

How Long do Fiberglass Boats Last?

The same feature that helped launch the fiberglass boat industry in the 1960s may be hurting new boat sales now. According to a Boat/US Magazine, Jan, 2006 article, "In 2004, 71% of boats changing hands were pre-owned, as compared to 63% in 1997, according to a recently released study by the National Marine Manufacturers Association (NMMA). The 2004 Pre-Owned Boat Market Study reported that more than one million used boats were sold in 2004 and more than 75% of first-time boat buyers bought a used boat." The durability of fiberglass boats forces the industry to innovate each year with new product features and styling to attract buyers.

But just what can we say is the expected lifespan of a fiberglass boat hull? The answer varies with type of construction, choice of materials, and overall workmanship. However, since we are reaching the 50-year milestone for some venerable classes of boats that are actively being used, we can step back in time with some of these boats that have either been maintained over the years or recently restored to get a feel for how long these structures hold up in a marine environment.

Shields #231

We know that wood eventually rots and steel corrodes at a set "allowance" per year. Maintenance is key to achieving even normal life expectancy with wood or metal boats. However, fiberglass hulls have been pulled from out of the weeds and up from the depths to be restored to original luster. A case in point is the salvage of Shields #231, which sank in 60 feet of water in 1999 when swamped by a Long Island Sound Easterly. She was floated again on October 2, 2002. Figure 1 shows the boat as it was hauled from the bottom and Figure 2 shows her restored with a new paint job. The boat went on to race competitively in her fleet.



Figure 1 Pictures of Salvaged and Restored Shields Hull # 231

http://www.shieldsfleetone.org/Photos/Photos_231_Salvage/231%20salvage.htm

Many owners of or shoppers for old fiberglass boats realize that the hulls themselves often outlive the wood trim and mechanical systems - which we all know can be a lot more costly to replace. It's true that the very early fiberglass boatbuilders were conservative with their laminate schedules, which perhaps has contributed to the longevity of some classes. The reason solid skin laminates were 3/8 to 3/4 inches thick was because the laminates of the time had what we would today consider to be poor mechanical properties.

Coast Guard 40 foot Patrol Boat

An example is the US Coast Guard 40 foot patrol boat that was developed in the early 1950s for law enforcement and search and rescue missions. The boats are 40 feet overall with an 11 foot beam and displace 21,000 pounds. Twin 250 horsepower diesel engines produced a top speed of 22 knots. Single skin FRP construction was reinforced by transverse aluminum frames, a decidedly conservative approach at the time of construction. Laminate schedules consisted of alternating plies of 10 ounce boat cloth and 1 ounce mat at 3/4 inch for the bottom and 3/8 inch for the sides.

In 1962, Owens-Corning Fiberglass and the U.S. Coast Guard tested panels cut from three boats that had been in service 10 years. In 1972, more extensive tests were performed on a larger population of samples taken from CG Hull 40503, shown in Figure 3, which was being retired after 20 years in service. It should be noted that service included duty in an extremely polluted ship channel where contact with sulfuric acid was constant and exposure to extreme temperatures occurred during one fire fighting episode. Total operating hours for the vessel was 11,654. Visual examination of sliced specimens indicated that water or other chemical reactants had not entered the laminate. The comparative physical test data is presented in Table 1.

Table 1 Physical Property Data for 10 Year and 20 Year Tests of USCG Patrol Boat [Owens-Corning Fiberglass, Fiber Glass Marine Laminates, 20 Years of Proven Durability]

Hull CG 40503		10 Year Tests	20 Year Tests
Tensile Strength	Average psi	5990	6140
	Number of samples	1	10
Compressive Strength	Average psi	12200	12210
	Number of samples	2	10
Flexural Strength	Average psi	9410	10850
	Number of samples	1	10
Shear Strength	Average psi	6560	6146
	Number of samples	3	10

Figure 3. USCG Hull 40503 [Owens-Corning Fiberglass, Fiber Glass Marine Laminates, 20 Years of Proven Durability]



Triton

A Northrop and Johnson ad in the Aug '60 "Yachting" cites the Triton sailboat as being introduced in Jan 1959. Sales to June 1960 were listed at 173 at a production schedule of 3 boats per week. The listed price was \$9590 for the sloop. Everett Pearson developed the construction standards for fiberglass: "We designed the hull laminate from the waterline down so that the boat, laid over on its side with the entire weight of the boat resting on the keel and one square inch of the hull would yield not more than 1/2 inch and produce no structural damage to the boat." This is part of the reason so many of the early Tritons are still sailing today.



