IBEX ISSUE!

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SAFE BOATS INTERNATIONAL
STEPPED HULLS
MANAGING A REMODEL
FUNDAMENTALS OF APPRAISALS

Infrared Imaging

Skeptical of this technology? So was the author, until he watched it accurately map areas where water was trapped in the cored bottom of a 15-year-old FRP sailing yacht.

by David King

The owner of *Freya* first contacted our yard, Townsend Bay Marine, at the end of July 2002. He had owned the Tayana 52 (15.8m) sailboat, built in 1987, for about a year. In addition to a list of maintenance items and upgrades, he wanted to address her badly blistered bottom.

TBM is a full-service boatbuilding and repair facility in Port Townsend, Washington. We'd recently completed a refit on a 44′ (13.4m) Swan whose problems included shallow blisters that did not reach the underlying laminate. On that boat, we just spot-ground and puttied the blisters and then applied Interlux's Interprotect 2000E epoxy coating system. *Freya*'s blisters were much larger and deeper, and a full bottom peel was warranted. We proposed to haul the boat out, peel the bottom, and leave her outside behind our buildings for some time in order to let her dry out before we relaminated the bottom.

We reached a repair agreement with the owner, hauled the boat, and peeled the bottom in November 2002. We actually had to peel twice because of the poor condition of the outer laminate. After peeling, we monitored the bottom moisture with a Wagoner L609 moisture meter. We called the meter's manufacturer to discuss our application, and were assured that their unit—although calibrated for wood—was adequate for relative readings on the FRP hull. So, we waited for the bottom readings to go down relative to the topsides readings. But she wouldn't dry out. At most locations the meter stayed pegged at 22%—its highest reading.

The bottom *appeared* dry. The laminate wasn't the best quality; there was quite a lot of air in the chopped mat, but no moisture was bleeding out of it (nor was there any oil in the bilge area, fortunately). We waited and waited. We left her outside for several months to allow air to circulate around the hull. We moved her into the building in February to begin other work for which we'd contracted,

*The 52′ (15.8m) sailboat pictured above (**left**) came to Townsend Bay Marine (Port Townsend, Washington) for repair of the deep and pervasive osmotic blisters on her bottom (**right**), as well as for maintenance items and upgrades. TBM's original plan: peel the bottom, then leave the boat outside for some time to allow the boat to dry before relaminating.*

expecting that she might dry out more quickly in our heated shop during the winter.

Inside the building there was still no change in the hull bottom's moisture-meter readings, but neither was there any evidence of surface moisture. We were beginning to doubt our methods until one of the crew drilled a quarter-inch (6mm) hole in the boat's bottom in order to mount a ground plane, and water poured out. Quite a lot of water.

At this point we knew we had a serious problem. We had no idea of the extent of the water saturation or its effect on the hull. We did several 1½" (38mm) core samples and found that the hull was cored with scored PVC foam, and the kerfs had not been filled with resin or bonding putty. The core was basically one big limber-hole system.

On the other hand, the core in our samples looked to be in pretty good shape, with the foam firmly bonded to the inner and the outer skins. Apart from some graying, there was little evidence of deterioration in the core itself. Still, half a dozen core samples could not give us a comprehensive picture of the hull's condition. Some of them were dry, some were damp, and water dribbled out of others. We didn't feel we could assure the owner that our proposed repair program was adequate. In fact, the original approach represented considerable liability risk for TBM—maybe not

DAVID KING

The bottom actually had to be peeled twice, due to the poor condition of the outer laminate. Still, the hull failed to dry out over the next several months. After a TBM crew member drilled a hole in the boat's bottom to mount a ground plane and water poured out, the yard bored several hull samples and discovered that the kerfs in the PVC foam core had not been filled with resin or putty. As the author says, the core was "one big limber-hole system." The core itself, though, was in good shape, and firmly bonded to the skins.

