THE DO-IT-YOURSELF ENGINE SURVEY

NOTHING CAN REPLACE PROFESSIONAL MARINE SURVEYS, BUT WE CAN ALL LEARN FROM THEIR APPROACH.

story + photos **STEVE ZIMMERMAN**

Most engines receive closer attention during a pre-purchase survey than during the term of ownership. A pre-purchase inspection by a mechanic trained in an engine brand provides a thorough evaluation of the present condition, along with recommendations for upcoming maintenance.

If you are contemplating the purchase of a previously owned boat, or if you are preparing for a long cruise on a boat you have owned for many years, then it pays to understand what a thorough inspection includes. The following information will help you know what to expect if you hire a professional inspector, and how to proceed if you want to inspect your own engine.

BEFORE STARTING THE ENGINE

You might be surprised by how much time a professional spends in the machinery space before starting the engine: at least a couple of hours for a single-engine boat. A cool engine and machinery space are more conducive to close inspection, and are safer, too.

The inspection process hinges on gathering accurate data. Finding the manufacturer's ID numbers on the engine provides a good starting point, followed by obtaining the proper manual or specs for that engine. Those resources will let you confirm the expected wide-open throttle rpm for the sea trial—a critically important piece of information. In addition to the engine manual, prior service records will be helpful. The manual will specify required service intervals. Unless you can prove that they have been completed, the services are needed.

The bilge or engine pan should be inspected for any indications of leaks, and clean white absorbent pads should be placed there for the trial run. A flashlight and mirror will facilitate looking under and around the engine for hard-to-find oil or coolant leaks. Be sure to have a close look at the raw water pump: Most have an opening so that oil or seawater leaks will be visible.

In a pre-purchase inspection, the mechanic will pay close attention to breaks in the paint finish that point to prior repairs or problems, or to the absence of a required service task. On new engines, the paint usually spans over seals and gaskets; once those components have been removed, the paint line will have a jagged edge.

The visual inspection will include a close look at the belts for indications of wear and/or belt dust pointing to misalignment. Engine mounts will be inspected for alignment

The engine seawater pump has openings which will reveal oil or seawater leaks through failing seals. The green verdigris in this image points to the seal on the seawater side.

You don't have to see water to know there is a leak. Weeping connections at this oil cooler have taken a toll on the engine mount below it.

Here's a benchmark that shows the right stuff. This 30-plus year-old Ford Lehman has been well cared for by professional delivery captains Wendy and Jerry Taylor, proving that age and hours don't necessarily lead to leaks and rust.

problems, rubber condition (cracked or compressed) and any indication of movement. The mounts will be inspected again later during the trial run.

Heat exchangers should be inspected for signs of leaks or corrosion. The inspection will not include replacement of the required anodes, but in preparation for a season or a cruise, or if the status is unknown, these zincs should be replaced. Here's where service records can make a difference: An air intercooler or aftercooler can cost thousands of dollars to replace, and a failed one can cause serious engine damage. You will need to know if the maintenance records can verify compliance with the manufacturer's service recommendations.

Hoses can be inspected for dryness or cracks. Squeeze them, and then listen and feel for any crunchiness—a sure sign of impending failure. Boat owners often overlook hoses; service life varies depending on the application and brand, but seven years would be a good run. Beyond that, replacement might be due.

The turbocharger should also be inspected at this time. Oil leaks, blade pitting, excessive play or carbon buildup can all point to trouble. In addition to doing visual checks, a professional will set up equipment to measure the "boost" pressure that the turbo generates underway.

Engine crankcase pressure provides one of the most reliable indicators of internal engine condition. Compression tests on diesel engines can be difficult, but low compression creates increased crankcase pressure as the gas escapes past the pistons and rings. A mechanic will set up test equipment to check for these problems before starting the engines.

Exhaust back pressure should also be measured. The size of the exhaust riser, muffler and hose, combined with the number of turns, can create excessive resistance for the engine and will lead to premature failure. The engine warranty will be voided if the back pressure falls outside the specified range. If the exhaust riser has a threaded port, then the test equipment can easily be connected there.

With the cold engine inspection complete and the test equipment connected, it is time to start the engine. First, however, disconnect the shore power cord so you can make sure that the batteries have the condition and capacity to start the engine without the assistance of any external charge sources, and specifically without battery chargers. Many engines always start with a battery charger on, masking a weak battery.