Figure 4. Two Classic Triton Sloops
[<http://www.pearsontriton.com/history/billbell.shtml>]

FiberClassics

Although old, restored fiberglass boats seem to blend well with the timeless designs typical of New England builders, some fiberglass powerboats hardly blend with today's styles. Sure you have a classic Bertram in the mix but some of the older powerboat classics took their styling cues quite literally from Detroit.



Figure 5. www.FiberClassics.com

For an amusing trip down memory lane, visit the web site www.FiberClassics.com, shown in Figure 5. There are many examples of the early Glastrons and other powerboats.

The web site shows "one of the most exotic and sought after of the Classics. It is a 1956 Lone

Star, Meteor. The pink boat shown is at the end of a multiyear restoration and is of the highest quality. The boat cost \$1,600.00 new, about 3 times the price of an ordinary 15 foot boat. The motor and trailer were sold separately, typical of the time period. The '56 was the most detailed and expensive Meteor made and is the most collectible, subsequent years were cheapened with less trim and bench seats in an attempt to improve sales. The boat's designer, Bob Hammond, left Lone Star in 1956 to found Glastron.

Many of these classics from the 50s and 60s are being restored these days, showing that the composite structure long outlives contemporary styling.

Figure 6. Carp DeVille from page 4 of "Boats in the Belfry- the KevFin Collection"
[\[www.fiberglassclassics.com/galleries/bitb/default.htm\]](http://www.fiberglassclassics.com/galleries/bitb/default.htm)



Most gel coat on 50-year old fiberglass boats won't restore to showroom quality shown in Figure 6. Restored fiberglass boats of this era are now typically painted with polyester urethane topcoat, such as Awlgrip. However, we're still concerned about how long the mechanical properties of the pure laminate can last. Keep in mind that the part of the structure that will invariably fail first is not somewhere in the middle of a hull panel but at the edges where it is attached to hardware or bulkheads. Again, good selection of attachment methods and workmanship can drastically increase the life expectancy of an FRP structural detail.

Submarine Fairwaters

A while back, the Navy wanted to know how the strength of submarine composites was holding up. The Navy had developed a fiberglass replacement for the aluminum fairwaters that were fitted on submarines. The fairwater is the hydrodynamic cowling that surrounds the submarine's sail. The motivation behind this program was electrolytic corrosion and maintenance problems. The laminate used consisted of style 181 Volan glass cloth in a general purpose polyester resin that was mixed with a flexible resin for added toughness. Vacuum bag molding was used and curing took place at room temperature.

The fairwater installed on the U.S.S. Halfbeak was examined in 1965 after 11 years in service. The physical properties of the tested laminates are shown in Table 2. After

performing the tests, the conclusion that the materials were not adversely affected by long term exposure to weather was reached. It should be noted that a detailed analysis of the component indicated that a safety factor of four was maintained throughout the service life of the part. Thus, the mean stress was kept below the long term static fatigue strength limit, which at the time was taken to be 20 to 25 percent of the ultimate strength of the laminate.

Table 2 Property Tests of Samples from Fairwater of U.S.S. Halfbeak [Fried & Graner, Durability of Reinforced Plastic Structural Materials in Marine Service]

Property	Condition	Original Data (1954)*	1965 Data		
			1 st Panel	2 nd Panel	3 rd Panel
Flexural Strength, psi	Dry	52400	51900	51900	51900
	Wet†	54300	46400	47300	46900
Flexural Modulus, psi x 10 ⁶	Dry	2.54	2.62	2.41	2.52
	Wet	2.49	2.45	2.28	2.37
Compressive Strength, psi	Dry	—	40200	38000	39100
	Wet	—	35900	35200	35600
Barcol Hardness	Dry	55	53	50	52
Specific Gravity	Dry	1.68	1.69	1.66	1.68
Resin Content	Dry	47.6%	47.4%	48.2%	47.8%

