

The Tale of Two Thru-Hulls

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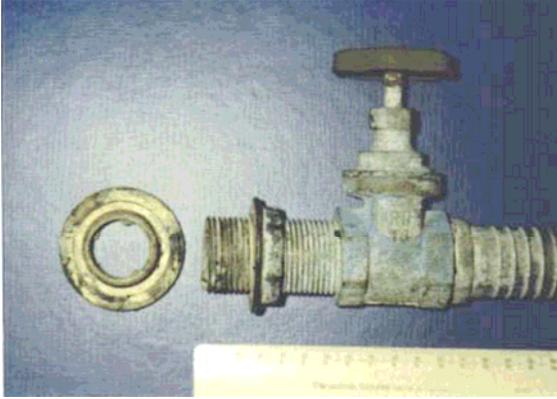
This is the story of two boats that heavily flooded and nearly sank resultant to thru-hull fittings that failed from dezincification. Michel & Christen Marine Loss/Damage Surveyors^{T1} attended the boat on the left in the following photos and tables, for an insurance company². Testing³ on the failed aft head thru-hull fitting was done, and it was discovered that this factory original fitting is an alloy of high zinc content Brass!

Being completely surprised to find a brass thru-hull fitting on a blue-water yacht from a highly respected builder, we undertook some research to see if this may be a larger problem. On the web, we discovered a Marine Accident Investigation Branch report⁴ on the investigation of the flooding of the UK charter-fishing vessel *RANDOM HARVEST*. This vessel also heavily flooded and nearly sank resultant to a high zinc content Brass head inlet thru-hull fitting. The findings and recommendations in that report are a must read for every surveyor.

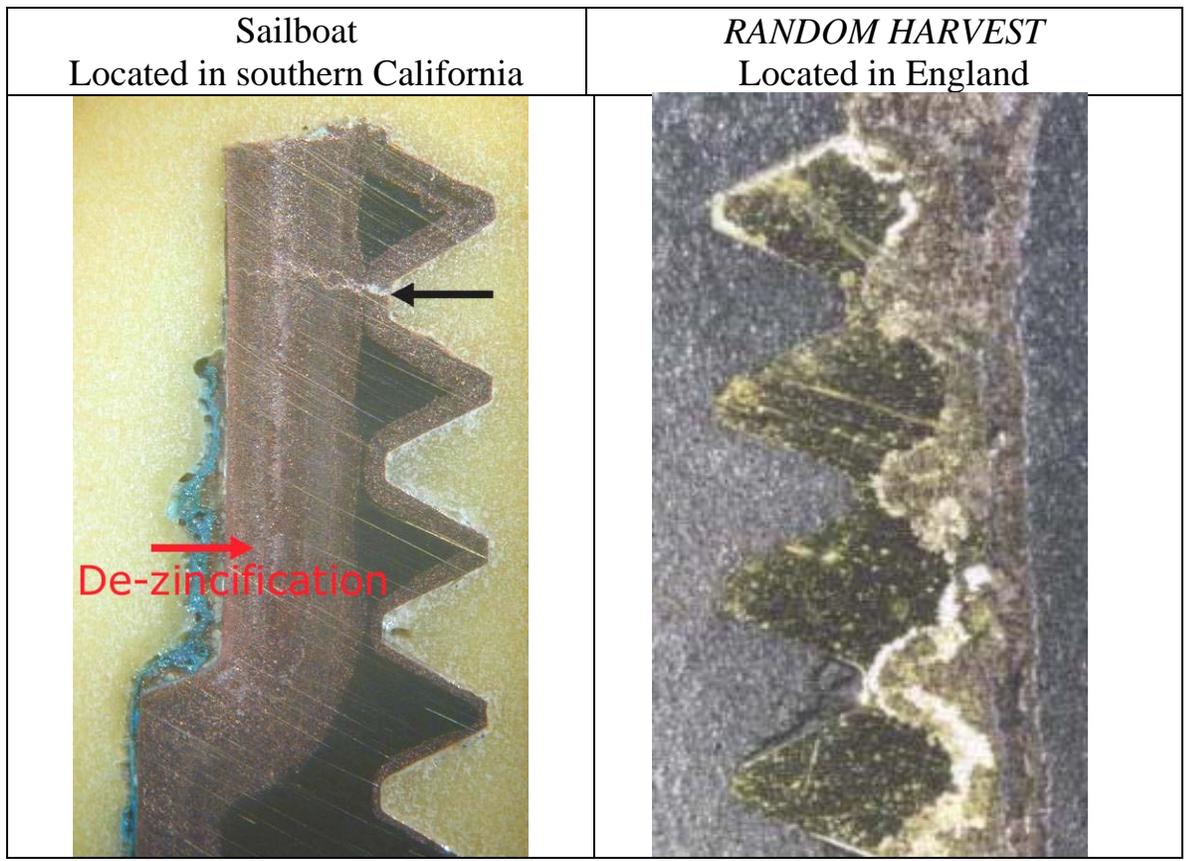
The difference between brass and bronze thru-hull fittings will be of primary interest to any surveyor or boat owner attending or owning a boat used in seawater. Galvanic corrosion is not as significant a problem for vessels in fresh water, and since there are far more recreational boats in fresh water than seawater, this may be one of the reasons so many brass fittings are available to decorate the underwater areas of a boat.

