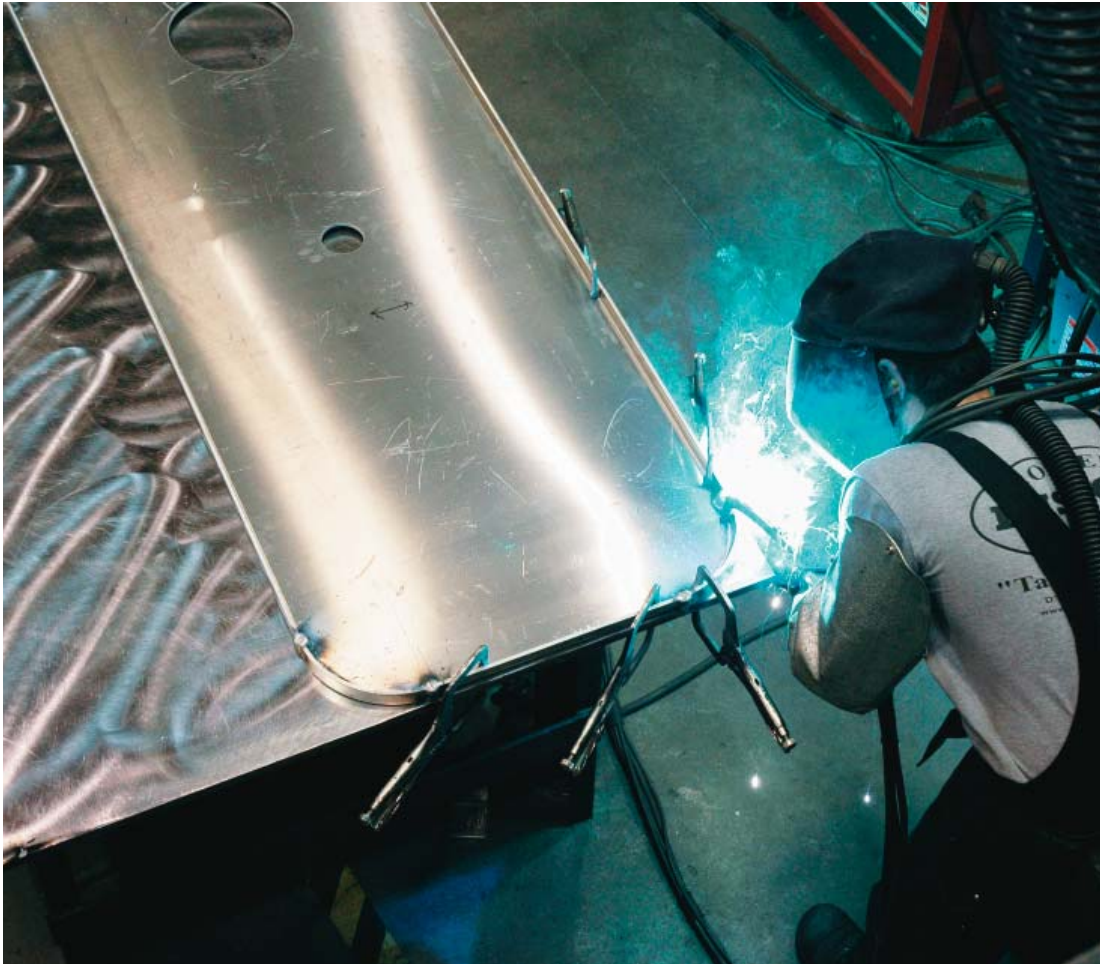


Heaven's Door

FROM CONCEPT TO CLOSURE

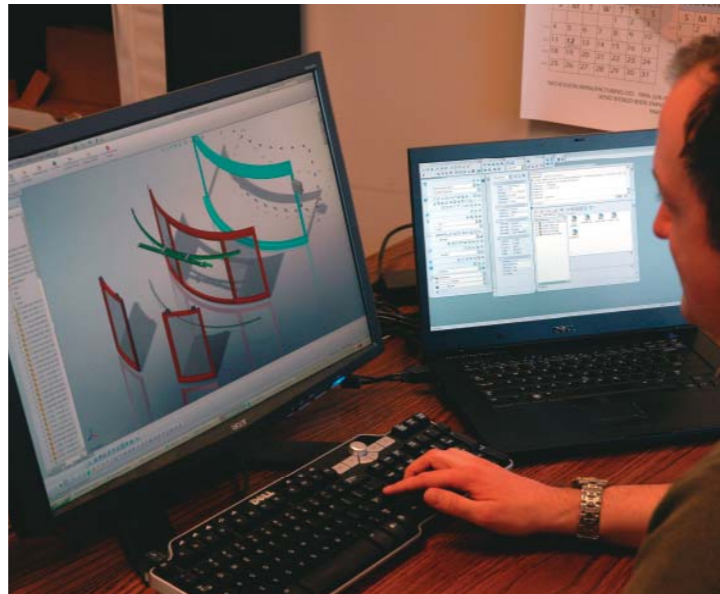


A door may be – as a wit once quipped – “what a dog is perpetually on the wrong side of”. But for owners they are the portal to their pleasure (yacht) or in the opposite direction a portal into fun sea and sun. They must fulfil many design and regulatory criteria too in an aesthetic and affordable manner. Despite this we rather take these complex machines for granted as their engineering design and construction are complicated, and almost always remote for the yard where the yacht is built and thus demand great accuracy, rigour and sound communications. Craig Dixon and Dean Robinson of Pacific Coast Marine Industries (PCMI) guide us through the process of how they arrive at a specific design and how that goes from a flat metal plate to a finished door.

THE SELECTION OF CLOSURES FOR A YACHT PLAYS A pivotal role in the aesthetics, function and seaworthiness of a vessel. Building and designing yacht windows, doors and hatches that will withstand the rigors of the sea and provide long-term functionality require expertise that combines good design, practical engineering and a high degree of craftsmanship. High-quality closures will contribute to the enjoyable use of the vessel and ultimately its resale value. The design of windows, hatches and doors starts when the first concepts are imagined by an owner; realised by the designer; then translated into profile drawings. This style and design process not only affects the aesthetics of the yacht, but also begins to set the requirements that closures must meet to support them.

Specification of windows, doors and hatches usually starts with a discussion between the yard, yacht designer or naval architect and an established fabricator that has the technical expertise and capabilities to produce the correct enclosure for the application in standard to complex designs. By understanding the concept or vision of the design and the openings required this group can begin to define the correct product based on form, fit and function. Several key factors are taken into account that will have an effect on the final closure – this includes the standards that will need to be met in order to supply a final product fabricated in accordance with classification society rules. Using type-approved closures can speed up the inspection process and approval period for a classed vessel. Influencing factors are the location of the opening, the size of the opening, how the client wants the closure to function and, certainly not least, its appearance. The combination of these requirements defines the complexity of the closure and ultimately the cost.