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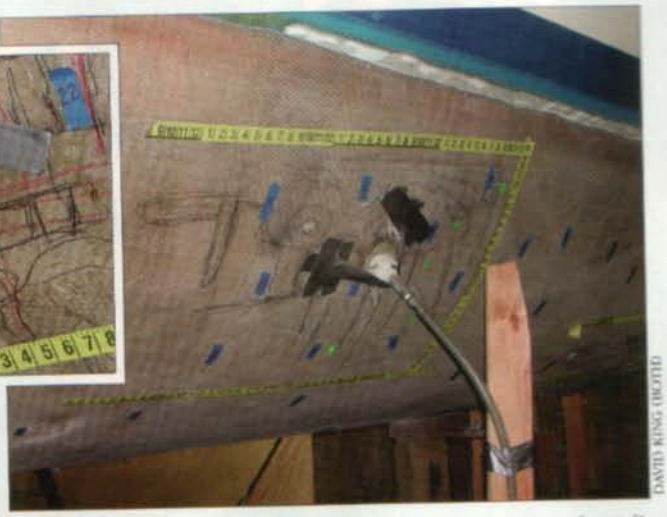
TBM hired Todd Schwede of Todd & Associates to do an infrared scan of the boat's bottom to determine the extent of water intrusion. The photos on this page give a good sense of how the infrared scanning process works. Note the cross-hatched area in the center of the hull in the photo ***above, left****. The vertical line to the left of the cross-hatching corresponds to a line demarcating areas of core laid out at different angles. Moisture had migrated from the forward area of the hull (to the left); the moisture was stopped by a putty dam along this line. The moisture buildup shows as the darker area at the left of the scan* ***above, right****. Note the five whitish dots that imply a vertical line—that's the putty dam. The large red and white spot (partially obscured by screen data) is where TBM drilled through the outer skin to reveal core beneath, shown in the photo* ***left****. The cracks in the foam core are unfilled kerfs. The author readily admits that it takes a specialist to perform and interpret an infrared scan. On the basis of the infrared survey, TBM determined that the boat did not have systemic core and moisture problems, and that wet areas in the hull could be dried out and relaminated.*



DAVID KING (BOTH)

To dry out the hull, TBM attached a vacuum pump and ran it night and day for several weeks. The yard moved the pickup point around the hull, guided by Schwede's infrared map.

from the current owner, but from a future buyer.

The repair we felt was called for—peeling the entire outside skin, replacing core as needed, filling the kerfs, and relaminating—was prohibitively expensive. We liked this owner, who'd been very patient with our efforts, and we hated giving him the news that his boat was full of water. We suggested that he call a surveyor for an independent assessment of the problem, and gave him the name of Larry Montgomery at Montgomery Maritime Survey, also located in Port Townsend.

Larry (with whom we've worked in the past) came and looked at the boat and at the coupons we'd bored. He told us that he had been seeing the same problem on cored boats built prior to the late '80s—before builders understood the need to fill all scores and voids in the core, and before they began installing cores by vacuum-bagging. He suggested that we contact Todd Schwede of Todd & Associates (San Diego, California) to have him scan the hull with infrared equipment. Larry believed that with this equipment, we would be able to ascertain the extent of the damage and offer a repair solution appropriate to the problem. I've worked a lot with Larry, like his conservative approach, and trust his judgment. Trapped as we were between two unworkable alternatives, we took his advice.

We discussed some type of partial repair with Larry. Before Todd came to do the actual scanning, we communicated our plan to the owner: to scan the hull, and to dry and repair only those areas indicated by the scan to be problematic. We had our attorney draw up a supplemental agreement to our original repair contract for the owner to sign. It clearly stated that the cost to fully repair the hull may exceed the current value of the vessel, and that the owner agreed to the more limited repairs we proposed, referencing the specific repair recommendation as an attachment. In the document, the owner agreed to "release and indemnify" the yard from damage and loss. We'd kept the owner fully informed throughout this process, and he was well aware of the boat's condition. We hoped that the repair strategy we developed would not only allow the owner to use the boat in confidence but would help to maintain the boat's value in case the owner wanted to sell her. The purpose of the document was to protect the yard from any third-party lawsuit by a future owner.

A few days later, Todd Schwede showed up with his suitcase full of gear. His infrared camera, which resembles a standard video camera, has a handheld portable display that looks like a Ping-Pong paddle attached to the camera by a wire. Here's an excerpt from Todd's business brochure that describes what he does: "In infrared thermographic inspection, infrared energy is applied to the exterior of the hull laminate surfaces, and the infrared thermographic camera detects the migration and conductivity pattern of the infrared energy, and displays a color image. Subsurface anomalies including disbonding, delamination, water entrapment, voids, and other deficiencies appear in the image, which is subsequently mapped on the hull of the vessel to assist in the repair process." Todd started work late on Wednesday afternoon, and by seven o'clock that evening he and Larry had scanned and marked the entire port side.