The following information is the result of our research to date.:

	
<p>Sailboat Located in southern California</p>	<p><i>RANDOM HARVEST</i> Located in England</p>

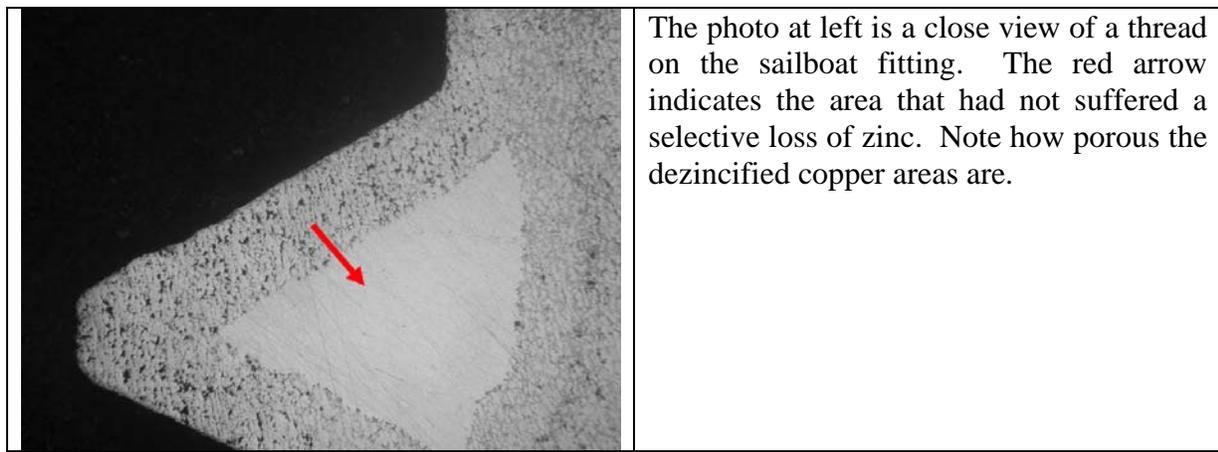
Sailboat Located in southern California	<i>RANDOM HARVEST</i> Located in England
	
	
Head discharge assembly	Head inlet assembly
Not Bonded	Bonded
Time in Service - 7 years	Time in Service - 16 months
No Backing Block on FRP	Backing Block on FRP
Not stressed from over-tightening	Stressed from over-tightening
Original fitting with new boat	Owner purchased replacement fitting

Fitting alloy composition as determined by laboratory testing Brass 60/40		Fitting is Tonval® Cu 59 <i>The alloy composition of Tonval® is listed from an Italian website⁵</i>	
55.61%	Copper	Copper	59.00 to 60.00%
38.20%	Zinc	Zinc	34.42 to 38.70%
2.71%	Aluminum	Aluminum	0.50 to 0.08%
1.80%	Lead	Lead	1.80 to 2.50%
1.07%	Ferrous (Iron)	Ferrous (Iron)	Max. 0.80%
0.61%	Silicon	Silicon	Max. 0.05%
		Tin	Max. 0.80%
		Nickel	Max. 1.20%
		Manganese	Max. 0.15%



These are magnified photos of the threaded portion of each thru-hull. The sailboat fitting shows dezincification from the wet side and dry side. The only portions that are not dezincified are the small dark triangles within each thread. The black arrow indicates a crack and incipient failure. The fracture is at the top of the sailboat photo.

