SOME COMMENTS ON CRUISING BOAT DESIGN AND CONSTRUCTION

Sailing vessels like most anything you buy are available in various levels of quality depending on their intended use. Some are designed for racing, others for recreational sailing on a lake, harbor or coastal; while others are for long distance cruising. These vessels will vary in price because they are built differently. Our objective is to build a boat that will last a life time and is capable of crossing oceans without worry of deterioration or breaking apart in the roughest of seas. To build a boat of this quality requires hundreds and even thousands of skilled man hours and use of the best materials and building methods available. Unless the buyer is a boatbuilder or has extensive offshore sailing experience it will be difficult to determine what separates one boat from another. The buyer may listen to the salesman or read articles (not ads) about the boat and presume what is said or what he read is correct.

Recent boat building technology has been aimed at the lighter, faster vessels with as much living space as possible but at the sacrifice of structural strength and offshore safety. The Sam L. Morse Co. feels that this new technology is excellent but in some cases does not belong as a building method for long distant cruisers. Our intention is to explain the advantages and disadvantage of the methods now being used by other builders and compare these to the methods being used by the Sam L. Morse Company. We hope to enlightened the reader with information they may not have considered before.

HULL DESIGN: There are three issues to be addressed: The underbody hull shape, the transom design and the topsides surface area. Reference: *SEAWORTHINESS The Forgotten Factor by, C.A. Marchaj.*

Hull Shape: There are many different hull shapes, lets separate them into two categories: the racer type and the cruising or offshore type.

Racer Hull Shape: The racer's hull is usually round with a deep fin keel and spade rudder. The advantage here is there is less wetted surface so the boat will sail quicker than other shapes and designs. For the offshore sailor the concern is also one of speed but more importantly, a structurally strong boat with less draft and a keel shape that isn't so vertical, as these vessels will be sailing into unfamiliar waters and the likely hood of a grounding at speed may occur. There is also the possibility that they may hit a container, logs and general large flotsam which is increasing daily. There is even the danger of a collision with large sea life. With a fin keel and spade rudder the grounding or collision will be abrupt and could cause severe damage. When a deep fin keel boat does go hard aground it is more difficult to kedge off because the anchors are set lower than the deck level of the boat thus pulling the stern downward aft, digging the back of the keel deeper into the bottom. The deep, nearly vertical keel and spade rudder will catch fishing nets and may be damaged by even a small log. If damage were to occur at sea it would be nearly impossible to make repairs until a proper boat yard is reached where the vessel could be taken out of the water. This hull shape is difficult to beach for bottom cleaning or repairs and it is no simple matter to stand on the hard without ample support to keep it from falling. If the rudder post is bent and the boat is set out of the water a hole in the ground must be dug so the rudder can be removed from its housing.

An equally important concern is that the fin keel, spade rudder is quick at the helm, meaning it will turn quickly with the slightest movement of the helm. This is important for the racer but the offshore sailor wants a longer keel shape so the boat will track and hold her course for long periods with little work at the helm.

Because the fin keel is deeper with less wetted surface fore and aft of the keel it is difficult to impossible to "heave to" in storm conditions. The ability to "heave to" easily is an important storm strategy for the offshore sailor.

Cruisers Hull Shape: Unlike the racer's hull the cruisers hull will have a wider beam which gives more living space and adds to its "Form Stability". The cruiser will be concerned with a comfortable motion of the boat both at sea and at anchor. The keel should not be as deep or as vertical. It would be better if its shape was more gradual with less draft so it can go into shallower waters with less danger of a grounding. If a grounding does occur the keel will hopefully ride up onto the reef rather than coming to an abrupt stop. The rudder will be supported by a skeg or attached to the transom for protection.

There are two common types of cruising keel shapes, the full *cutaway* keel and full *swept back* keel. In the old days of building offshore vessels a full keel ran the length of the boat from bow to stern and was nearly parallel to the waterline. This shape provided excellent tracking but didn't go to weather too well because there was too much wetted surface forward. This long keel was slow to respond to the helm. The *cutaway* and *swept back* keel shapes are a compromise between the full long keel of the past and the fin keel of today.

The *cutaway* keel has a "dog leg" shape where the keel meets the hull. It is like a swept back keel with a notch forward. The rudder is supported by a skeg or extension to the aft end of the keel. The concern here is how this skeg is attached to the hull. If it is part of the actual hull, built into the mold, it will be strong enough to support the rudder even in a grounding. If it is attached afterward the buyer should look carefully at its construction and method of fastening. The skeg should support the rudder, not the opposite. The abruptness of the notch or angle of the forward cutaway will determine how much damage could occur in a grounding at speed. This will vary with each boat builder. The design of the keel and skeg should have the keel considerably deeper than the skeg so if a grounding did occur the skeg and rudder would not be damaged.

