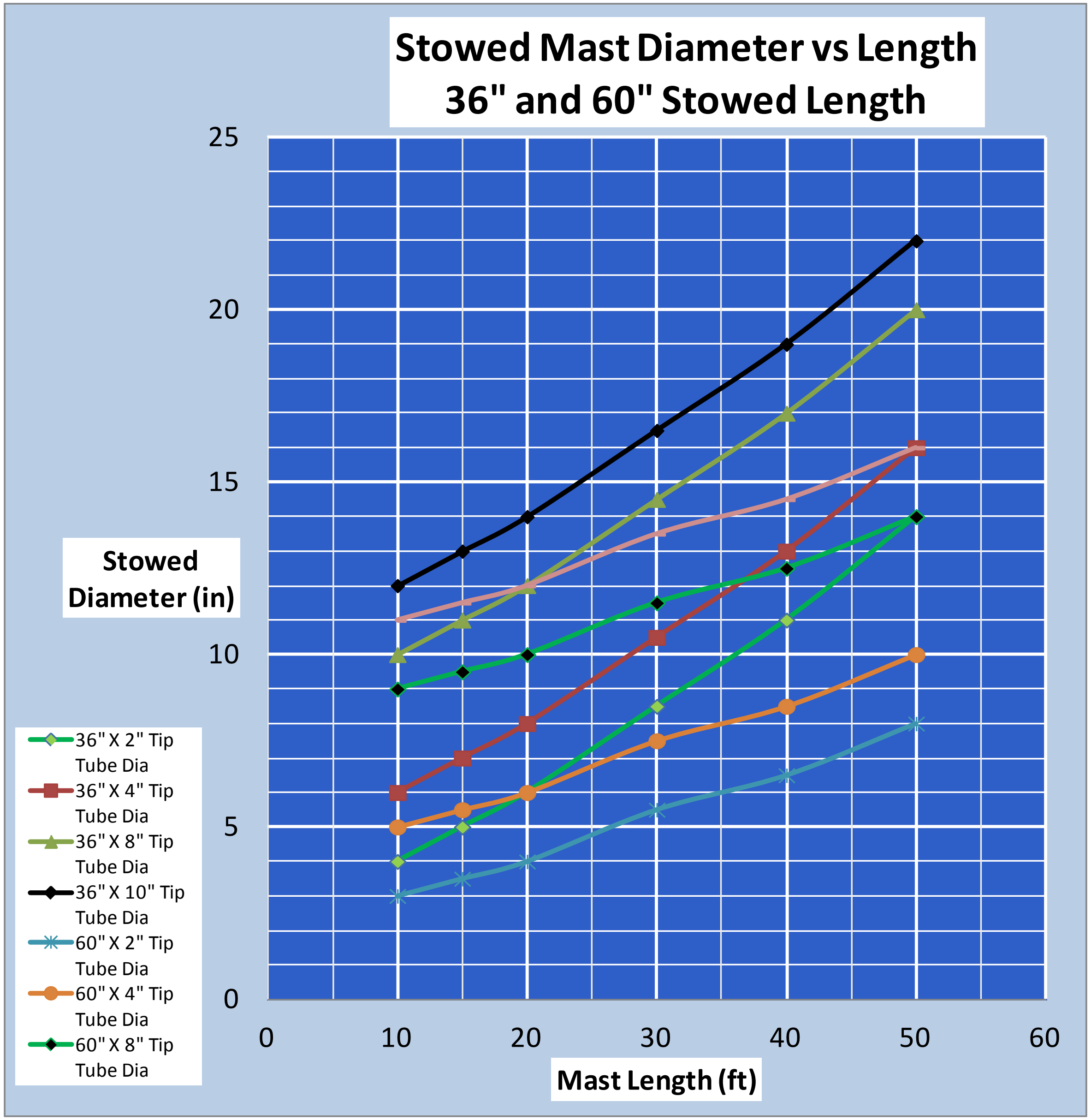
Note: 36” x 2” is a mast with a 2” dia innermost segment and 36” stowed length

Stowed Diameter vs Tip Tube Dia and Mast Length

The mast stowed envelope is related to the mast innermost tube diameter and the stowed length. As each segment is added to increase the length, the stowed diameter grows by 0.5”. Fewer segments are usually better, which tends to favor a long stowed package.

This chart shows the stowed diameter for mast lengths over a range from 10 to 50 ft based on a stowed length of 36 or 60 inches. Contact Astro for help with other lengths.