The dezincification on the *RANDOM HARVEST* sample has taken a different form, as it appears to be on the wet side only. The *RANDOM HARVEST* failure occurred within 16 months, whereas the sailboat fitting dezincification took place over 7 years.



An analysis of the various parts of the failed sailboat fitting was undertaken. Deposits on the interior and exterior thread surfaces of the fitting were analyzed and two areas of the fractured face were analyzed. Here are the results:

	Original Alloy	Deposits on Inside and Outside of Fitting		Dezincified Area Analysis	
		Thread Deposit	Inner Deposit	Fracture Face Sample 1	Fracture Face Sample 2
Copper	55.61%	1.59%	4.58%	68.78%	78.24%
Zinc	38.20%	72.72%	47.86%	10.09%	15.35%
Aluminum	2.71%	1.31%	0.71%	0.55%	0.52%
Lead	1.80%	5.70%	5.91%	8.44%	1.50%
Ferrous (Iron)	1.07%	0.35%	1.09%	1.20%	1.25%
Silicon	0.61%	1.24%	1.54%	0.39%	0.20%
Chlorine		17.09%	6.26%	1.25%	2.04%
*Carbon			28.37%	7.71%	
Calcium			2.02%		
Cadmium			0.89%		
Titanium			0.77%		
Tin				1.59%	0.90%
	100.00%	100.00%	100.00%	100.00%	100.00%

*Carbon is from bottom paint that was coating the inside of the thru-hull fitting.

Brass, Bronze or Melt-Awaymium

The difference between Brass and Bronze is essentially Zinc content – Brass has it and Bronze (in general) does not. The primary alloys of brass are copper and zinc. The primary alloys of bronze are copper and tin. Common names of alloys cause confusion as “Manganese Bronze” (inexpensive propeller material) and “Tobin Bronze” (naval brass) are actually alloys of 60/40 brass with about 1% manganese or 1% tin added.

The amount of Zinc in Brass varies from 5% to 45%, with the 60/40 or 70/30 (copper/zinc) alloys being the most common and causing Brass thru-hull fittings made from 60/40 to be pretty good sacrificial anodes or Melt-Awaymium. If the Zinc content is less than 15%, the addition of 1% Tin or other alloys will make it reasonably resistant to stress-corrosion cracking and dezincification. The 60/40 brass alloys are susceptible to dezincification and stress-corrosion cracking under appropriate conditions such as immersion in stagnant or slowly moving seawater⁶.

- Brass: Copper-zinc alloys of varying composition. Red brass (15% zinc) is highly corrosion-resistant. Yellow brasses contain from 34 to 37% zinc. Cartridge brass contains 30-33% zinc. Muntz metal (40%) zinc. Some brasses also contain low percentages of other elements, e.g., manganese, aluminum, silicon, lead, and tin (admiralty metal, naval brass)⁷.

Codes and Standards – The Commandments

ABYC Standard H-27 Seacocks, Thru-hull Connections, and Drain Plugs⁸

All materials shall be galvanically compatible and resist degradation to salt water, petroleum products, UV light, ozone, cleaning components likely to be encountered, marine growth, and the effects of heat aging. Copper-based alloys shall meet the requirements of the 10 Day Moist Ammonia Air Stress Cracking Test in UL 1185, *Portable Marine Fuel Tanks* (Note: This reference appears to be an error and should be UL Standard 1121).

UL Standard 1121 Marine Through-Hull Fittings and Sea-Valves⁹

Materials: The components of a through-hull fitting or sea valve shall be formed of galvanically compatible materials having the strength and resistance to corrosion necessary to withstand intended and abnormal use to which they are likely to be subjected.