The technical design of a closure starts with the specification of the hull or superstructure plate cut-out. This determines the size of the finished opening that will be closed with a door, hatch, window or portlight. Windows and portlights are typically measured by clear view or sight lines (the amount of viewable glass) that are required. Engineers look at the yacht's construction material – composite, aluminium or steel – to determine the type and style of support frame that will be needed to prevent failure and allow the yard to easily install it. The frame selected could be a large cross-section of steel welded in place, a through-bolted



Top: 3D CAD design
Middle: Assembly start
Bottom: CnC frame machining

aluminium frame or a two-piece frame specifically fabricated to allow for variances in wall thickness.

For Class, a watertight door may need to be tested to meet specific requirements to resist seawater pressure as specified for the vessel class type. This level of resistance is called “head pressure” – a number that quantifies the force a door (or closure) can withstand from seawater pushing against it. A pressure test simulates a wave or flooding condition encountered at sea and quantifies the force the closure can withstand. The watertight doors and hatches are typically engineered and tested for an internal and external head pressure of 3.5 metres of water with zero leakage. The internal head pressure is applied against the door pushing away from the seal on the interior side of the door panel, opposite of the pressure normally encountered in heavy sea conditions and unlikely. Closures can be built to meet higher head pressures if required.

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Understanding how to engineer to a certification standard and being able to apply that knowledge in a practical application to meet the requirements is a key requirement to look for in a manufacturer. The availability of engineering expertise during the early design and review stages can result in changing the material combinations including a heavier skin, or metal sheeting, on the door, a different combination of internal stiffeners to support the skin, and number of latches or ‘dogs’ to keep the door snug against the seal or gasket. This specialised help early in the process can save the yard and owner time and cost. Additionally liaising between the client and Class Society helps to provide documentation information, strength calculations and construction details.

The functioning of a hatch, window or door requires that the correct system is chosen to move the enclosure away from the opening and keep it secure when closed. A good example would be pilothouse door hinges. There are several options from standard butt hinges that function much like a house door swinging open from a fixed side to the complex



Top: Door assembly
Middle: Careful final assembly
Bottom: Custom sliding door assembly and testing

(manual or powered) pantograph hinges. These latter ones allow the door to move away from the opening in the least amount of space and closely parallels the yacht's exterior surface when fully open.