Note that the stowed length is from the bottom of the STEM drive unit to the top of the inner segment.



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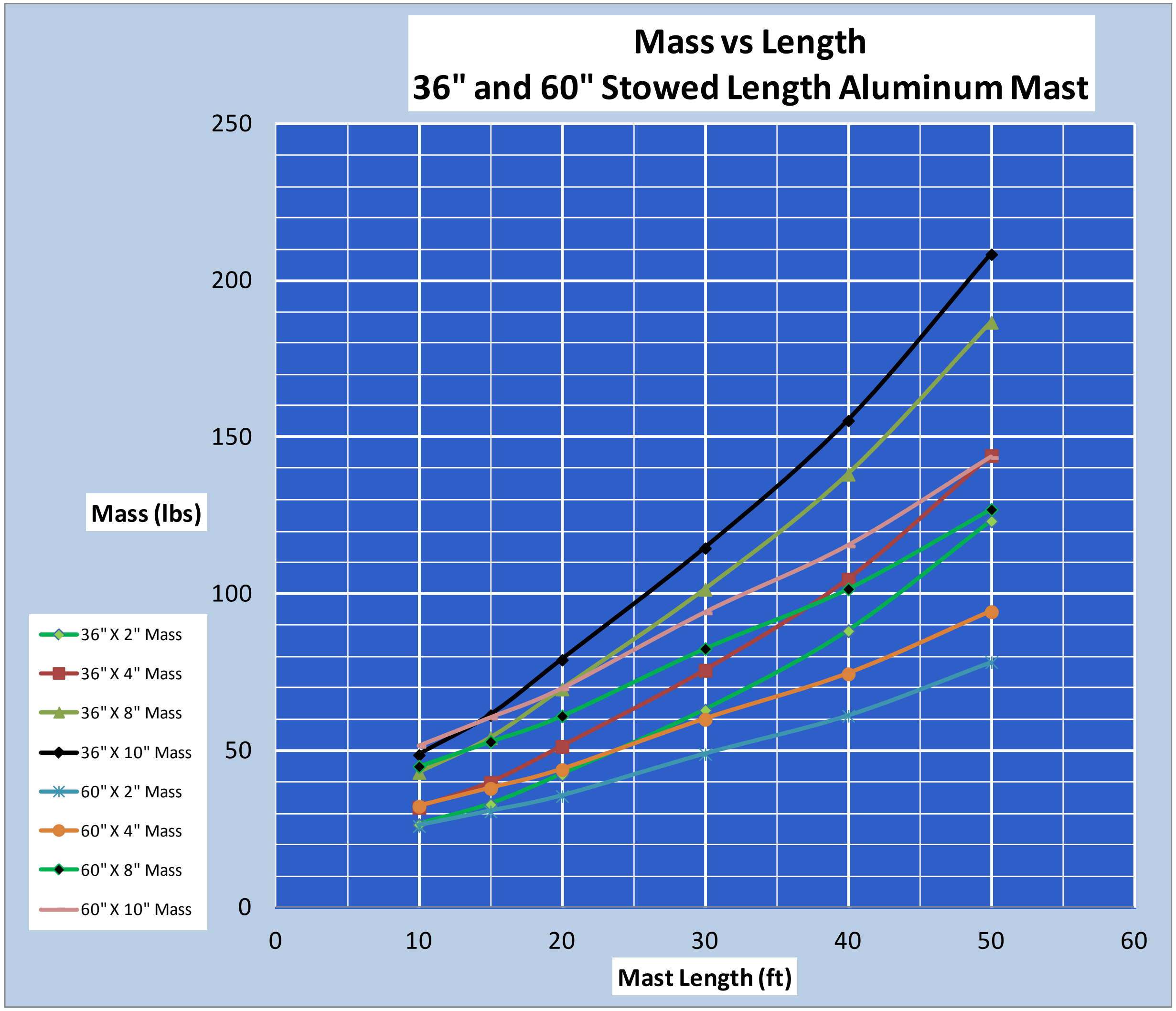
Mast Mass vs Deployed Length for Various Sizes of an Aluminum Mast

This chart is used to determine the mass of an aluminum mast for a stowed length of 36” or 60” for various tip tube diameters. In the legend a “36” X 2” Mass” is for a mast that has the smallest tip tube diameter of 2” and a 36” stowed length.



