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Boating Safety Circular 79

THERE ARE NO "MAINTENANCE-FREE" METALLIC FUEL TANKS

With today's recreational boat building technology most boats are constructed of very durable materials with the potential for a long service life. As a result, the typical purchaser probably expects that any permanent appurtenance provided with the boat, such as a fuel tank, will provide as long a service life as the hull itself. Unfortunately, many Coast Guard defect investigations have found that aluminum fuel tanks, which were not installed in accordance with the Coast Guard Fuel System Standard or the voluntary standards published by the American Boat and Yacht Council or the National Fire Protection Association, are badly corroded after only a few years.

Each year funds are available through the Boat Safety Account of the Aquatic Resources Trust Fund (revenue from motorboat fuel taxes) for award to national nonprofit public service organizations to fund boating safety projects. In fiscal year 1992, the Coast Guard awarded a grant to Underwriters Laboratories (UL) for the purposes of studying problems associated with the use of aluminum fuel tanks.

UL conducted a limited survey of boat owners to determine how many had problems with leaking fuel tanks and to obtain as many details as possible about each particular tank. These details included:

1. the age of the tank,
2. the particular aluminum alloy,
3. the method of construction, and
4. the method and location of the installation of the tank in the boat.

UL located owners of boats fitted with badly corroded aluminum fuel tanks by publicizing details of the research effort in monthly newsletters and magazines published by the Boat Owners Association of the United States (Boat/US), the U.S. Power Squadrons, and the United States Coast Guard Auxiliary.

The goal of the UL survey was to answer the following questions:

1. What was the extent of problems with aluminum fuel tanks?
2. Did the responses from survey participants indicate a common factor such as geographical location, boat manufacturer, or method of tank installation or was there a common factor associated with the use, storage, or maintenance habits practiced by vessel owners?
3. If a common factor was not apparent, could UL identify fuel tank installations which seemed to be experiencing reliability problems? What were the parameters affecting these particular situations?
4. Would the collected data allow the prediction of the average "life span" of an aluminum tank?
5. Could UL identify a root cause of aluminum fuel tank problems? Was there a feasible remedy which could be implemented in new boats as well as boats already in the field?

Underwriters Laboratories mailed 250 survey forms to respondents to its calls for information; 160 completed forms (64%) were returned. Although the survey was not a statistically valid representation of the entire boating population, the limited data gathered during this research effort showed that aluminum fuel tanks failed in many different makes,

Inside:

types and models of recreational boats.

One of the most significant issues facing designers and manufacturers of recreational boats is the challenge of integrating all the necessary equipment into a boat while maximizing space, efficiency and serviceability. In addition to the engine(s), other equipment such as generators, water tanks, and, for many boats, accommodation spaces often compete for the precious space afforded by the bilge. As a result, items which are considered maintenance-free, like the fuel tank, are relegated to the less accessible areas in the bilge. Therefore, when a fuel tank develops a problem, the problem source is not only difficult to detect, but any necessary repairs are usually complex.

While 92 percent of the aluminum fuel tank failure cases examined during the UL study were reportedly caused by corrosion, discussions with repair yards and examinations of various fuel tank samples showed that failures due to fatigue cracking at baffle welds may also be a significant cause of failures. The fatigue failures were primarily confined to fuel tanks constructed from 0.090 in. thick aluminum sheet; however, fatigue failures at baffle welds are not easy to see, and the presence of any corrosion in the vicinity of the failure may have led to misdiagnosis of the problem.

Several owners of one brand of boats reportedly had to replace fuel tanks which failed due to abrasion. The boats had been constructed with the fuel tanks permanently mounted beneath the rear deck. The platforms on which the tanks rested were covered with rubber, presumably for the purposes of either cushioning the tank, or isolating the tank from contact with the plywood platform which may eventually have become waterlogged. The rubber material was attached to the base plywood platform with metal staples, which were not recessed into the rubber. Over time, there was abrasion and perforation of contact areas on the bottom surface of the fuel tank because of contact with the staples.

Field Inspections

One aspect of this research effort was a fact-finding trip to the Southeast in order to find some evidence of the extent of fuel tank failures in the field. Boat repair yards, and both custom and OEM aluminum fuel tank manufacturers were visited for the purposes of examining various perspectives. Visits to both a boat repair yard and a metal fabrication shop yielded several discarded aluminum fuel tanks.