I must admit—at this point, I was fairly skeptical. Todd would "wash" the hull surface with what seemed like an insignificant amount of heat from a heat gun, making the surface barely warm to the touch. Then, viewing his Ping-Pong-paddle screen, he began to mark on the outside of the hull what the scanner was showing him about the core. "*This* is a putty dam between two sections of core. *Here's* where the core ends. *This*

DAVID KING

After drying the hull, TBM restored the outer skin with two layers of mat and vinyl ester resin.

DAVID KING (BOTH)

***Top**—The bottom was faired with vinyl ester putty after laminating. **Bottom**—Bottom paint was applied with an airless sprayer.*

is an area of bonding where the core was not pushed firmly into the bonding putty." Yeah, right. The adjustments he made on his handheld screen were incomprehensible to me and made the colors on the display vary wildly. It looked like a cross between an ultrasound scan and a '60s rock-concert light show.

After he finished scanning the whole boat, we made some test borings, each of which bore out (pun intended) his evaluation with remarkable precision. Putty dams, imperfect bonds, unfilled scores, and pockets of moisture were all as he indicated. It was as if he'd traced the core on Mylar and transferred it to the hull surface.

Once we'd verified his results, we felt we could draw two conclusions about *Freya*'s condition. First, most of the problem areas were restricted to the forward third of the bottom. Aft of that, there were fewer indications of water pockets or other imperfections. Second, test borings in the areas that the scan showed as having the most serious problems revealed that even in those spots, the defects were not that dire. Some putty dams were damp and crumbly, but the foam was firmly attached to both the inner and outer skins and was in reasonably good condition. There was evidence of previous water intrusion in some areas now dry.

Todd's formal report arrived a few days later. His recommendation was to dry the hull in the problem areas located by the scan and to relaminate "utilizing standard shipyard repair practice and established fiberglass repair lamination procedures." In one area on the starboard side forward, among a cluster of through-hulls, he recommended removing the outer skin and re-coring. Otherwise, he wrote, "in the opinion of the undersigned, the vessel did not exhibit a systemic problem of water intrusion throughout the bottom of the hull." After examining all the openings and the bond between the core and the skins around those through-hulls, we decided that it wasn't necessary to remove the outer skin and recore it. Since the scan and associated samples verified that the boat did not have systemic core and moisture problems, we felt that it was preferable to maintain the integrity of the inner and outer skins. The owner agreed.

We pulled all the through-hulls and carefully sealed the openings and, for several weeks, dried out the hull by running a vacuum pump night and day. We moved the pickup point around on the hull, guided by Todd's map.

The moisture-meter readings for the hull bottom began to go down, ultimately reaching the 16%–18% level (relative to the 12% readings from the topsides). At this point we felt we'd removed pretty much all the "free" water in the core. We weren't able and didn't expect to remove the "bound" water—the dampness of the core material itself.

When we finished drying the hull, we ground and patched all our test holes. Then we relaminated with two layers of 1½-oz mat laid up with Reichhold Hydrex, a modified vinyl ester resin. After relaminating we primed the hull with Duratec 1799 vinyl ester primer, did some minor filling with Duratec 1804 vinyl ester putty, and sanded her out. We then applied the Interlux Interprotect 2000E system and Sherwin-Williams Pro-Line 1088 bottom paint.

While all this was happening below the waterline, we were refinishing the railcaps, detailing the deck, and rebuilding and reinstalling hatches. We relaunched *Freya* on June 26, with most of the owner's cruising season still ahead of him. On Monday, June 30, 2003 the owner called at 8:00 a.m.—before our 9:00 a.m. production meeting—to tell us how happy he was with the boat and how much he appreciated our work. As I said, we liked this customer!

The *Freya* project was our first encounter with infrared scanning at TBM. It gave us a remarkably accurate image of the condition of the cored hull, which we were able to verify by taking core samples. With the scan information in hand, we could recommend a cost-effective repair to the cost-conscious owner of an older boat. Certainly, completely removing the outer skin and vacuum-bagging on a new core would have created a structure better than new. But that was never a reasonable alternative. The infrared scan gave us good information to guide the repair. We'll use it again.

Actually, let me rephrase that: we'll use Todd again. The screen images from which he mapped the core were indecipherable to me. The hardware's going to get cheaper; that's the nature of electronic equipment. But the ability to interpret what's displayed will always depend on the skill and experience of the operator. Todd's help was timely, cost-effective, and welcome. PBB

***About the Author:** David King is a managing partner and the CFO of Townsend Bay Marine in Port Townsend, Washington.*