A part made of drawn brass or machined from brass rod containing more than 15 percent zinc shall be subjected to the 10-Day Moist Ammonia-Air Stress Cracking Test (Section 19). After being tested, a brass part containing more than 15 percent zinc shall show no evidence of cracking or delamination when examined using 25X magnification.

American Bureau of Shipping (ABS)¹⁰

Note: This Guide is applicable to motor pleasure craft 79 ft. or greater in length overall up to 200 ft. in length, that are not required to be assigned a load line.

Section 20 Pumps and Piping Systems

Section 20-d Brass Piping Components in Salt Water Systems

Where brass is used, only alloys with a zinc content of 15 percent or less or which contain dezincification inhibitors such as tin, antimony, arsenic are to be used in saltwater systems.

ISO 9033-1:1994(E)¹¹

Through-hull fittings for water shall be corrosion resistant, defined as material used for a fitting which, within a service time of five years, does not display any defect that will impair tightness, strength or function.

- Marine Accident Investigation Branch – Report No. 28/2000
2.6 Human Factors

The guidance offered on the selection of corrosion-resistant material in ISO 9093-1:1994 *Small craft – Seacocks and thru-hull fittings*, is vague and of little practical help. While it specifies the desired outcome, a five-year resistance to the effects of corrosion, it does not specify a procedure for testing compliance. The MCA should make representations to the European Committee for Standardization to improve the utility of this standard.

To Marry or Just Live Together (Bonding)

Current wisdom is not to bond thru-hull fittings. It is one of the recommendations in the MAIB report on *RANDOM HARVEST* and the testing lab for the sailboat loss advised that in their opinion bonding would not have saved the fitting from failure. The water in a thru-hull is often stagnant inhibiting any benefit from bonding. *High zinc content brass is susceptible to dezincification and stress corrosion cracking in stagnant seawater.*

Backing It Up

The thru-hull fitting on the sailboat did not have a backing block in place. Without a backing block of wood, the potential for over-tightening and stressing the threads is higher when trying to snug against the hard surfaces of FRP. Although *RANDOM HARVEST* did have a backing block, one of the findings was that the thru-hull failed from stress-corrosion cracking resultant to over-tightening.

The UL 1121 standard is very precise regarding how much torque is to be applied when setting up a thru-hull fitting for testing (and they include a backing block in the set-up). The torque requirement is different for each size of fitting and is measured in pound-inches. When was the last time you saw a torque wrench used for installing a thru-hull fitting, and how many fittings come with precise installation information in this regard.

High zinc content brass is particularly susceptible to stress-corrosion cracking and cracking resultant to over-tightening.

Intended Use – Head Discharge?

Sailboat: The boat owner (who is the original owner of the vessel) also reported that the other (forward) head discharge thru-hull fitting failed about three years earlier (without flooding the boat or becoming a claim). The failed fitting is the aft head discharge.

RANDOM HARVEST: Within the MAIB report, we are advised that both the head inlet and discharge thru-hull fittings were changed approximately 16 months before the inlet fitting failed. Both the inlet and discharge fittings were removed following the loss, and both were tested. The discharge thru-hull fitting was also Tonval® and it was also heavily dezincified, it just had not yet started to leak.

As head discharge fittings are usually larger than the inlet thru-hull fittings on most boats, and because they have more “meat”, they may be presumed to be stronger. However, the UL Standard calls for testing all thru-hull fittings with more than 15% Zinc alloy for ten days within a moist Ammonia environment. As the head discharge will contain urine, and urine will convert to Ammonia, this may be another vulnerability for Melt-Awaymium. Also, most boat owners will pour a variety of chemicals into their heads for deodorizing and cleaning which may react negatively with high Zinc content alloys. Having a “stagnant water” circumstance where a volume of water is not also sent through the head with the cleaning compounds could increase a potential problem.

Urine and treatment chemicals that are poured down a marine head without thorough flushing may contribute to dezincification and stress-corrosion cracking in high zinc content brass fittings.

Truth in Advertising – Information Please

In July, 2005 a Google® search on “brass thru-hull” resulted in a lengthy list of hits:

- One boat manufacturer and the names of all their dealers, advertising a particular current production boat that includes “Brass Thru-Hulls” as standard equipment and stainless thru-hulls as an optional upgrade. The ads state that the vessel construction is “NMMA Approved”.
- A list of fish finder thru-hull transducers from various manufacturers
- Advertisements for a “2005 Brass Thru Hull with Scupper” fitting on boattraderonline.com sold by a company that advertises themselves as the “Nation’s #1 Marine Liquidator”.