Discarded tanks had been foamed-in place, secured by straps, and retained by brackets. There was evidence of the contact of the bottom of the tank with water in the bilge, incomplete encapsulation of the tank with flotation foam, and collection of water underneath the foam adjacent to the tank. Tank labels were peeling or illegible, coatings were incomplete, rubber strips were haphazardly glued to the tank surface, and brass fittings were screwed directly into the aluminum tanks. Several of the fittings were found to have been covered by putty or foam, evidence that boat owners may have resorted to a quick fix before inevitably having to remove the tank.

There were signs of corrosion underneath the foams on tanks which had been foamed-in-place; where the tank was in contact with water in the bilge; underneath the rubber strips glued to the tank; at weld seams; and even on and around tank fittings. In fact, all of the tanks examined showed corrosion of various types and to different extents over all surfaces. The common result of all of these examples, was clear evidence that they had not been installed in accordance with the Coast Guard Fuel System Standard in Subpart J of 33 CFR Part 183, or the voluntary standards published by the American Boat and Yacht Council (ABYC H-24 and H-33) or the National Fire Protection Association (NFPA-302).

Replacing damaged tanks

According to the responses from boat owners who participated in the UL survey, a great amount of confusion exists in the boating world as to what constitutes an acceptable and reliable fix for a leaking aluminum fuel tank. Some owners settled for temporary repairs, while some owners and manufacturers replaced failed tanks with OEM specification tanks using original installation methods. Some boat owners also went to great expense to try to modify the original installation, although the effectiveness of the fixes was also questionable.

According to the UL report, one of the most convenient courses of action for both new vessel

Eighty-one percent (123 of 152) of the boats used as the basis for the UL study were fueled by gasoline, while the remaining 19 percent (29) were diesel powered. One of UL's most startling findings was the fact that 23 percent of the owners of gasoline-powered boats continued to operate their boats after a fuel tank problem was detected, i.e., almost one-quarter of the owners of gasoline-powered boats responding to the survey do not fully comprehend the hazard of leaking fuel in the bilge of a boat. Since the majority of the respondents to this survey were members of the major boating organizations which promote boating safety, the UL study concluded that the proportion of uninformed boaters was probably higher in the general boating population.

construction and for repair/replacement of damaged aluminum fuel tanks is to use thicker aluminum sheets for tank construction. The report states that pitting for aluminum has been shown to be proportional to the cube root of time. Therefore, while it can be shown that by merely doubling the thickness of the material, the time required for perforation due to pitting is theoretically increased by a factor of eight. However, in the absence of more practical experience with tanks constructed of thicker aluminum sheeting subjected to the conditions in the bilge of a boat, the UL report notes that there is no way to determine a suitable thickness, which would guarantee an acceptable service life in relation to the service life of the boat itself.

Some of the people who were interviewed during the course of the UL study stated that the "industry fix" for corrosion problems with 0.090" wall thickness aluminum fuel tanks was to switch to a thicker 0.125" sheet aluminum for any replacement products. The 0.125" sheet aluminum not only reduced the susceptibility of the tanks to corrosion, but also reduced the number of fuel tank failures due to fatigue at the baffle welds. However, some of the failed tanks which were examined were constructed of 0.125" thick aluminum, meaning they had service lives which were similar to the thinner 0.090" material. Other considerations for assessing the limitations of a thicker aluminum sheeting are the extra cost, the weight penalty, and the increased difficulty in manufacturing the tank.

Stainless Steel

The UL report indicates that some boat owners chose stainless steel as the material for replacement fuel tanks, since this material is obviously "stronger" than aluminum; however, it is also susceptible to pitting and crevice corrosion in the marine environment, although at a different rate than aluminum. Stainless steel is also susceptible to stress-corrosion cracking and is even more prone to that type of failure at weld areas.

Only the 316L stainless steel alloy with a specified minimum wall thickness of 0.031 inches is considered suitable for use in the construction of marine fuel tanks. American Boat and Yacht Council standards ANSI/ABYC H-24, ABYC H-33, and ANSI/NFPA 302 all require stainless steel fuel tanks to be less than 20 gallons in capacity and cylindrical with domed heads to limit the wall stresses experienced in service.

While the uninformed boat owner who happens to construct a small capacity rectangular tank may be lucky enough to avoid a failure due to stress corrosion cracking; some boat owners who participated in the UL study spent considerable amounts of money to have replacement tanks constructed to capacities as high as 150 gallons. Many other boat owners who were surveyed mentioned that, on a cost independent basis, they would have preferred to have used stainless steel for their replacement tanks.