After several consultations with the designer or yard to determine the exact criteria a preliminary proposal is developed of the door's look and function. Providing clients with design details generated by a combination of 2D and 3D CAD software is most beneficial at this stage. Starting with a take-off from the actual vessel design, this CAD model is developed to match plate curvature, hatch position and opening function. Adjustments are made in the design to ensure there is adequate space to open and close correctly and that the enclosure can still be easily installed. Complex curved windows and openings often require an actual template. This may be provided by the client, yard or designer matched to the vessel's section. This template is used to check the accuracy and shape of the closure during development and production. The process ensures accurate fitting of a key part of the high-quality yacht finish that clients seek. Once the drawing details are signed off by the client, the project is ready to go to production.

The production is now started by releasing the drawings to the shop floor. That is where experienced quality craftsmen make a big difference as they carefully cut, shear, form, bend, weld, grind and finally assemble the components.

Let's follow the process of making an example door. The door design was developed with a specific frame and a panel combination. The process started by selecting the correct extrusion profile designed to capture the door edge, which was then bent into a frame. We combined custom built and designed bending equipment and craftsmen to build square, mitred corner or radius corner door frames that are welded together from a single strong unit. The doorframe is then used through construction as a template and "check point" to ensure that the door is built to the correct dimensions with the proper reveals (reveal is the continuous space between a door and frame).

Constructed from the correct thickness of sheet metal and the combination of multiple sub-components the door itself is fashioned into a single weathertight unit. Fabrication starts with the door skin. It is cut using a CNC water-jet system driven from the CAD files. This cutter trims



Top: Complex curved windshield
Middle: Custom adjustable stainless hinge
Bottom: Extrusion detail

the sheet stock to the required dimensions with curves and tabs that will be bent to form the side of the door skin. The sheet metal is then carefully fabricated into a door panel by forming and bending into a shallow box ready for the reinforcing stiffeners or web system to be welded or adhered into place. Stiffening material is engineered to optimise the strength-to-weight ratio while ensuring the specified resistance to wave and flooding forces. This is a proprietary process developed through a careful engineering and testing program.

The components are dry fitted then welded to the door panel. The door is then sanded and prepared for preliminary assembly of the internal working components. At this juncture the complete door panel is mounted on a 5-axis CNC milling machine to accurately locate and machine all the openings for the mortises, hinges, locksets and handles. After machining, the internal components are fitted and installed. Then the door and all the hardware is mounted to the door frame and its functioning tested. These processes take from a few hours to several days depending on complexity. When the door has been assembled and proved, it is prepared for final finishing by disassembling all of the components and then it gets a final light sanding in preparation for painting.

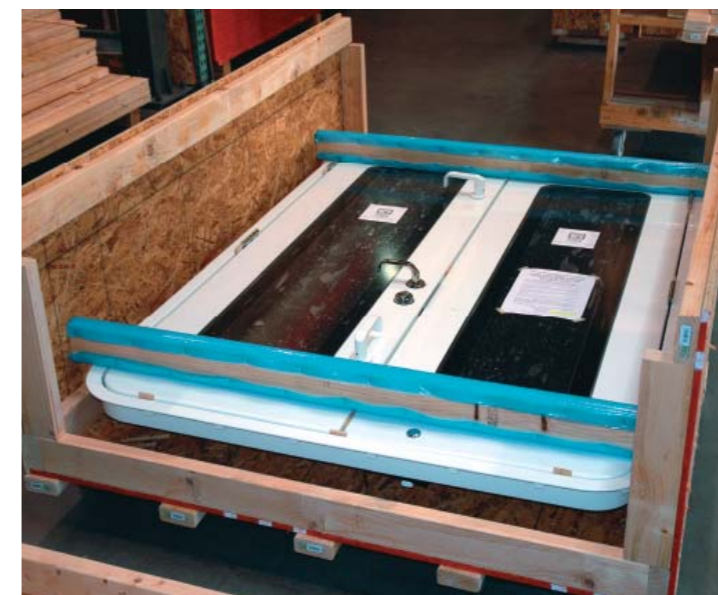
Resilient coating and finishes that seal the components from saltwater and the marine environment are a necessity for longevity. Paint preparation is carefully executed to assure that the undercoating adheres properly. Aluminium door components are dipped in a sealer against porosity. Steel doors are sprayed with a high-quality catalysed priming system. The final step is painting the door with a high-quality catalysed topcoat to match the yacht's. The paint is cured in a temperature-controlled sterile chamber.

The finished components are then reassembled for the last time, checked for final fit, function and quality. Any final adjustments are made then the door is wedged into the frame, capturing the reveal and securing the whole assemblies for easy installation at the build yard. Finally, a custom-shipping crate is constructed, filled with the assembly and sent (very possibly) halfway round the world to the build yard.

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Images: PCMI

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Top: Handwheel and hinge detail
Middle: Watertight dog open
Bottom: Custom shipping crate