Solid Fiberglass Hull: The solid FRP (fiberglass reinforced plastic) hull should be nearly as thick as the cored hull. It will have similar stiffness characteristics but it will be considerably heavier. The additional weight on a cruising vessel will give the boat a better motion in a seaway so this is not a disadvantage but an advantage. The solid thick hull will be stronger with better impact resistance. Because it is a thick, solid hull it will resist moisture ingress longer and there is nothing to hold the moisture. The solid glass hull will have the furniture bonded directly to the hull adding to the total strength. Unlike the cored hull, the thru-hull fittings will pass through and fasten to the solid thick hull.

The solid fiberglass hull is only as strong as the method and materials used for the lay-up. Fiberglass hulls get their strength from the resin saturated fiberglass matt, roving and cloth. Resin by itself has little if any strength, in fact it is brittle. To produce a structurally strong lay-up there should be a layer of matt to absorb and hold the resin and a layer of heavy roving also saturated with resin. The important factor is to remove all excess resins and any air bubbles that may be trapped within these layers. If any excess resin remains it will be a brittle spot. If any air bubbles remain it will react with the moisture as it enters the hull and will expand causing separation and huge blisters. There are many different methods used to remove the excess resins and air bubbles. The Sam L. Morse Co. contracts Crystaliner to build their hulls. Crystaliner has a long standing reputation for building strong offshore vessels such as the Westsail and lifeguard rescue vessels. The hull is laid up entirely by hand; each and every square inch is hand squeegeed of excess resins and air bubbles. This procedure is closely supervised so that each hull receives the same treatment and number of lay-ups.

When you visit a boat yard ask to see the plugs from the holes cut for the thru-hull fittings. The plugs should be of various thickness from different parts of the hull. It should increase in thickness as it gets deeper into the hull. It should be thicker forward to take the pounding when sailing hard to weather; at the location where the chainplates are installed; at the transom and anywhere you would expect impact or additional stresses. Also, look to see that the layers are all of equal thickness. If not that means the excess resins were not uniformly removed. Look for air bubbles or any signs of anything but a solid thick hull with evenly spaced lay-ups, count the number of lay-ups in the different part of the hull.

INTERIOR INSTALLATION: The interior furniture of the boat should add to it structural strength.

Thwart Ship Reinforcement: A thick, properly laid up fiberglass hull will still work or flex in a seaway without additional reinforcements. The submarine would collapse if it were not for the internal bulkheads that strengthen an already strong steel shell. Sailing vessels use bulkheads to strengthen the boat athwart ship.

The most important bulkhead is the one at the mast location. The Rigging and forces of the wind put tremendous compression on the base of the mast. This "pulling down" by the standing rigging adds stress to the hull at the location of the chainplates. The hull wants to pull towards the center of the boat to reduce this stress. This "main" bulkhead prevents it from happening. Additional bulkheads should be located forward to absorb the stress of the pounding seas. Other bulkheads should be located after to prevent the hull from "tweaking" or "twisting" in a seaway. In fact, the more bulkheads a boat has installed the stronger the boat.

In order for the bulkhead to add maximum strength it should be bonded to the hull and deck all the way around and on both sides. The wider the fiberglass bonding or "tabbing" the stronger the join. This wide bonding also distributes the pressure over a wider area. One concern is that the bulkhead should not make direct contact with the hull because it will cause a hard spot where the hull will work on either side of the bulkhead.

The Sam L. Morse Co. installs four completely bonded bulkheads to the Bristol Channel Cutter and two to the Falmouth Cutter. In addition to these full bulkheads there is a half bulkhead further forward and four quarter bulkheads in the center of the interior. Twelve inches of bonding fiberglass material is used on the main bulkhead, and 8" on others. There is a 1" rigid foam strip installed between the bulkheads and the hull to act as a cushioning strip to prevent a hard spot. To further strengthen this installation method, 2" holes are drilled, evenly spaced at about 18" around the circumference of the main bulkhead so when the bonding takes place on both sides of the bulkhead the fiberglass material makes contact through the holes, locking the bond to the bulkhead.

For the bulkheads to provide the maximum strength they must be bonded to the underside of the deck as well as the hull. If a builder has the interior all completed before the deck is set into place it is unlikely the bulkheads will ever be bonded to the deck.

