Moorings

Important recommendations for safe moorings from INAMAR

INAMAR®

Recreational Marine Insurance

an ACE USA company

Since 1792, INAMAR, through its affiliated company INA (Insurance Company of North America), has been providing insurance coverage for marine interests. This experience has taught us the importance of loss prevention and loss control.

As a special courtesy, INAMAR is providing you with this exclusive publication dealing with moorings. We hope you will find it both interesting and informative.

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Introduction

On August 11, 1991, six short years after Hurricane Gloria, Hurricane Bob made New England and the Eastern seaboard painfully aware that our present moorings are inadequate. In harbors from Chatham to Connecticut – Padenarum, Marion, Mattapoisette, Woods Hole, Cotuit and Hyannis – hundreds of wrecked boats were left piled ashore. According to FEMA (the Federal Emergency Management Agency), more than 3,000 vessels between Narragansett Bay and Hyannis alone – 15% of all those moored in that area – were driven ashore by the hurricane.

Weather forecasters indicate that we are entering a period of increased hurricane activity. Since even the frequent northeasters account for a significant number of mooring failures, we must improve our mooring systems.

Two facts that stand out about this particular storm are:

1. Many vessels were driven ashore with and without their moorings.
2. Many vessels survived on their moorings.

Why does one vessel survive while another does not? Is it luck? Fate? A good mooring system? There are many scenarios, with different problems and solutions.

Often, one boat will break free and come down on top of another, pulling it from its mooring. A chain reaction effect is created and many vessels break loose. But why does that first boat break free? Did its mooring pennant chafe through? Though this is an all-too-common scenario, it can be corrected easily.

Many vessels dragged their moorings ashore fully intact. Were the moorings undersized? Short-scoped? Not set? The wrong type of anchor for the bottom? Too much wind? It's true there was a lot of wind with high gusts, but more often than not, a pre-existing condition was involved.

Here are a few examples:

- A 42′ ketch had two 150-lb. mushrooms shackled together at the shank in an attempt to meet its harbor's weight requirement.
  Undersized and improper use of this type of anchor
- A 30′ powerboat came ashore with one-half of a 55-gallon drum of concrete for an anchor.
  Wrong type and undersized
- A 40′ sailboat took its 500-lb. mushroom to the beach. It had been pulled for inspection last spring and its scope was 2.5:1.
  Not set and short-scoped
- Cotuit Harbor, Ropes Beach, was lined with more than 200 vessels, most with their mooring systems fully intact, from the bow to the mushroom anchors.
  Wrong type, not set and short-scoped

Other vessels came ashore with totally inappropriate anchors: a bathtub, radiator, engine blocks and 5-gallon pails of cement. These might work for a small dinghy, skiff or sunfish, but not for a yacht.

Another problem was that people picked up moorings from absent boaters, knowing nothing about their condition or capacity. In several instances, yacht clubs rented absent members' moorings without any knowledge of what material they consisted of, their holding capacity or when they were last inspected or serviced.

In the last decade, the boating population has exploded. The number of yachts vying for space in our harbors has stretched beyond the limits of safe refuge. Years ago, only "inner" harbors were used for mooring areas. Now "outer" harbors, and even bays and ocean-front properties, have moorings that are very exposed. Because many harbors are crowded, with moorings too close and scope ratios reduced to accommodate more and more vessels, "swinging room" no longer exists in many anchorages.

Though much could be written on mooring systems and anchors, we wish to highlight a few problems and some possible solutions.

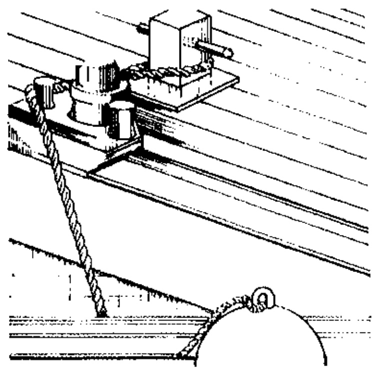
Pennants

Failure Due to Chafing

Almost all chafing failures occur at the bow chocks. The major contributing factors are poor design of the chock and poor layout of the cleats and chocks.

On many vessels, the cleat/chock layout is designed for the vessel to be berthed in a slip. The angle of the cleat to the chock is commonly 30°, 50° or even 70° off the centerline. This requires the pennant to make a sharp turn through the chock to lead forward to the mooring system. The sharper the angle that the pennant must turn at the chock to lead forward to the pennant, the greater the pressure on the line, resulting in a tremendous increase in chafe.