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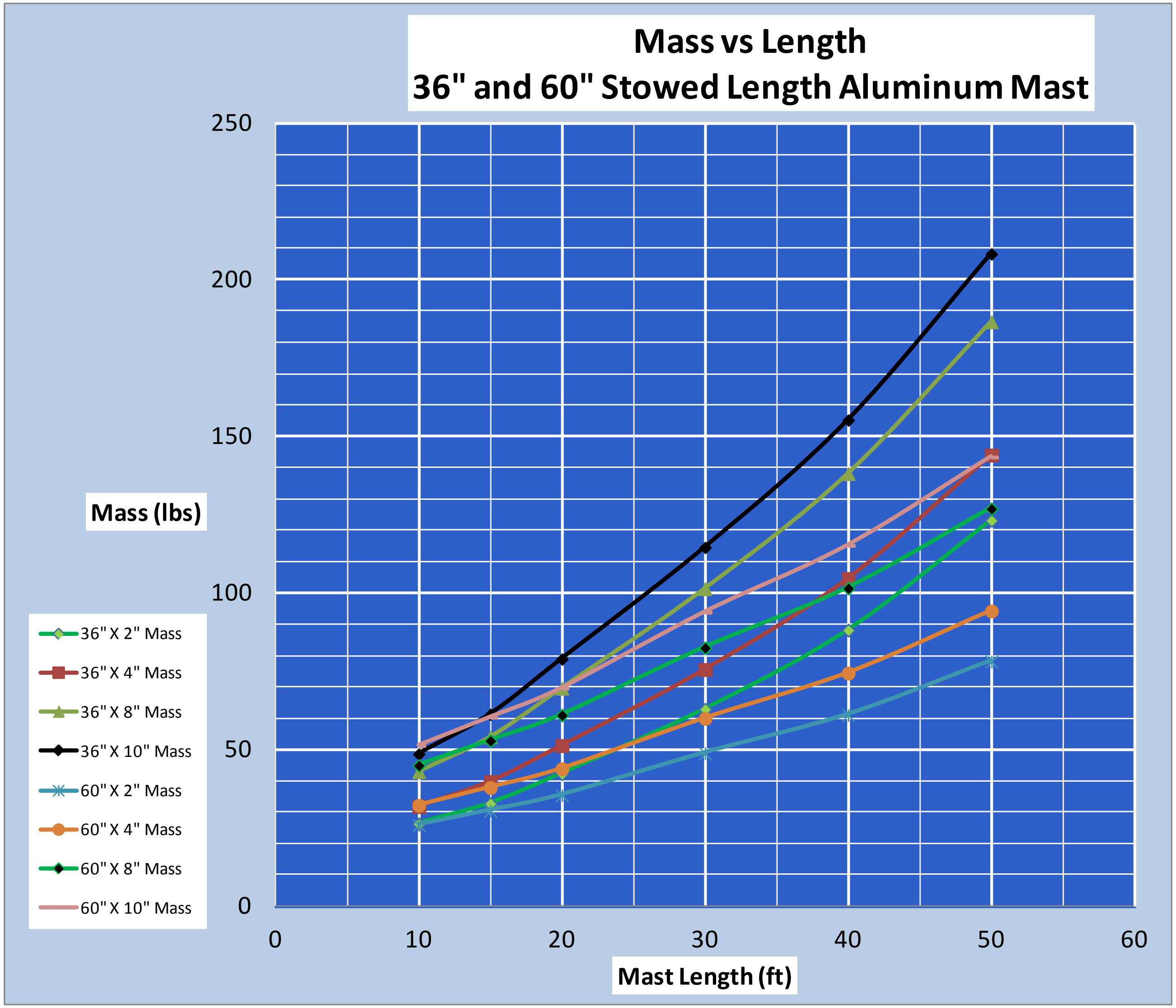
Mast Mass vs Deployed Length for Various Sizes of a Graphite Mast

