right angles to the shaft line, and leaves the trailing edge of the blades at a differing angle, *b*. This angle varies all along the length of the blades, and the average of these differing angles is the virtual pitch. The virtual pitch is the real or true pitch of a propeller. It is never specified by manufacturers; its importance lies in the fact (see below) that it may vary among propellers having the same face pitch, and the behavior of these propellers in use will vary somewhat as a consequence.

Analysis Pitch, P_0 Like virtual pitch, *analysis pitch, (P_0),* also called *experimental pitch,* is another way of measuring true or effective pitch. *Analysis pitch* is the pitch of a propeller as measured by the water speed and RPM at which the propeller cannot keep up with the water flow—in other words, the speed and RPM when thrust falls to zero.

When at a given speed through the wake, *Va* (see Chapter 6), at a given RPM, the propeller thrust vanishes, the analysis pitch, P_0 (in feet) is 101.33 times the speed through the wake (in knots) divided by the RPMs at zero thrust, N_0. For a propeller delivering zero thrust at 2,800 RPM through a 21-knot wake, the analysis pitch would be 0.76 feet or 9 inches (231.5 mm) [**101.33 × 21 knots ÷ 2800 RPMs = 0.76 ft = 9 in**].

Formula 3-1 Analysis Pitch Formula

Formula 3-1

Analysis pitch = P_0 (in feet)

$P_0 = 101.33Va \div N_0$

Where:

Va = speed in knots through wake at zero thrust

N_0 = shaft RPM at zero thrust

Pitch Comparisons Increasing blade thickness and increasing blade width both have the effect of increasing the virtual pitch. Since propeller manufacturers specify their propellers based on face pitch—it would be a prohibitively complex undertaking to calculate virtual pitch—it is important to compare propellers of comparable blade thickness, blade pattern, and width; otherwise their real or virtual pitches will be different even though their specified face pitches are the same.

Even measuring simple face pitch poses some problems. Since the blade angles vary all along the length of the blades, from the root to the tip, you would get a different pitch measurement depending on where you took the measurement. By convention, however, the face pitch is always measured at 70 percent of the radius out from the shaft center. For instance, a 44-inch (1117.6 mm) diameter propeller would have its face pitch measured 15.4 inches (391.16 mm) out from the shaft center [**44″ diameter ÷ 2 = 22″ radius, and 22″ × 0.7 = 15.4″**].

Pitch Ratio Pitch is defined in terms of inches or millimeters; however, it is also very useful to define pitch as a ratio of diameter—*pitch-diameter ratio, pitch ratio* or *p/d ratio*. A 20-inch (508 mm) diameter propeller with a pitch of 18 inches (457.2 mm) has a pitch ratio of 0.9 [**18″ ÷ 20″ = 0.9**].

Formula 3-2 Pitch Ratio Formula

Formula 3-2

Pitch ratio = P/D

Where:

P = pitch

D = diameter

Pitch ratios generally fall between 0.5 and 2.5; however, the vast majority of vessels operate best with propellers having pitch ratios between 0.8 and 1.8. Very roughly, a pitch ratio of 0.8 can be expected to produce efficiencies of around 0.65, while pitch