Ideally, the pennant should run as straight as possible – from the cleat through the chock to the mooring buoy. This may require moving the cleat and/or the chock. It is not uncommon to find that a knowledgeable owner has rearranged and installed larger, stronger bow hardware to allow for proper lead to the mooring. But when moving the bow hardware, large backing blocks must be installed. Assuring that these attachments are strong is of utmost importance. And doing the job with large bolts, washers and backing plates costs little.

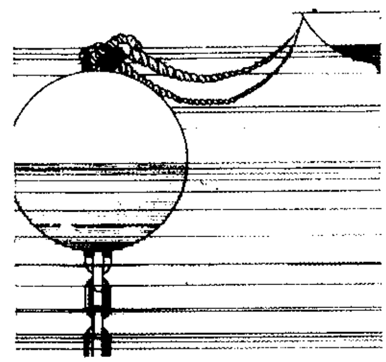


On some midsized production yachts, the chocks are undersized and are not able to accommodate a properly sized pennant and chafe gear. Many can only hold a 5/8" line without chafe gear. Also, many yachts have small chocks with sharp corners, or a very small radius across which the pennant must lay. These small surface areas increase the pressure on the pennant and consequently, the amount of chafe. Increasing the size and strength of the bow hardware is the best method of correcting this problem.

Without moving the bow hardware, a quick method to eliminate chafe at the bow chock is to use a chain lead from the cleat through the chock. Although this eliminates pennant chafe, the chain can chew up the chock. This can be minimized with chafe gear on the chain. The chain lead should just clear the bow and shackle into a Dacron pennant – spliced with an eye and thimble. The importance of a long, Dacron pennant is to absorb the energy of the vessel as it surges on the mooring system.

Another failure occurs if the pennant wraps the top chain when both the pennant and top chain are shackled to this single buoy point. This can be solved by using a mooring buoy with two attachment bails, one at the top and one at the bottom. When using these buoys, one can easily see at a distance if the pennant has wrapped the top chain. Another method to prevent the pennant from wrapping the top chain is to run clear tubing (nylon-reinforced PVC) as chafe gear from eye (splice) to eye (splice), when making up the pennant. The full length of chafe gear prevents the pennant from wrapping the top chain, and from slipping out of the bow chock. The swivels in the mooring chain must be maintained to allow the mooring chain and pennant to unwind.

Urethane-impregnated firehose is the best chafe gear. Reinforced, clear PVC tubing is very resilient and permits inspection of the line. Ends of tubing used for chafe gear must be "faired" to prevent the chafe gear from chafing the pennant. All chafe gear must be checked frequently. Secure it well to prevent it from slipping out of the chock.



Safety Pennants

No mooring system is complete without a safety pennant. Some harbors require safety or secondary pennants. This extra line is inexpensive compared to the cost of your insurance policy deductible. The safety pennant should be of equal size (diameter and strength) and 25%, or three feet, longer (whichever is less) than the primary pennant. The theory is that the safety pennant will be in "perfect" condition when the primary fails. Marblehead has studied this issue and requires two primary pennants of line, the longer one being the safety pennant. During Hurricane Bob, Burr Brothers Boats, in Marion, Massachusetts, used a storm pennant of 5/8" poly-reinforced wire on their vessels which proved to be very successful. Experience has shown that the primary (or shorter) pennant should have the chafe gear run from eye to eye, to prevent it from slipping out of the chock. The length of the pennant described in many standards is given as 2.5 times the height of the free board. At some harbors, the pennant size and length are based on vessel length.

Storm Pennants

In discussing storm pennants and the problems of short-scope and swinging room with several boatyards, we touched on the pros and cons of using a long storm pennant. The consensus was that each vessel tied to a mooring should have a storm pennant made up of a large diameter line with double bridle (to the bow chocks) having a length equal to mean water depth (MHW), or longer. Most, if not all, vessels could be released prior to the storm and the scope of all vessels improved without changing ground tackle. When each vessel tied to a mooring has an oversized storm pennant, those vessels which have not been hauled or moved to a hurricane hole could be released from their standard pennant to ride on their storm pennant.

Because we do have harbors which are very crowded – at 2:1, 2.5:1, up to 4:1 scope ratios – and we know that all vessels either cannot be hauled or depart for safe locations, a storm pennant of at least one factor of scope will reduce storm shock/surge loads on the mooring system. As the vessel pulls the line and chain, the buoy will be pulled underwater. The buoy's resistance to being pulled under water will absorb significant energy. It will also provide margin for scope loss caused by the storm surge. In shallow harbors this storm surge dramatically reduces mooring scope. Reduced scope accounted for the losses experienced in many harbors, such as Cotuit and Hyannis.