Longitudinal Reinforcement: Equally important to add structural strength to an already strong hull is longitudinal reinforcement. On smaller boats the furniture is bonded to the hull providing this longitudinal strength. On larger boats over 35 feet where there is more space between the pieces of furniture, stringers are bonded to the hull. For our purpose, smaller boats, it is the furniture and how it is bonded to the hull that determines the structural results. At one extreme you will find manufacturers who will use one huge fiberglass liner for the entire interior. It may only make contact with the hull around its

External Ballast: External ballast is when the lead keel is bolted through the hull. There are several concerns with this method. The hull, at the location where the keel will be attached, must be exceptionally strong. Look carefully at how the builder lays up this area and if it will take a hard grounding without damage. The keel bolt material is another concern. Water will eventually reach the keel bolts. This means they will be exposed to oxygen starvation corrosion and electrolysis. If the bolts are made of monel there will be little problems because it is high on the Galvanic Scale. If stainless steel is used it is less noble than many other metals and could act as an anode. Another concern with the keel bolts is there size. If a one inch rod is threaded then the minor diameter of the rod is 3/4" and will have the same strength as a 3/4" rod. Another concern is the method the keel bolts are attached within the ballast. Since lead is soft it is possible that the bolts may work loose after years of stress. In a recent article in Professional Boatbuilder the write talks about keel bolts that loosen and need to be tightened as the boat gets older. His comment was that the nuts don't loosen but everything else compresses and works which requires the nuts to be tightened.

Presuming that all the above is satisfactory and there is a hard grounding with the external ballast. The advantage is that the lead will absorb a lot of the damage but the joint between the hull and the ballast will take the maximum stress. It is possible to break this bond and elongate the keel bolt holes which could let water dribble into the bilge. How many groundings will it take before the ballast must be removed and resealed to the hull?

If the decision is to have an external ballast boat make certain that the keel bolts are all accessible for regular inspection. It would be advisable to look at an older boat you are considering buying to see if there are any signs of water ingress or separation between the ballast and hull. Also visit boatyards that have external ballast boats out of the water. Look for repairs, cracks and water weeping out of the ballast to hull joint.

Internal Ballast: The Sam L. Morse Co. sets the lead ballast inside the hull. The hull is extremely thick throughout but exceptionally so at this location. After the boat is leveled the pre-cast lead ballast, which is shaped to the hull cavity, is set in place. A dam is bonded to the aft end of the ballast to hold the resins that will encapsulate the lead. The ballast cavity is filled with slow curing resin totally covering the lead. This is followed by multiple layers of mat and roving to further strengthen this installation. The ballast will never make contact with any water or moisture for the life time of the boat.

If a hard grounding occurs there will be some gel coat chipped off but the hull is about 1-1/2 thick at the bottom and it would take a considerable amount of time to grind it away. If either an external or internal ballast boat is grounded and continues to set upright it is 99% floating which means it can be kedged off. Boats are lost when they fall over on their side and the damage occurs at the turn of the bilge. In this situation it would be best to have the thickest hull with strong internal strengthening regardless if the ballast in internal or external.

MAST STEP: The mast can be deck stepped or keel stepped.

Deck Stepped Mast: The mast can be set on the deck for two reasons. First, is if it is intended to be raised or lowered for transport or going under low bridges. The other is to provide more room below decks. This method is well accepted in the boat building industry as long as there is a substantial compression post installed to transfer the compression load to the mass of the keel. Make a close inspection of the material used between the two to ensure that it will not compress in time.

Keel Stepped Mast: The keel stepped mast passes through the deck and sets directly on the solid mass of the keel; there is nothing to compress. The advantage is that it is structurally a stronger installation. After all, the mast will stand by itself if all the rigging were removed so it has to be a stronger installation. The disadvantage is that the mast passes through the inside the boat taking up living space.

Some boat builders who build deck stepped masts state that the keel stepped mast will tear off the cabin if the mast is lost during a storm. I would ask this builder if they build their cabins so lightly that this could happen. The mast is an aluminum tube and would break in half before it would ever threaten tearing off the cabin. The Sam L. Morse Co. Bristol Channel Cutter passes the mast through the deck, not the cabin. The deck is reinforced to 2" thick at this location.