Coatings

The UL report also indicates that some boat owners have tried various coatings such as zinc chromate primers and paints, and epoxy-based coatings, while others covered their old leaking aluminum tank with fiberglass to form a new tank. The problem with these methods for repairing a damaged tank is the difficulty in achieving sufficient adhesion of the film to the base metal, and in applying a uniform and sufficiently thick protective layer free of pores, or "holidays" through which water may penetrate. Any water penetration will eventually lead to destruction of the film and renewed, or accelerated, corrosion attack of the base metal.

The UL report notes that the effectiveness of any coating highly depends on the conditions of the surface to which it is applied, the ability of the type of coating to withstand the environment to which it is exposed, the durability of the coating, and both the extent and manner in which it is applied. If properly applied to the tank, chromate treatments and epoxy paints may well be effective in delaying or preventing corrosion.

Fiber-Reinforced Plastic (FRP) or Polyethylene (PE) Tanks

Fiber-reinforced plastic fuel tanks (commonly known as fiberglass tanks), which are constructed in the same manner as boat hulls, but with the use of fire-retardant resins, have been in existence for many years. While FRP fuel tanks have proven their effectiveness, they are very labor-intensive to produce, making this option time- and cost-prohibitive to many of the high volume manufacturers of low and medium priced boats.

The polyethylene fuel tanks probably most widely known to recreational boaters are the red portable plastic tanks which have been produced for many years and are commonly used in smaller outboard powered boats. Today the use of PE for the construction of permanently installed fuel tanks may represent as much as 75 percent of the market.

FRP and PE tanks which are installed in a boat which is subject to the Fuel Systems Standard in Subpart J of Part 183, are still subject to the same requirements as metallic fuel tanks, as well as some additional requirements concerning the integrity of the material after aging and exposure to solvents. The critical test is the 2.5 minute fire test as specified in 33 CFR 183.580, which may be conducted in a fire chamber or in an actual or simulated hull section. Experience has shown that PE tanks, depending on the construction details and the particular installation conditions, have the capability of withstanding this test with acceptable results.

The UL report notes that PE fuel tanks have some drawbacks in that they tend to swell upon initial exposure to fuel and certain PE resins may be susceptible to environmental stress cracking. The biggest advantage with the use of nonmetallic fuel tanks is that they do not corrode, and, if they are properly manufactured and installed, they should last for the expected service life of the boat. As a result, any owner of a boat with a metallic tank which has failed, should consider a replacement tank constructed of PE.

Installing an aluminum fuel tank

The most important consideration with the use of a permanently installed aluminum fuel tank is being careful to make a good installation:

Aluminum as a fuel tank material can be very good if special care is taken to choose the proper aluminum alloy, the proper welding rod, and the method of installation. Aluminum is a very anodic material, and the basic fuel system in a boat consists of copper and bronze.

Aluminum and copper, in the presence of moisture, always create a very bad galvanic cell and special efforts must be made to avoid any direct contact. This can be done by inserting a 300 Series stainless steel fitting between the aluminum tank and any copper or brass fittings.

Aluminum tanks must be carefully installed so as to avoid any condition that will entrap moisture against the tank because aluminum in direct contact with salt water will corrode. A tank should be installed so that water will drain off quickly.

The aluminum alloy must be a salt water resistant alloy such as 5052, 5083 and 5086, which have very low copper content.

The aluminum surfaces must be prepared carefully and thoroughly (degreased and primed or etched) to assure a bond of the foam to the tank, prevent attack of the aluminum by the substances in the foam and to preclude moisture.

The foam must meet certain requirements concerning cell structure, moisture resistance, and density such that the foam will bond without voids, there will not be damaging water absorption and

> Several years ago a marine engineer reported removing an aluminum fuel tank which had a hole in it. The hole in the tank was almost directly below the fill pipe and it was theorized that a chip of brass from a brass fitting (thread chip) dropped into the tank and then corroded its way through. The rest of the four year old tank was in excellent condition. If problems such as this are to be avoided, aluminum fuel tanks must be thoroughly cleaned and great care must be exercised to avoid coupling aluminum to copper alloys (even the small thread chip left in a tank).

there will be a certain inherent strength to preserve the bond to the tank.