Scope

Forces on mooring systems are caused when the wind pushes the vessel back, first creating a horizontal force, which puts pressure on the mooring rode and then creating a vertical force that pulls up on the anchor. In this combination of forces, scope dictates the dynamics of the system.

The short-scope effect is to pull the anchor out of the bottom, increasing loading on the ground tackle and pennant. At scopes less than 2:1, the vertical force pulling the anchor off of the bottom is greater than the force of the wind pushing against the vessel. Storm surge effect on short-scoped moorings in all but the deepest of harbors multiplies the loading on the anchor.

Anchors and Bottom Type

The type of bottom has a great deal to do with the holding power of anchors. Manufacturers of mushroom and similar design anchor systems state that the anchor must be buried. Sketches in their literature show the anchor buried vertically where it has maximum holding power in all directions. Mushroom anchors should not be used at scopes less than 4.5:1. If mushrooms are used, their weight must be calculated as a "deadweight" anchor.

The holding power of an unburied mushroom anchor at best is equal to twice its weight. When set, its holding power can increase to 10 times its weight. Wind loads on a 40′ vessel in 64 knots is 5,500 lbs. Thus, a 500-lb. mushroom on a 40′ vessel, at best with adequate scope, may only be good for hurricane winds of 64 knots. When the mushroom breaks free, it offers little resistance and the vessel drags the mooring.

A rocky or coarse sand bottom is not a good place for mushroom-type anchors. These anchors work on the principle of surface area and suction effect. Cohesion of the bottom material is very important. Rocks, gravel or coarse sand lack good cohesive properties, allowing the anchor to pull free. Mushroom anchors in sand will not bury completely. They will only sink to displace an equal weight of sand. Their large round dish design is not well-suited to penetrating the bottom. They work best in a silt or mud bottom.

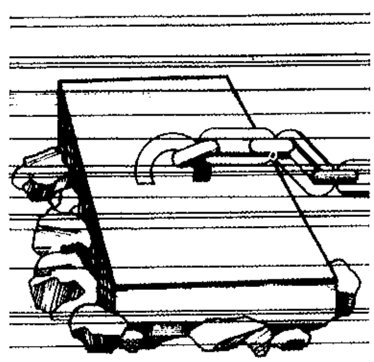
Mushroom Anchor "Spin Out"

Mushroom anchors, not embedded in the bottom, will get "spun out" and lose what little holding power they have when partially buried. All too often, mushroom moorings are pulled for the winter, or for inspection and maintenance of worn components. When replaced, they are often just dropped and then pulled to make sure they are not standing upright. The problem is that the mushroom never gets a chance to bury itself in the bottom.

In New England, prevailing winds set the anchors in the westerly direction. Along comes a roaring northeaster, or hurricane opposite the westerly set and the mushroom gets spun around 180° and rolls out of the bottom. Away goes the vessel, mooring and all.

When the mushroom is not buried in the bottom or standing up, the chain will often wrap around the anchor, consuming valuable scope. This commonly occurs with the vessel following the tide, pulling the chain from one side to the other of the mooring, wrapping around the stock. To correct this situation, mushroom anchors should be left in and allowed to set. Inspection and maintenance should be done in the water. If the mooring is pulled, the anchor should be jetted (using a stream of water to blow a hole in the bottom for the anchor) into the bottom.

A common method to protect against multiple wind direction is to use a three-point mooring system allowing a vessel to swing in any direction without spinning the anchor. Once multiple anchors are set at equal angles and connected to a common point, the riding or top chain is also connected to that point. Also, anchors may be set for specific wind direction or sea exposure. If the harbor is long and narrow, or a vessel is moored in a river, two anchors may be set – one up harbor, and one down harbor. In the design of this system, the bottom chain between the center point and the anchors should be equal to, or greater than the bottom chain requirement of a single mooring anchor system.



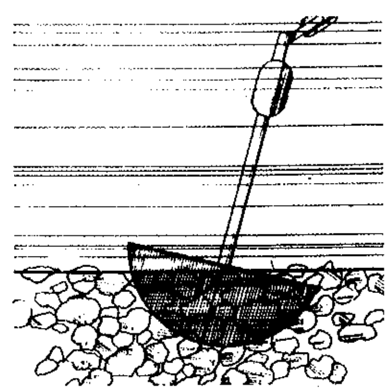
Deadweight Anchors

Deadweight anchors work on the principle of being heavy. Whether the anchor is a block of stone, concrete or iron, its holding power is weight. Once the weight is on the bottom for several years, it may become partially embedded in the bottom and a suction effect may increase its resistance to being lifted. Deadweight anchors provide the greatest reliability. If they are dragged, they will resist with constant force. By contrast, once a mushroom breaks free from the bottom, it will not reset and will simply skip along the bottom. Deadweights are the best choice for rock, gravel or coarse sand bottoms.