MISCELLANEOUS ITEMS TO CONSIDER:

General Quality: When looking for a quality boat there are other factors to consider other than those directly related to structural integrity. These may seem trivial but they reflect the builder's attitude towards quality rather than expense:

- Does the builder use the best quality hardware and materials such as metal ports holes and cowl vents instead of plastic?
- Are the lifeline stanchions double walled for strength?
- Is the cabin sole solid teak or is it a plywood veneer?

with stainless steel lifelines. The stanchion bases are bolted through the deck and top of the bulwarks providing maximum strength.

Water Tank Location: Water tanks are made of stainless steel, fiberglass or polyethylene. They are all good materials and all have some limitations. The stainless steel tanks have problems with electrolysis attacking the welds and after a few years small pin holes dribble water. This can be prevented by using the proper welding rods that match the tank material. Fiberglass tanks will always taste like fiberglass but will not leak and will last a long time. Polyethylene is what most of the marine industry is now using. It is the same material used in bottled water purchased at the local market so it is tasteless. The only disadvantage is that it is a softer material and can ware away if not properly supported during installation. Since baffles cannot be installed in these rotary molded tanks individual tanks can be installed providing the same capacity. This can be a bonus because a diverter valve can be installed between the tanks so either tank can be selected in case questionable water is taken aboard. Regardless of the water tank material, they should be capable of replacement if damaged and there must be an easy access for cleaning the inside.

As mentioned above, water weighs 64 pounds per cubic foot or 8.4 pounds per gallon. There is only one place for water tanks and that is in the center of the boat as low in the bilge as possible so it adds to the yachts ballast. The tanks must be easily removed for accessing keel bolts (if external ballast), repairing leaks and cleaning. They should have an easily accessible inspection plate for cleaning. The Sam L. Morse Co. boats use polyethylene tanks installed over the internal ballast, under the cabin sole, as low as possible and in the center of the boat. They can be quickly and easily accessed by removing a few screws that hold sole cover.

Berths: Most boat builder have a "V" berth forward because it is a simple place to install a double berth without interfering with the rest of the boat's interior. The advantage is that it can be a wide long comfortable berth. The disadvantage is that it is the most uncomfortable berth on the boat when underway or in a rough anchorage. There is more violent movement to the boat forward than any other part of the boat. While at anchor, the sound from the anchor rope, chain and waves slapping against the hull is transferred into this area. By installing a long "V" berth forces the builder to install the chain locker far forward which can effect the safety of the boat in rough conditions. The best location for a berth is amidships in the center of the boat, as low as possible. This is where there is minimum movement. However, it is difficult to build a berth at this location because it is the living area.

Sam L. Morse Co. Bristol Channel Cutter has the double, pull out berth, located amidships on the port side. A single settee berth amidships on the starboard side, a quarter berth on the starboard side aft. Because we are a custom boat builder we can add a single or double berth forward. We can make the starboard single settee into a pull out double or make any necessary changes the owner may want. The Falmouth Cutter has a large quarter berth on port and starboard sides and a double berth forward. If the buyer wanted an outboard engine instead of an inboard the area between the quarter berths could become a huge double.

Head and Showers: A totally enclosed head and shower have the advantage of privacy. The disadvantage is that the space is used for 10 or 15 minutes a day and the rest of the time it takes up valuable space. Many head and shower installations are not properly vented and will not dry out adequately in warmer climates. The Sam L. Morse Co. boats install the head and shower forward. The shower curtains is set around the inside of the scuttle hatch which can be opened during and after showering for maximum ventilation. The head and shower area is also the work bench, hanging lockers, sail locker, chain locker and more so the area serves more than one purpose.

Propane tanks: Most all boat builders today use propane as the primary cooking fuel. If properly installed it should never give an owner any problems. The primary concern is that the tanks be installed so they will vent overboard even with a bad leak. Coast Guard approved installations require that the propane locker be used only for stowing propane tanks and nothing else. The Sam L. Morse Co. boats have the aluminum propane tanks stored in deck boxes located on both sides of the mast. There would be no problem if a buyer wanted kerosene or natural gas installed instead.

Chain storage: Anchor chain is heavy and should <u>never</u> be stored above the waterline or too far forward. The best location for anchor chains is low, near the centerline and as far aft as possible. The Sam L. Morse Co. boats store the chain deep into the bilge far aft. When making a passage 300 feet of chain can be pulled back into the shower sump just forward of the mast and still lead out as normal if needed.

Boom Gallows: It is hard to understand why all boat builders don't use boom gallows. They support the boom when the sails are down. In rough weather the boom can be lashed to the gallows making it impossible for it to come loose and swing across the deck. They provide a perfect place to install an underway sun awning between the dodger and the boom gallows. When