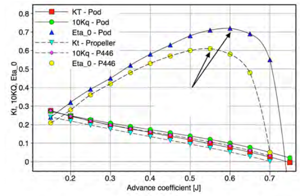
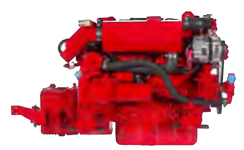
KINGpropulsion propTECH

King Propulsion Technical Bulletin

Propeller Sizing for your Varifold



+



=

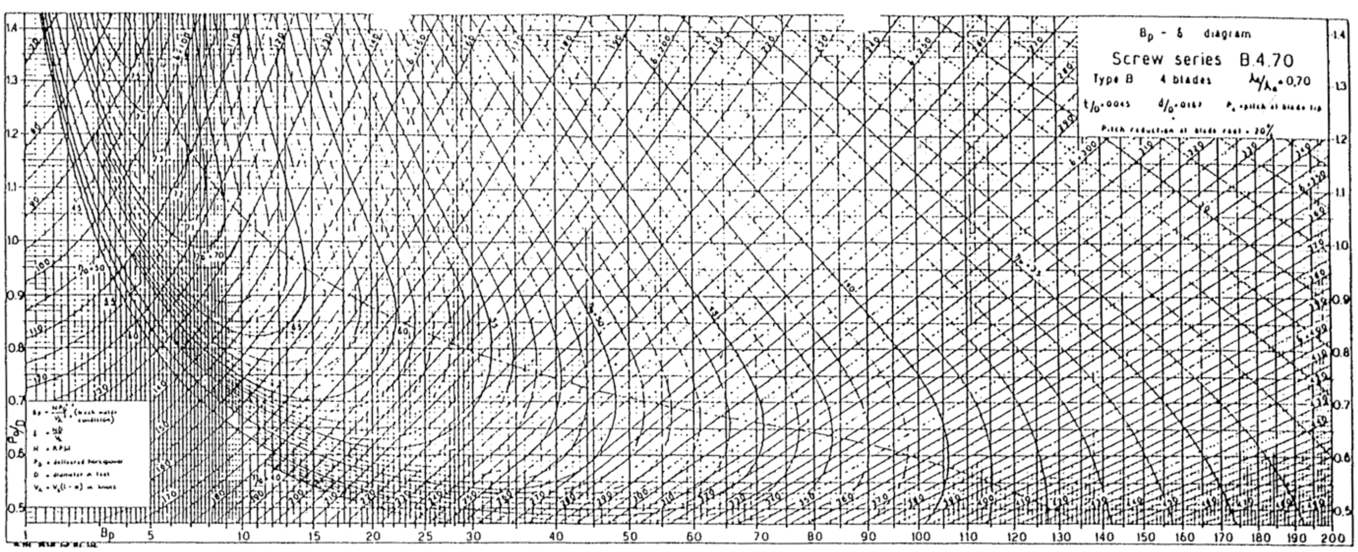
OPEN WATER PROPELLER TEST DATA

SAILBOAT, ENGINE AND GEARBOX SPECIFICATIONS

OPTIMUM VARIFOLD PROPELLER

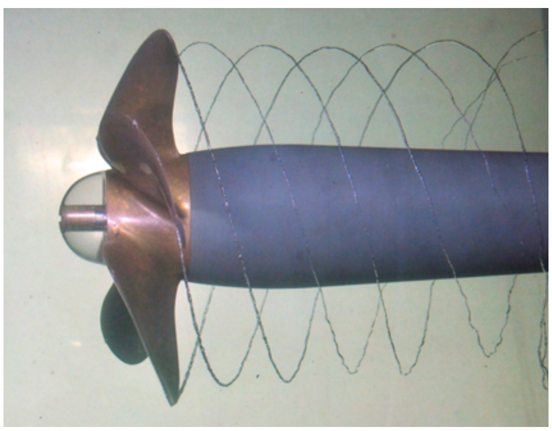
So you have several quotes for your new propeller in front of you, like a 3 blade 16 x 12 or 2 blade 14 x 11, with each manufacturer quoting something completely different. How do you make sense of the numbers? Well, most commercial propeller designs are not custom but based on what we call standard designs, this bulletin will help explain how we do our power predictions for Varifold Folding Sailboat Propellers.