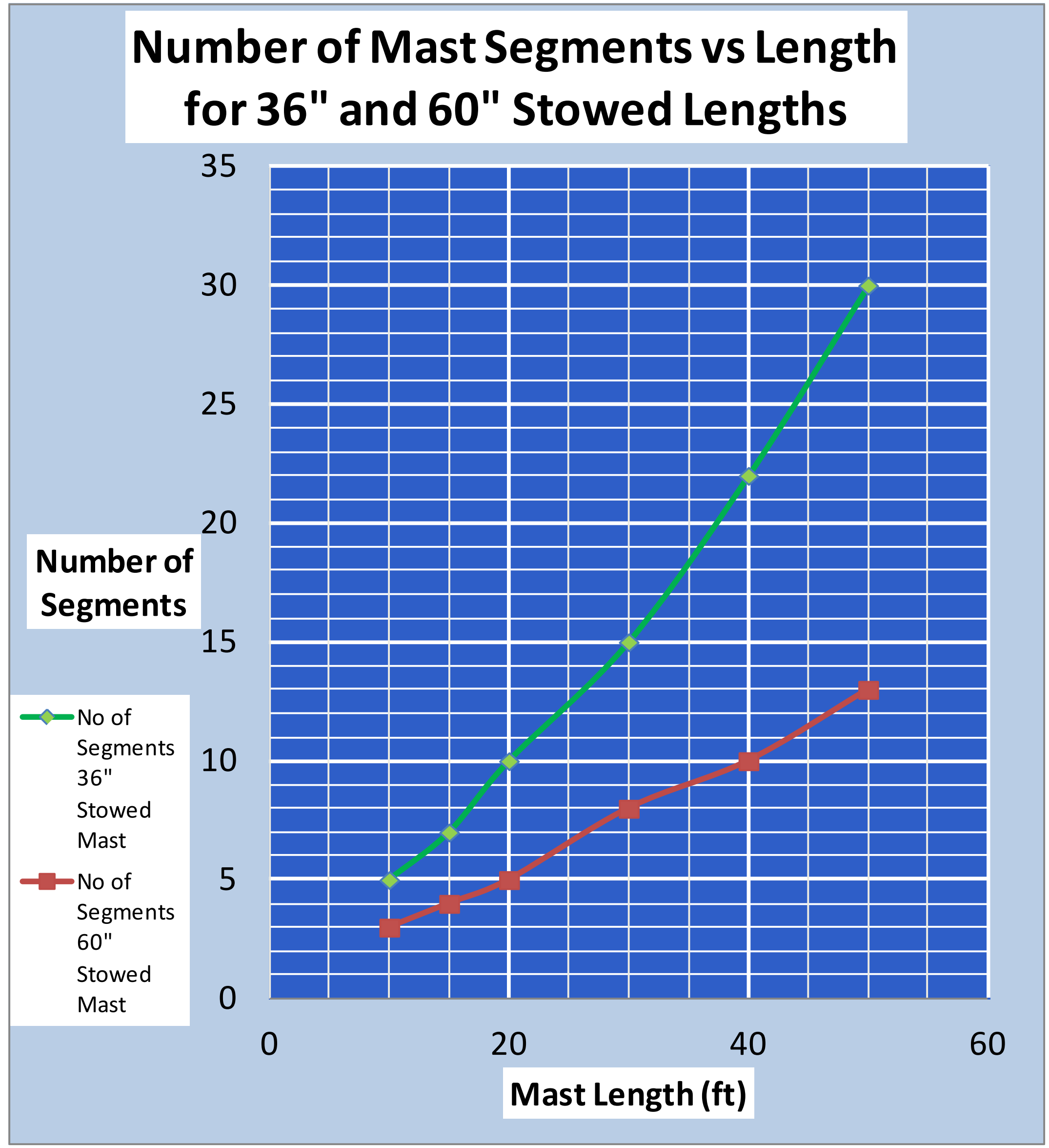
This chart is used to determine the mass of a graphite mast for a stowed length of 36” or 60” for various tip tube diameters. In the legend a “36” X 2” Mass” is for a mast that has a tip tube diameter of 2” and a 36” stowed length.



Number of Segments vs Length for Stowed Mast Lengths

The mast is ideally stowed as a long package. If the mast stowed length is short and the deployed length long, then the number of mast segments to reach the deployed length increases. An ideal mast is between 4 and 12 segments for most purposes. This chart indicates how many segments are required to reach the deployed length given a particular stowed length. The chart gives data for 2 stowed lengths 36” and 60”.

This chart may be extrapolated between the 36” and 60” lengths for other stowed lengths. For instance, for a 30 ft mast with a desired stowage height of 48” (halfway between the 36” and 60” line) the number of segments will be 11.5 segments so the mast will work with 12 segments and may work with 11 segments. The mast diameter grows by 0.5” per segment so the new mast diameter would be (12-8)*.5 = 2” greater than the stowed diameter of the 60” mast that has 8 segments.



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