H-24, Gasoline Fuel Systems, is available from the American Boat and Yacht Council, 3069 Solomons Island Road, Edgewater, MD 21037-1416. The price is $35.00 per copy plus $1.00 postage and handling.

A Study on Problems With Aluminum Fuel Tanks in Recreational Boats is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (Tel: (703) 487-4650). The price is $21.50 and the document accession number is PB95191664.

Conclusion

Examination of the data received from participants in the UL survey, as well as research into marine aluminum alloys has confirmed the existence of certain problems with aluminum fuel tanks in recreational boats, primarily due to failure to install them in accordance with recognized safety standards. The increased growth in the availability of polyethylene fuel tanks shows that they are realistic and effective alternatives to the use of aluminum. The use of thicker aluminum sheet for the tank construction, combined with a protective coating may be a temporary solution to the problem for both existing and newly constructed boats. The shortcomings of aluminum fuel tanks in recreational boats are mainly controlled by the environmental parameters in the bilge.

The crucial point is that permanently installed metallic tanks are assumed by the general boating population to be safe and reliable throughout the entire service life of the boat. The UL report indicates that the general boating public needs to become more educated about a product which many take for granted. Boat owners need to take an increased initiative in the inspection, care and maintenance of their boat's fuel system.

PERSONAL WATERCRAFT CONSPICUITY

Accidents involving Personal Watercraft (PWC) have been attributed to a wide variety of factors including the fact that due to their relatively small size and unusual patterns of maneuvering relative to other vessels, PWC are not easily recognized visually.

The most prevalent type of accident involving PWC is a collision with another vessel -- 80 percent in 1994; 83 percent in 1993; 82 percent in 1992; and 80 percent in 1991. A little more than half of the collisions involve PWC operators who intentionally operate in close proximity to other boats -- either riding in formation with other PWCs, or deliberately wake jumping behind another vessel.

In 1995 the Marine Technology Society was awarded a grant to study ways to improve the conspicuity of Personal Watercraft (PWC). Highlights of the report are described in this article.

The enhancement of conspicuity, according to the report, requires improving how the human eye is first alerted to the presence of a PWC and how the mind processes this information to determine the identity, position, and motion of the object relative to the observer. Several general enhancement methods were considered based upon earlier research regarding the conspicuity of motorcycles and other motor vehicles.

Six conspicuity enhancement methods were chosen for evaluation:

1. A flashing amber light;
2. A flashing automotive headlamp;
3. The operator's use of an international orange colored lifejacket;
4. The use of international orange material to cover the bow and stern surfaces of the PWC;
5. The operator's use of an international orange colored lifejacket and covering the bow and stern surfaces of the PWC with an international orange material; and
6. A vertical water spray, which is featured on one PWC manufacturer's models.

A group of evaluators observed each of the conspicuity methods (except the vertical water jet which had been observed in actual use earlier in the study) from various angles and distances when PWC were operated at various speeds. The composite average evaluation results are printed below. All of the observers commented on the effectiveness of the bright international orange color as a most significant factor in attracting their eyes to the vessel.

The use of the strobe light was not effective in improving conspicuity because the energy produced by the light was lost in the brighter background of the marine environment on a reasonably bright day. The strobe light would have been more effective in a low light condition.

The use of the automotive headlight was not effective in improving conspicuity, unless the observer was in direct alignment with the beam of light.

The vertical waterjet only operated at planing speed, when the PWC was already leaving a significant wake. As a result, the added effect of the roostertail was nearly insignificant.

The international orange surfaces were very noticeable and the color is in common use where conspicuity is critical. When both the rider's lifejacket and the front and rear surfaces of the PWC were international orange in color all observers reported a very significant degree of improvement in conspicuity.

EVALUATION RESULTS

PWC Modification	Head On	From Rear	From Side
Amber Strobe	3.0	2.1	2.7
Flashing Headlamp	2.4	1.0	1.1
International orange lifejacket	3.0	3.6	3.0
International orange bow and stern	3.3	3.1	2.0
Int'l orange bow and stern and lifejacket	4.4	4.6	3.4
Roostertail (vertical waterjet)	1.8	2.0	1.8

No Change	Slight Improvement	Noticeable Improvement	Significant Improvement	Very Significant Improvement
1	2	3	4	5

COAST GUARD ISSUES WARNING ABOUT UNAPPROVED LIFE JACKETS

On December 16, 1996 the U.S. Coast Guard issued a news release warning the public about a potential problem with certain unapproved inflatable life jackets. The problem does not exist with inflatable life jackets approved by the Coast Guard. Life jackets are also known as personal flotation devices or PFDs.