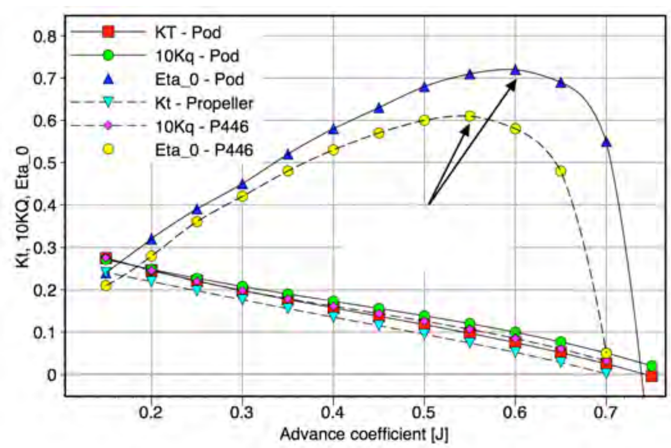
First, there are many methods to do this prediction. The simplest and very common in the sailboat market is Crouches method. This is a statistical / Empirical method based on similar propellers for similar vessels. It is what has worked on a similar vessel in the past should work on mine kind of approach. It is a great method for lightly loaded propellers (such as sailboats) where optimum efficiency is not critical, but still important. We don't use this method for final design, but it gives a great first shot. See the book “Propeller Handbook” By Dave Gerr for a great explanation of this method and the next one we are presenting which uses diagrams like the one below - yikes!.



So back to the propeller size quoted for your sailboat. There is an important relationship in the numbers. Your propeller will be number of blades, Diameter then Pitch, (e.g. 3 blade 16 x 12) with the Pitch to Diameter ratio (P/D) being derived as the key parameter. The crazy diagram above is known as a Bp delta diagram and it is setup to take the torque of your engine, against the rpm and find the optimum efficiency. This over simplification of the diagram yields a point in the middle of it somewhere, then it is a case of reading to the left and you have your P/D ratio for the propeller. We know the maximum propeller diameter for your vessel and then it is straight forward to calculate pitch from the P/D ratio. Again a simplification as there are additional parameters but it explains the concept fairly well.

So to enter data into our diagram we need to know details about your vessel, what type it is, the engine horsepower, maximum rpm, gearbox ratio and so on. The last value is often overlooked and it is important. Most sailboat engines run at about 3000 rpm, at this speed the propeller would cavitate like crazy. So to make the propeller spin slower and put the same power down a gearbox (typically 2:1-ish) is introduced. Knowing this value is critical in predicting the right propeller to absorb the right power.





Once the boat engine and gearbox specifications are known a power prediction can be made . The Bp delta diagram is the backbone of the design. and It stems back from the days before computers, in drawing offices where graphical data was easy to create and use. Engine Manufacturers typically used a propeller design (not theirs) such as the B-Series (very common) which was tested between 1930-70 in Wageningen; it is still the standard design today for most manufacturers.

The B-Series project took about 30 propellers and varied the pitch and blade area systematically for 2, 3, and 4 blade propellers. Each propeller had the same blade section (aerofoil shape) and diameter. Each propeller was tested from low to high speed and the performance recorded in what we call an open water test. The pictures to the left shows the test in progress with a little cavitation present and to the right the results. The open water test outputs thrust, torque and efficiency.

Now if you do this test for 30 systematically variations of the same design, picking one from the matrix is straight forward. So that is what the Bp Delta diagram does, it takes the torque, and efficiency of all the propellers and combines them into one diagram that with a little training you are able to specify an optimum pitch and diameter for a propeller using those blade sections of your design. It is known as basic design as there is no wake introduced and the propeller is considered to operate without the presence of the hull - further complications! Different manufacturers will use different blade sections and you will get different results. For example Varifold uses airfoil sections with a true helical pitch distribution (pitch changes along the blade) like a regular fixed propeller which is good for noise and vibration. A feathering propeller has to have the same pitch along the blade as it has to align with the flow to be a low drag unit under sail. Both propellers will therefore have different pitch / diameter combinations for the same vessel.

A search on B-Series or Bp delta diagrams will yield more information. Most of the fixed pitch engine manufacturers specifying a standard design for the boat which will work great under motor and this will be based on their experience and, most probably, the B-Series data above. However Varifold is a different type of propeller, with different blade sections, the camber of the blades is different (a big factor in how these propellers generate lift and suppress cavitation) and the pitch is different at different radii, so differences are expected. With the Varifold the blades also fold behind the hub to reduce the drag which gives the benefits of good propeller design and the folding allows for the unit to be streamlined under sail.

Based on the above methodology it is easy to see why Varifold is consistently quoted as being a smooth and quiet propeller both under sail and under motor. Sailboats don't like propellers but we think we have a great solution to this problem with the Varifold Folding Sailboat Propeller - I hope you agree!

If you have any comments or questions about Varifold please call me, I'd be delighted to help.

Dr Roderick Sampson

Principal Naval Architect