

GENERAL HULL FORM EQUATIONS

$$\text{Displacement to Length Ratio} = \frac{\text{Long Tons Displacement}}{(.01 \text{ LWL})^3} = \frac{\Delta_{\text{LT}}}{(.01 \text{ LWL})^3}$$

$$\text{Prismatic Coefficient} = \frac{\text{Cu.Ft.Displacement}}{\text{Midsection Area} \cdot \text{LWL}} = \frac{\nabla}{A_m \cdot \text{LWL}}$$

$$\text{Block Coefficient} = \frac{\text{Cu.Ft.Displacement}}{\text{LWL} \cdot \text{WLB} \cdot \text{Body Draft}} = \frac{\nabla}{L \cdot B \cdot D_B}$$

$$\text{Midsection Coefficient} = \frac{\text{Midsection Area}}{\text{WLBeam} \cdot \text{Body Draft}} = \frac{A_m}{\text{WLB} \cdot D_B}$$

$$\text{Prismatic Coefficient} = \frac{\text{Block Coefficient}}{\text{Midsection Coefficient}} = \frac{C_B}{C_M}$$

$$\text{Waterplane Coefficient} = \frac{\text{WP Area}}{\text{LWL} \cdot \text{WLB}}$$

These are all dimensionless coefficients of form, and allow comparison with other boats, or even with models, independent of their differences in size.

COEFFICIENTS OF FORM

DISPLACEMENT TO LENGTH

Ranges for Δ/L have been slowly re-defined over the years, tending toward lighter displacements within each range. Heavier displacement requires more power & more sail area. Heavier displacement is generally more comfortable.

Sail

Light Multi - Hulls	40 - 50
Ultra - Light Racers	100 - 150
Light Racers	150 - 200
Light Cruisers & Offshore Racers	200 - 275
Medium Weight Cruisers	275 - 325
Heavy Cruisers	325 - 400

Power

Light Displacement	75 - 200
Medium Displacement	200 - 300
Heavy Displacement	300 - 400

SPEED TO LENGTH RATIO

For a displacement boat, speed is a function of waterline length.

$$\text{Speed to Length Ratio} = \frac{\text{Velocity in Knots}}{\sqrt{\text{Waterline Length}}} = \frac{V}{\sqrt{LWL}}$$

This is the speed that a pair of waves can move through the water. Above this speed the boat begins to try to climb its bow wave.

The maximum speed is ordinarily considered to be 1.34 times the square root of the LWL, however a vessel having light displacement to length will be able to exceed that "limit" and a vessel having heavy displacement may not be able to actually reach that theoretical speed potential.

PRISMATIC COEFFICIENT

The prismatic coefficient is the ratio of actual underbody volume to the volume of a prism having a length equal to the DWL, and a section equal to the boat's maximum sectional area.

The prismatic coefficient provides an indication of the distribution of displacement. It is an indication of the fineness of the ends in relation to the midsection of the hull. A low prismatic means fine ends and large mid-body. A high prismatic means there is more displacement distributed toward the ends.

For any given speed to length ratio, there is an ideal prismatic coefficient. Fullness or fineness of the ends has a large effect on wavemaking resistance.

Optimum prismatic coefficient depends on the expected speed range.

- Up to SLR of 1 the least resistance is with a prismatic of .53.
- At SLR of 1.2 the ideal prismatic is .58.
- At SLR of 1.35 the ideal prismatic is .62.
- At SLR of 1.8 the ideal prismatic is .70.

Sail

Opinion varies regarding the range of ideal prismatic coefficients. Most sources suggest that for average conditions, the optimum prismatic is between .54 and .56.

Light winds and calm water favor a lower range of about .53 to .55. Heavy winds and ocean sailing favor a higher range of about .55 to .58. The higher prismatic gives greater buoyancy in the ends, and displacement in the ends contributes favorably to stability.

Philips-Birt and others suggest that it is better to err on the high side to allow the least penalty at higher speed. Light wind sailing suffers less from a low prismatic than fast sailing suffers from a low prismatic.

Opinion also varies regarding whether the keel should be included when figuring the prismatic. If the keel contributes significantly to the displacement of the ends, it should be included.

The keel should be excluded when figuring the prismatic for a canoe body and fin - keel. With a full bodied sailboat, having an integral full keel that fairs gradually into the hull, the prismatic must include the keel.

With a well defined keel, whether full or not, if you figure the prismatic coefficient for the hull separately, you have a much better idea of the overall hull shape. In this case a value can be given for the prismatic both with and without the keel. The keel *does* contribute to the dynamic displacement of the hull as it moves through the water.

Power

Opinion varies here as well. For displacement power boats, the same ranges as for sailboats would apply, except that it may be easier to predict the usual operating speed.

- For planing power boats some favor a range of from .60 to .70.
- Semi-planing boats would benefit from a range of from .60 to .65.
- Full planing boats would benefit from a range of from .65 to .70.

Planing is more easily achieved with a higher prismatic which provides a greater distribution of displacement toward the ends. For planing, many of the same considerations apply as for displacement hulls.