In the UK, a specific Recommendation of the MAIB in the *RANDOM HARVEST* report was that all Tonval® thru-hull fittings be clearly described in advertising literature as made of a “brass (not inhibited against dezincification)”. The report also indicates that Tonval® had been referred to as bonze in advertising. A July '05 Google® search on “Tonval®” resulted in numerous listings of UK marine hardware vendors that list “Skin Fittings” (UK term for thru-hull) that are made of Tonval®. None of the part descriptions reviewed made any mention that this material is a Brass-60/40 or that it is prone to dezincification.

Thru-hull fittings that meet ABYC H-27 are entitled to so mark the fitting, and thru-hull fittings that are UL Listed are also entitled to so mark the fitting.

- The Listing Mark of Underwriters Laboratories Inc. on the smallest unit container in which the product is packaged or on the product is the only method provided by UL to identify products manufactured under its Listing and Follow-Up Service.

UL publishes an annual Directory of Marine Products¹² that contains Listings and Classifications and Recognitions in effect as of an annual date. Manufacturers that have submitted thru-hull fittings and sea valves for testing and that have passed UL 1121 standard, are listed in this catalog. The catalog identifies which particular models, and sizes of specific manufacturers that have achieved UL Listing and are entitled to display the UL Listing Mark.

Marine products catalogs in general do not indicate which, if any, of the “Bronze” thru-hull fittings offered for sale are UL Listed or meet H-27. Some of the manufacturer’s products offered, such as Perko® and Conbraco® do have thru-hulls that are UL Listed, but the UL catalog of listed products gives model numbers that do NOT easily correlate with the catalog information. (For example, is the “Perko 0331DP6PLB” in the West Marine catalog, the “Fig. No. 331” of the UL catalog.) Because not every thru-hull model and/or size from a particular manufacturer may be UL Listed, a prudent buyer with the UL catalog in one hand and the marine products catalog in the other is still not able to be sure what they are buying.

However if you turn the page in the West Marine catalog to seacocks, the listing for Apollo Full Port Flanged Bronze Seacocks states: “UL-listed [and] Comply with ABYC H-27 and ISO-9093-1 requirements”. There are other seacocks offered on the same page from companies that have UL Listed seacocks (and may include the models offered) but there is no indication in the ad description this is the case.

Also on the thru-hull fitting page, The West Advisor® in the '04 catalog comments as follows:

Several letters from boaters to *Practical Sailor* in 1999 brought to our attention some confusion over the plumbing fittings in our catalog. In our 1996 catalog, we labeled our brass pipe nipples as bronze. We caught the error and corrected it in subsequent catalogs, but by then it had crept into our store shelf labels. By the time you read this, the shelf labels will have been corrected, but the exercise of getting to the bottom of it has taught all of us a lesson about marine plumbing.

Visits to marine chandlery stores in coastal communities with a walk through the aisles displaying thru-hull fittings and sea-cocks, were quite interesting. We found bins of thru-hull fittings marked “bronze” in a variety of sizes. All of the thru-hull fittings showed a “rough” texture (one of the possibly misleading methods of determining alloy, as bronze is usually sand-cast and will appear rough) and most of the fittings had a nice rosy red color. However, the largest diameter fitting displayed was also marked “bronze”, had a rough finish but was bright yellow in color – easily identified as quite different from the color of the other fittings.

We then looked closely at the thru-hull fittings in an effort to determine their manufacturer and model number, but no identification was obvious on the fittings that had been removed from shipping boxes and displayed loose in the bins. What we did discover was some of the fittings had a poorly adhering paper label stuck on the threaded stem stating the manufacturer name and UL mark. We observed no installation instructions and nothing explaining proper torque for the backing nut.

