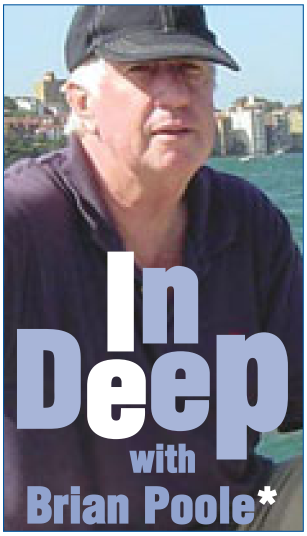


# Flooded Keels - Why They Can Be A Very Good Idea

**Marine industry operatives talk with authority about engineering and design concepts.**

There is always an element of truth in what they say but sometimes the technical reasoning given with a statement of fact shows a lack of understanding of the fundamental first principals of hydrostatics, hydrodynamics, and intact or damaged stability. This current series of articles attempt to give industry and other readers an appreciation of what is happening.

Last month, we looked at "free surface effect" and the moment of inertia of the water plane that the vessel is floating at. We discussed stability, measured by the distance from the vertical centre of gravity of the boat in the existing condition of loading to a point on the centreline called the metacentre (M).

**For a craft to be stable M must always be above G.**

We also looked at the effect of the free surface of any unrestrained liquid in the craft, either in tanks or free in the bilge or cockpit.. We discussed the concept that the free surface of the liquids has the same effect as if G was to rise to a position called G virtual, thus reducing the margin of stability as measured by GM.

The extent of the rise in G is dependent on the amount of free surface and the moment of inertia of that free surface about the craft's centrerline.

For a craft with free surface to be stable, the GM fluid, that is GM with the free surface accounted for, must always be below M. If the free surface affect causes G (virtual) to rise above M the craft will turn over. Note we are talking about the area of the free surface (square metres), not the volume of the liquid (cubic metres). The moment of inertia of the surface of the fluid is taken about the centreline and the further the extremities of the surface are from the centreline the greater the effect.

Likewise stability depends, among other factors, on the moment of inertia of the water plane of the craft. The greater the waterline beam the greater the initial stability. If we increase the beam at the waterline we increase stability in the upright condition. Because the moment of inertia depends on the beam and the square of the distance from the centreline, any increase in beam at the chine has a considerable positive effect on stability. Likewise any increase in the width of free surface has a negative effect. Free surface must therefore always be controlled to the greatest extent possible.

To understand how some water ballast concepts makes a craft more comfortable when at rest we must first appreciate these forgoing concepts.

In strictly technical terms, water ballast is water contained in an internal tank. It is used on warships and merchant ships as a means of keeping G (solid) low so the ship has an adequate GM and consequently a sufficient margin of stability. The free surface in tanks is taken into account to obtain GM fluid. What happens is that the weight of the volume of water causes G (solid) to drop but the free surface effect of the area of water surfaces has the same effect as if G were to rise to G (virtual). The latter is usually the lesser of the two. In the true sense, on a large displacement speed ship, if the compartment is open to the sea, it is not a ballast tank but rather a free flooding space or compartment.

The weight of the water in a free flooding space would not be part of the ships displacement (in tones).

For example, let's say a small ship had a loaded displacement of 210 tonne including 10 tonne of ballast water. If it were a free flooding space its weight would be 200 tonnes as there is only 200 tonnes of buoyancy. The volume of the free flooding space is not contributing to supporting the craft.

Free flooding centreline keel tanks are used on 20-degree deep vee planing craft. The actual weight of the craft when stopped and when planing is the same, if we ignore any interim effect of trapped water during draining of the water while the craft is getting up on to the plane.

The vertical position of G solid does not change.

When the craft is on the

plane, the water in the space drains out the back, meaning that the craft is not carrying water in the keel space. This is a big plus. If the water were contained in an internal tank the craft would be carrying the extra load.. This weight would affect speed and seagoing performance. Planing craft must be as light as practical. The heavier the craft the larger the slamming loads, and the power required to make it plane.

A self draining keel space has always been a feature of the Avon rigid inflatable boats (RIB's). The Avon had a deep vee and at speed the collars are clear of the water. When the RIB stops the keel floods and the RIB floats with the collars in the water. This increases the moment of inertia considerably and makes the craft more stable and comfortable as a work platform.

Similarly fitting the chine modifications to F&B's *Far-Away* increased the inertia of the water plane and added to stability and comfort.

The same thing happens with a conventional light displacement deep vee hull fitted with a free flooding centreline keel space. Deep vee hulls, without free flooding spaces, often float with the chines out of the water.

With a free flooding space, when the craft stops, the centreline space floods, the chines sink into the water, the inertia of water plane increases, making the craft more stable and much more comfortable.

It does not matter if it is called a ballast system or a flooding system, the resultant effect is the same. I shall not go into the engineering reason why this so, except to say that when we calculate the stability of damaged ships, we can use either an added weight or a lost buoyancy method to get the same result.

In the case of a heavily loaded deep vee, the craft would weigh more; the chines would be in the water, and there is (usually) no need for the floodable keel.

When the craft is planning it still weighs the same but is no longer supported by the upward force of buoyancy but by the upward dynamic hydrostatic forces on the bottom of the hull. This is why, when we talk of stability, we generally call it "static stability" that is stability at rest or a slow displacement speed before the craft starts to plane.

Dynamic stability at speed is another matter. A speeding planing craft will heel over in the direction of the turn due to dynamic forces where as a slower displacement speed vessel will heel outboard .

An alternative approach, that I have used on custom designs, is what I call the "Delta Keel". That is, the keel is about 600 wide at the transom going to a point on the keel at about one quarter of the waterline length from the forward end. It takes buoyancy out of the hull but not as much, I would think, as would be the case with the Bar Crusher design. The Bar Crusher team have put a lot of effort into getting the floodable keel or as they call it "Quickflow ballast system" working well.

However there is an advantage with the delta keel, in that with a single outboard, the motor can be set up higher. The transom height for an outboard is measured from the underside of the hull to the underside of the engine mounting on the centerline of the motor.

This means that with a deep vee hull, the single motor is lower than with a twin-engine installation.

When a single engine is used, a delta keel has some advantages, particularly for craft under 5.5 metres which will sit upright of the hard or on a beach.

The Army SAS 9 metre KBM RIB's have a delta keel and sit upright on a wharf with out any supports. I notice also that some inboard motor ('centre-mount') wake board boats have a delta keel. In this case it would not only add to the efficiency of this type of hull but also reduce the shaft angle and draught to the underside of the propeller tip. These are concepts that a designer must consider to get the best all round functional performance from a craft in all its intended operations.

The free flooding keel or "ballast" keel system has advantages on 5.5 to 7 metre trailable deep vee craft.

For those owners who want to go as fast as possible offshore, or in adverse conditions in sheltered waters, and also want a fishing platform as stable as possible when stopped, it offers a worthwhile solution.

It is well worth having when incorporated into a production craft such as the Barcrusher. For smaller craft that will be beached, often a Delta keel with no more than a 15 degree vee deadrise hull is, in my opinion, the better all round option.

**F&B**

**Without doubt, one of the Bar Crusher's most impressive features is the outstanding stability at rest, thanks in part to its excellent 'water ballast' or 'flooded keel' system. This works by removing some of the boat's displacement when it is at rest in the water. The boat thus settles lower in the water, fully immersing its chines until it takes off again, and all the water in the hollow keel rushes out.**


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