* Average of three panels

† Specimen boiled for two hours, then cooled at room temperature for one hour prior to testing

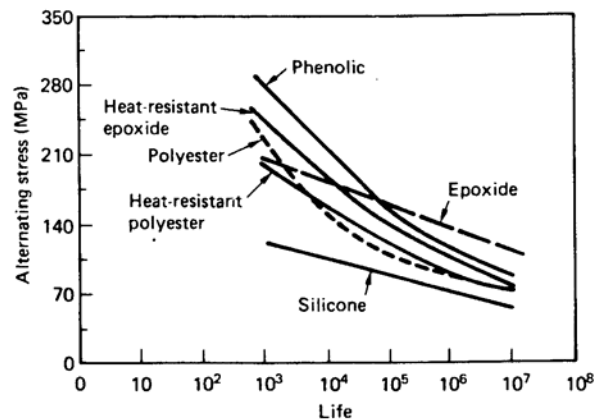
Fatigue

The conclusion from the Halfbeak study is important because it stated that the long-term cyclic stress loads on the part were about 25% of the part strength. Indeed if a hull or propulsion related assembly experienced fatigue cycling on the order of 10⁵ cycles, we'd expect to see a design safety factor of 4, in which case the cycling profile would determine the life of the structure. That is, we'd predict failure when the shaft turned say "one million times" instead of after 40 years of service. Figure 7 is a graph that shows how various resin systems respond to cyclic stress.

Figure 7 S-N Curves for various Resin Systems [Konur & Matthews "Effect of the properties of the constituents on the fatigue performance of composites: a review," Composites, vol 20, no 4, July, 1989]

UV Exposure

Fiberglass antennas experience some of the harshest UV ageing of any marine composite structure. Shakespeare Composite Structures tests its weather-blocker protection system in accordance with the American Society for Testing and Materials (ASTM) G154, Standard Practice for Operating Light and Water Exposure Apparatus for Exposure of Non-Metallic Materials using a fluorescent UV-condensation apparatus. Among scientists, Florida is the international benchmark for



durability testing of materials because it is considered worst case and produces faster deterioration than in northern climates. Under these conditions, Shakespeare composite poles and crossarms exhibited no fiber exposure, crazing, chalking or color change within a 2,500-hour test period. Further accelerated tests have substantiated UV weathering abilities beyond 15,000 hours. Shakespeare has also conducted extensive accelerated testing by other means, including a 996-day test utilizing the EMMAQUA sunlight concentrating machine in the Arizona desert (ASTM G90-91 Procedure B). In addition, their engineers have been able to observe real-time, real-world weathering effects on our products that have been in service for more than 35 years.
[<http://www.skp-cs.com/poleproducts/pdf/whitepapers.pdf>]

Overall Life Expectancy

So what do all the tests and anecdotal evidence tell us about how long composites will last in a marine environment? Of course poor workmanship or improper use of materials can lead to premature structural failures, as observed by veteran repair shops such as Paul E. Luke. They find themselves working on aging fiberglass hulls that are often plagued with water impregnation of decks and bulkheads. They have extensive experience “re-coring” fiberglass decks and restoring the integrity of bulkheads with water damage, as shown in Figure 8.



Figure 8. Deck “Re-coring” at Paul E. Luke, East Boothbay, Maine
[http://www.peluke.com/Yacht_Repair/yacht_repair.html]

However, sandwich construction can also last a long time if careful attention is paid to fasteners and other details. Sandwich laminates do have thinner skins that tend to have higher fiber volume fractions, which may be somewhat problematic after decades of service. Many fiberglass boats are still in service after fifty years. Today’s resin systems and manufacturing methods certainly have improved, suggesting we set our goal for 75 – 100 years. I’m not sure we can do accelerated testing out to 100 years, but I do know that there are a lot of 50-year old boats out there that could be cut up and tested!