Halkey-Roberts, a manufacturer of inflator mechanisms for the PFD industry, has reported that its manual-automatic mechanisms, Mark II (product number V80000) and Mark III, (product number V83000), when used in combination with carbon dioxide cylinders with a half- inch threaded neck produced by Nippon Tansan Gas Company (NTG) and distributed by either NTG or Leland Limited, sometimes fail to pierce the cylinder when activated automatically by water. The same potential condition holds for United Moulders, Ltd., (UML) Mark III manual- semiautomatic mechanisms when used in combination with the NTG/Leland C02 cylinder.

According to the news release, the Halkey-Roberts inflators are not marked with an identifying product number and come in black only. Likewise, Leland/NTG cylinders are marked Leland or NTG but may be coated, making the marking invisible.

The news release emphasized that the products named are not faulty in themselves, but that they may not work well together. No problems have been reported to the Coast Guard in the manual operation of these devices, nor have any problems been reported with these parts when used in combination with other inflators or cylinders.

The Coast Guard urged owners of Techvests and Techfloats to check their model number against those listed because Survival Technologies coats its cylinders and NTG is not visible on the cylinders.

The list includes only information that has been provided by manufacturers. As a result, the Coast

Guard noted that manufacturers not listed may have inflatable PFDs with this inflator-cylinder combination and urged owners of inflatable PFDs to check their equipment for this combination of inflator and cylinder.

Because the products involved are not Coast Guard-approved, the Coast Guard cannot give authoritative instructions on how they should be handled. Owners of affected PFDs should be aware that unless the manufacturer is contacted and corrective action is taken, these devices might not provide any flotation unless they are inflated manually.

Coast Guard-approved inflatable PFDs are expected to be available to the public before the 1997 boating season begins, and they will be marked with a U.S. Coast Guard approval number starting with 160.076.

Consumers who want more information should contact the manufacturers of their inflatable PFDs. The following manufacturers have informed the Coast Guard of affected models and would like owners of these models to call:

MANUFACTURER	PFD NAME	PFD MODEL NOS.
LIFESAVING SYSTEMS (813) 645-2748	PRO-LITE	481-AO, 481-AN
MUSTANG (800) 526-0532	CREWFIT	C10171, C11601, C10173, C11603 (WITH HARNESS), C10014, C10019 (RECHARGE KITS)
SPORTING LIVES (800) 858-5876	SOSPENDERS	120A, 120AH, 123A
STEARNS (800) 783-2767	SECUMAR	1140, 1150
SURVIVAL TECHNOLOGIES (800) 525-2747	TECHFLOAT	TECHVEST B01322, B01325, B01615

COUNTRY CODES AND HINS FOR BOATS INTENDED FOR EXPORT

At the back of this issue of the **Boating Safety Circular** is a **Federal Register** document containing Supplementary Notice of Proposed Rulemaking (SNPRM) concerning Hull Identification Numbers (HINs) for boats. In the SNPRM, the Coast Guard proposes adopting the International Organization for Standardization (ISO) HIN format, which consists of a two character country code followed by a hyphen, followed by the existing 12 character HIN format. Use of the ISO HIN standard was mandated for use on all craft to be used in the European Common Market after June 16, 1996, as specified in the European Union and Directive for Recreational Craft.

As a result, several U.S. manufacturers have sought the Coast Guard's opinion on how to go about complying with the ISO HIN standard, without affixing two separate HINs.

According to 181.27 of Title 33, Code of Federal Regulations, "If additional information is displayed on the boat within two inches of the hull identification number, that information must be separated from the hull identification number by means of borders or must be on a separate label so that it will not be interpreted as part of the hull identification number.

As a result, there are several different methods manufacturers who export their boats for the purposes of sale overseas can use when affixing HINs to their boats and meet both the Coast Guard and ISO HIN format requirements:

1. Display two different HINs, one beneath the other.

ABC12345K696 (existing USCG format)
US-ABC12345K696 (ISO format)

2. Surround the country code and hyphen to the left of the existing HIN format with a border or display the country code and hyphen on a separate label.

US-ABC12345K696

US-ABC12345K696

US- ABC12345K696