SUMMARY:

Neither boats nor fittings are sold with a label that says: “Do NOT use in seawater”. As it becomes easier every day to make purchases over the web and through catalogs, we are truly living in a global marketplace. No matter where boat builders are located, it is more and more likely that not every component part of the boats they produce will be locally produced or intended for marine (seawater) use. The alloys used in making thru-hull fittings are plentiful and the identification is minimal.

- Codes and Standards are more and more important as the primary yardstick of quality. Codes and Standards are unclear and ambiguous relative to acceptable materials for metal thru-hull fittings used in seawater.
- Brass and bronze are generic terms, like steel and stainless.
- Advertising descriptions are unreliable.
- Field identification of particular metal alloys with any degree of accuracy is next to impossible.

A sad commentary on the state of this situation is the UK boat owner chat-room comments that metal thru-hull fittings now seem to need renewal every two years.

We have been advised that thru-hull fitting failure may account for as much as one-third of the boat flooding claims received from some recreational boat insurers each year.

As Everett Collier advises in *The Boatowner's Guide to Corrosion*:

“Thru-hull fittings constitute probably the greatest potential threat to the watertight integrity of the hull. Many boats have sunk as a result of failed thru-hulls. It is critically important not just to properly maintain your thru-hulls but to select the proper ones to begin with.”

Recommendations for Surveyors:

- Be aware that you have no ready means to determine the quality of a thru-hull fitting after it is installed.
- Do not automatically assume every metal thru-hull fitting is bronze.
- Be aware that catastrophic dezincification of a fitting may not be discoverable by scratch test of the exterior mushroom cap of a fitting. (The sailboat fitting did not show “pink” at the exterior.)
- When specifying new or replacement thru-hull fittings, include UL Listing as a standard of quality.
- Be cognizant that high zinc brass fittings are susceptible to dezincification and stress-corrosion cracking under appropriate conditions such as immersion in stagnant or slowly moving seawater, and head discharge fittings may be particularly vulnerable.
- Become informed about metal alloys and corrosion processes.

When surveying, be vigilant, vigorous and wary when inspecting thru-hull fittings!

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¹ Michel & Christen Marine Surveyors Inc, 501 E Bayview Drive, Shelton, WA 98584, 800-794-0089. Rex Michel, AMS and Jane Christen, AMS.

² Allstate Insurance Company

³ Northwest Laboratories of Seattle, Incorporated, 241 South Holden Street, Seattle, WA 98108-4359, 206-763-6252, www.nwlabsl896.com. NW Labs Report #L17056 Rainer Eckert, Forensic Engineer/Technical Director.

⁴ Marine Accident Investigation Branch (MAIB). “Report on the investigation of the flooding of the UK charter fishing vessel *RANDOM HARVEST* south-west of Brighton on 3 July 1999”. Report No. 28/2000. Southampton UK. Available for download at: http://www.maib.gov.uk/publications/investigation_reports/2000/random_harvest.cfm

⁵ <http://www.sitindustrie.com/pdf/pani/OTTONE.PDF>

⁶ Collier, Everett. “The Boatowner’s Guide to Corrosion”. Camden ME: International Marine, 2001

⁷ Hawley, Gessner G. “Hawley’s Condensed Chemical Dictionary”. Eleventh Edition revised by N. Irving Sax and Richard J. Lewis, Sr. New York NY: Van Nostrand Reinhold Company 1987

⁸ American Boat and Yacht Council (ABYC). *Standards and Recommended Practices for Small Craft. 1997 H-27 Seacocks, Thru-hull Connections, and Drain Plugs.* Edgewater MD: American Boat and Yacht Council, 1997.

⁹ Underwriter's Laboratories (UL). *Standard 1121 Marine Through-Hull Fittings and Sea-Valves.* Northbrook IL: Underwriters Laboratories, 1998

¹⁰ American Bureau of Shipping (ABS). *Guide for Building and Classing Motor Pleasure Yachts. Section 20 Pumps and Piping Systems.* Houston, TX: American Bureau of Shipping, 2000

¹¹ International Organization for Standardization (ISO). *Small craft – Seacocks and through-hull fittings ISO 9093-1:1994(E).* Geneva 20 Switzerland: ISO, 1994

¹² Underwriter's Laboratories (UL). *Directory Marine Products 2003.* Northbrook IL: Underwriters Laboratories, 2003.