Granite is a common choice of material in the Northeast as it is readily available and inexpensive at about $50 per ton. It is a bit awkward to handle, but once it is in position, it will not move. The further one travels south from northern New England, concrete and iron become more common.

In calculating the size of a deadweight anchor, the type of material of the anchor must be considered. Harbors commonly regulate the size of the deadweight required, but not the material, even though there is a significant difference in densities. For example, Marion, Massachusetts calculates the required deadweight by multiplying the vessel length by the beam, then by a factor of four. Marblehead, on the other hand, has developed a very good standard for deadweight size based upon the vessel length and its location and exposure in the harbor, i.e., sheltered, moderate or severe.

In water, concrete loses almost one-half its weight; granite loses almost one-third and iron loses only an eighth. This is significant. If a mooring is designed to withstand a 4,000-lb. pull, one needs 8,000 lbs. of concrete, 6,000 lbs. of granite or 4,500 lbs. of iron. At a minimum, over one ton is needed for even a small, 25′ yacht. To handle weights of this magnitude, a barge crane is needed. As long as this equipment is used to place the anchor, one might as well err on the side of excessive weight when placing it.



Anchor Alternatives

Pilings are not commonly found, but are very effective. They can be driven into the bottom, and in shallow harbors, extend above the surface for mooring vessels bow-to-stern. In moderate to shallow depths, steel pilings of pipe or "I" beam may be driven flush into the bottom with traditional ground tackle attached. Because a barge/pile driver is necessary to set the pilings, size should be generous, either a 6″ diameter pipe, or a 6″ "I" beam and larger.

Helical piles or sea screws are not common, but are exceptionally effective. These are long shafts of high tensile steel with an attachment eye at the top and large threads at the lower end. These "screw anchors" are screwed into the bottom. Common lengths are 8′ with threads of 10″ to 14″ in diameter. When embedded into the bottom with the top eye flush or into the bottom soil attached to traditional ground tackle, their holding power is exceptional. Recent tests have shown that their holding power is vastly greater than any traditional mooring system of mushroom or deadweight anchors. These anchors have been used by the offshore oil industry for more than 20 years and are quickly appearing in the yachting market.

A grid system is the use of two or more large anchors, connected by a ground line with multiple moorings taken off different points. Usually large ships' anchors will be set, interconnected by a large, heavy chain, with traditional ground tackle attached to the ground line, rising to mooring buoys. Patterns and layout can vary greatly, from a two-anchor "string" of moorings, or a three-anchor triangular pattern, to a square grid using four or more anchors. This system may cost more initially, but the grid, once laid out, can last far longer than other systems. The large anchors and chain are readily available from commercial salvage yards and require a tug and barge to set.

"Dor-Mor" anchors are a redesign of the traditional mushroom anchor and are a pound-for-pound equivalent to a mushroom anchor. Dor-Mors are a cast iron "pyramid" with a short shank at the base to attach the ground tackle. The pyramid design is to allow easy penetration of the anchor into the bottom. The short shank reduces the "spinout" effect of the long shank found on traditional mushrooms.

Conclusion

There are many design considerations in establishing a reliable mooring system. One must consider the size of the vessel, the exposure of the location, the type of bottom, the swinging room available, the chain and pennant size needed and the vessel hardware and layout. Each component is critical. Failure to consider just one may result in the loss of your vessel. If the harbor bottom is coarse sand or rocky, then the choice of anchors is limited.

If the harbor is crowded and every vessel is on a short-scope, then the anchor must be heavier, and the chain and pennants stronger to compensate. If the pennant takes a sharp turn at the chock, the cleat or chock should be moved.

It takes a good understanding of the forces involved when mooring a vessel, and a careful review of your system to ensure that your boat will be secure.

Preplanning with your marina, or boatyard and harbormaster is a must. You should develop your own plan for securing the vessel, or have someone secure the vessel in your absence. You will find that most harbors and facilities are reviewing their own storm plans and mooring systems. Now you should too. By the time you hear a hurricane warning on the radio, it's too late to implement.

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