GUIDELINES FOR PROPELLER TUNNELS ON SMALL CRAFT

1. All hull and tunnel surfaces should be as smooth and fair as possible, without discontinuities or knuckles. Shaft struts should be as small as possible, consistent with strength requirements, and the strut and rudderport palms should be flush with the tunnel surface. No intakes, outlets, transducers, or other "bottom clutter" should be placed in the tunnel, or on the hull bottom immediately in front of or alongside the tunnel. Spray strakes should not be placed directly in line with the tunnel.

2. In plan view, the intersection between the tunnel and the hull bottom should be roughly rectangular. In other words, the tunnel should be as wide at the forward end as it is in way of the propeller.

Hull-bottom tunnels, along with custom and new-style propellers, have helped reduce the cavitation and vibration problems on highly loaded installations.

3. In profile view, buttock lines within the tunnel should be fair, usually taking a gentle "S" shape. At the forward end, the tunnel should fair into the hull bottom without a knuckle.

4. In section view, the tunnel shape in way of the propeller should be a radius. For very deep tunnels, the sides of the tunnel should extend straight down to the hull bottom from the three o'clock and nine o'clock positions. (For fiberglass hulls, a couple of degrees of draft is okay to allow for pulling the part from the mold.) To maintain the rectangular intersection in plan view (guideline No. 2, above) means that sections forward of the propeller will have increasing radii. Some installations have also used sections forward of the prop that become somewhat elliptical in order to meet the area criterion of guideline No. 6, below.

Tip clearance should normally be 5% to 10% of the prop diameter. Better performance has been reported with the lower tip clearance, but increased vibration may result. For vibration-critical installations, some yachts use up to 15% tip clearance, but we don't feel this is necessary. Although the propeller is normally concentric with the tunnel, some builders have reported speed increases when the propeller is moved slightly outboard.

Opinions are divided on just how to sculpt the sides of the tunnel, where it intersects the hull bottom. Some recommend keeping it fairly sharp, providing only a small radius (¼" to ½") as necessary for laying up fiberglass, and claim increased speed as a result. Others recommend a more generous radius; this is particularly important where a tunnel that is either shorter or steeper than recommended may result in some transverse flow into the tunnel.

5. The slope of the tunnel roof, relative to the fair hull-bottom, should not exceed about 7° to 8° for high-speed (planing) boats, or 10° to 12° for moderate-speed (semi-planing) boats. Since the tunnel roof may be a curve, the slope is defined as arctangent ($\tan^{-1}$) of the height of the tunnel roof above the fair bottom at the propeller, divided by the length of the tunnel from the propeller to the forward end of the tunnel.

6. A graph of the desired cross-sectional areas of the tunnel at any point forward of the propeller can be developed by using the formula $A = 0.0237 \times d^2$, where "A" is the cross-sectional area and "d" is the distance aft of the forward end of the tunnel. The minimum length of the tunnel, from the prop to the forward end, is therefore 6.5 times the square root of the cross-sectional area in way of the prop, or $d = 6.5 \times A^{0.5}$.

7. Aft of the prop, the tunnel cross-section may vary. It can remain constant, extending straight aft, or it may turn down slightly if necessary to counteract a bow-high running angle. For some higher-speed boats, contraction of the tunnel area aft of the prop ("nozzling") has resulted in speed gains. In no case should the down-slope of the tunnel roof exceed that of the propeller shaft; i.e., the tunnel roof should not converge on the shaft, so nozzling is sometimes accomplished by bringing the tunnel sides in.

A final note: These rules of thumb are *guidelines only*, based on the best research and practical information available at this time. It is expected that tunnels designed to these guidelines will perform satisfactorily, but this cannot be guaranteed. If performance is critical and needs to be optimized, we strongly recommend you carry out scale-model and/or full-size testing to develop the final tunnel details.

—Dudley Dawson

RECOMMENDED READING

Unfortunately, detailed technical information on the design of small power craft cannot be found in any one reference. Much of the useful data is scattered in numerous technical papers and books, many now out of print. The New Jersey-based Society of Naval Architects and Marine Engineers (SNAME) is working to correct that. A comprehensive two-volume text, *Principles of Small Craft Design*, is currently being written and should be available in early 1998. If you'd like more information in the meantime, we recommend you purchase a copy of *Principles of Naval Architecture* from SNAME, and while you're at it, subscribe to *Marine Technology*, the Society's quarterly technical journal. SNAME membership will bring you the book at a discount and the journal at no cost. Call 800–798–2188, or 201–798–4800 outside the United States and Canada, for membership information and a publications catalog.

Further propeller information can be found in several SNAME papers co-authored in various combinations by Donald Blount, David Fox, and Nadine Hubble: "Sizing Segmental Section Commercially Available Propellers for Small Craft"; "Design Considerations for Propellers in a Cavitating Environment"; and "Small Craft Power Prediction."

A good starting point on the basics of hull form, engines, gears, and propellers is a booklet from Detroit Diesel Corporation, entitled *Elements of Marine Propulsion*; ask your local distributor for a copy, or, if you have the company's full-line catalog/manual, look under the Section I tab.

For further information on weight estimating and control, we recommend a SNAME paper by John Daidola, "Weight Definition and Control for Fast Craft."

Though the following books are out of print, you might be able to find a copy in a library, a used-book store, or through an out-of-print-book service: *High Speed Small Craft Design*, by Peter DuCane; and *The Design of Marine Screw Propellers*, by T.P. O'Brien.

Special thanks to SNAME for permission to reprint several figures in this article from Society publications. *—D.D.*