When Does Shallow Water Become a Problem?

A HydroComp Technical Report
Report 124

During sea trial analyses, users of NavCad and PropExpert have encountered situations where the drag and power were much greater than expected. In some of these instances, the shallow water effects may be the cause of this added drag and power. This report is written to help determine when shallow water becomes a problem.

OVERVIEW

Boats and ships can be easily affected by shallow water. Basically, we are witnessing a "Bernoulli" effect, where the water velocity around the hull must be accelerated due to the restriction of shallow water. This increase in velocity results in a higher drag comparable to this higher "effective" speed. In addition to this, the accelerating water can pull the vessel down (known as sinkage or squat), causing the ship the act as if it had a larger displacement. So when does shallow water cause a measurable loss of speed?

SHALLOW WATER

We describe the parameters of shallow water through the "depth Froude number", which is equal to $V / (gH)^{0.5}$. The parameter V is the ship speed, g the gravitational constant and H the water depth. In units of knots and feet, $F_{NH} = 0.297\ V_{KT} / (H_{FT})^{0.5}$. In knots and meters, $F_{NH} = 0.164\ V_{KT} / (H_M)^{0.5}$.

One widely-used analysis of speed loss in shallow water is the Schlichting method. It can give us a general sense of the potential speed loss. He found that there is typically no measurable speed loss as long as F_{NH} is less than about 0.4. As F_{NH} increases, however, the speed loss begins to take effect:

F_{NH}	0.0-0.4	0.6	0.8	1.0
Speed loss	no loss	1% loss	4% loss	14% loss

(**NOTE**: When F_{NH} is greater than 1.0, we typically see the speed loss quickly reducing to where we can even get a beneficial effect at high speeds, such as at planing speeds.)

We can turn this into a table of "critical depth" for each F_{NH}:

Speed	**Minimum depth for**			
	no loss	**1% loss**	**4% loss**	**14% loss**
5 kts	14+ ft	6 ft	---	---
10 kts	55+ ft	24 ft	14 ft	9 ft
15 kts	124+ ft	55 ft	31 ft	20 ft
20 kts	220+ ft	98 ft	55 ft	35 ft

This tells us that at "displacement" speeds, the vessel will slow down as water depth gets shallower. It also shows that "shallow" water need not be all that shallow, particularly at higher speeds. Remember - these are typical values only and each ship will be somewhat different.

EXAMPLES

- A fishing boat normally can run at 10 knots in deep water. If the water depth is 14 feet, then we can expect a speed loss of about 4%. That means that its speed is reduced by about one-half knot.
- A supply boat is expected to run 15 knots in deep water. However, during sea trials in 20 feet deep water it did not make this speed. The 14 % typical speed loss means that we would expect a bit less than 13 knots on trial.
- A river work boat is trying to run at 10 knots in 9 ft of water. It will lose almost a knot and a half.

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