One last step before starting the engine: Turn on the ignition key and listen for alarms. All warning lights and sounds should activate with the key in this position, confirming their proper operation.

UNDERWAY CHECKS

In almost all situations, starting the engines, untying lines and idling away from the marina and into more open water will provide ample time for the engine to warm up. Once you have room to navigate and operate at higher speeds, it is time to put the boat through her paces.

The process varies from mechanic to mechanic, but generally the engine rpm will be increased incrementally, and readings will be taken at each interval. You might start at a slow cruise for 10 minutes, then do a normal cruise for 10 minutes, and then go wide-open throttle (more about that shortly).

On most engines, the rpm on the tachometer cannot be trusted as an accurate indicator. Measuring rpm at the flywheel with a strobe provides a true reading and should be compared to the boat's tach.

At each rpm increment, the following data will be collected, if possible: rpm, boat speed, oil temperature, coolant temperature, engine oil pressure, engine oil temperature, transmission oil pressure, crankcase pressure, exhaust back pressure, and turbo boost pressure.

Additional information—such as raw water pressure on the outlet side of the engine seawater pump, and fuel flow restriction—also can be gathered. At each increment, the exhaust at the transom should be checked for smoke, and excessive engine vibration should be noted. At the conclusion of the trial run, a summary should be compiled noting the readings observed and comparing them to the manufacturer's specifications.

The following section provides one example of the overall process, but the readings are noted at wide-open throttle only.

TAKING TEMPERATURES

While underway, use an infrared pyrometer ("temp gun") to perform a number of checks. Just as the tach cannot be trusted, neither can the boat's temperature gauges. The temp gun will verify the true temperatures, and the difference between its readings and the gauge's readings can be noted for future reference. The temp gun also can be used to check many components, including the efficiency of all heat exchangers, variation in cylinder temperatures, exhaust temperatures and more.

Engine room air temperature provides another important data point. Engineers refer to the difference between the ambient air (outside the boat) and the air in the engine compartment as the delta T. This difference should not exceed

One of the best in the business, Tim Caruso, of Marine Diesel Analysts, has connected his test gauges and is completing the pre-start inspection as he puts a pair of CATs through the paces.

30 degrees Fahrenheit. The temp gun will not suffice for this test; a temperature probe used in conjunction with a multimeter should be placed at the intake air filter to read the air coming into the engine. If the delta T exceeds 30 degrees, then you might have a ventilation problem.

While considering airflow to the engine, you can use a basic test to check the sufficiency of the air inlets. At a fast cruise or at wide-open throttle, note the engine rpm and then open an engine hatch and a cabin door. If the rpm increases along with the new flow of air, then you are not providing the engine with enough air.

During this trial run, also check the DC battery voltage to verify that the alternators provide the proper charge.

BACKDOWN TEST

This test ensures that the engine will not stall under a load at idle (a good thing to know before docking) and

tests the condition and installation of the engine mounts. The test requires two people: one at the helm and another in the engine room.

Proceed in forward at 1000 rpm. After the speed levels off, shift to neutral for three seconds and then into reverse at idle. At this point, the engines should not stall, and you can increase throttle to 50 percent for three to five seconds.

Observe the motor mounts while at the 50 percent rpm. Look closely at each engine mount: A small amount of flex is normal, but the mount should not move with respect to the engine stringer.

Repeat the whole process as often as needed to put eyes on each mount.

WIDE OPEN

A full-throttle test should be conducted as part of almost all engine inspections. Every engine has a rating for the allowable proportion of time for wide-open operation (usually something like one hour out of every eight). The fear of breaking something keeps many boat owners from running, even briefly, at wide-open throttle. Trust me: If it breaks at full throttle, then you had a problem and didn't know about it. Better to find out during test conditions than during an emergency.

Additionally, the wide-open throttle test proves that the engine can reach the rated maximum rpm. Failure to hit that number indicates a problem with propeller size, fuel restriction, air restriction, the turbo or the drivetrain. Furthermore, on newer engines, failure to meet the maximum rated rpm will void your warranty.

If your engine never overheats, but it does so on the full-throttle test, then you have identified a critical weakness under benign conditions.

BACK AT THE DOCK

Once you have returned to the dock and the engines have cooled down a bit, it is time for fluid samples. At a minimum, check the engine lubrication oil and the transmission oil.

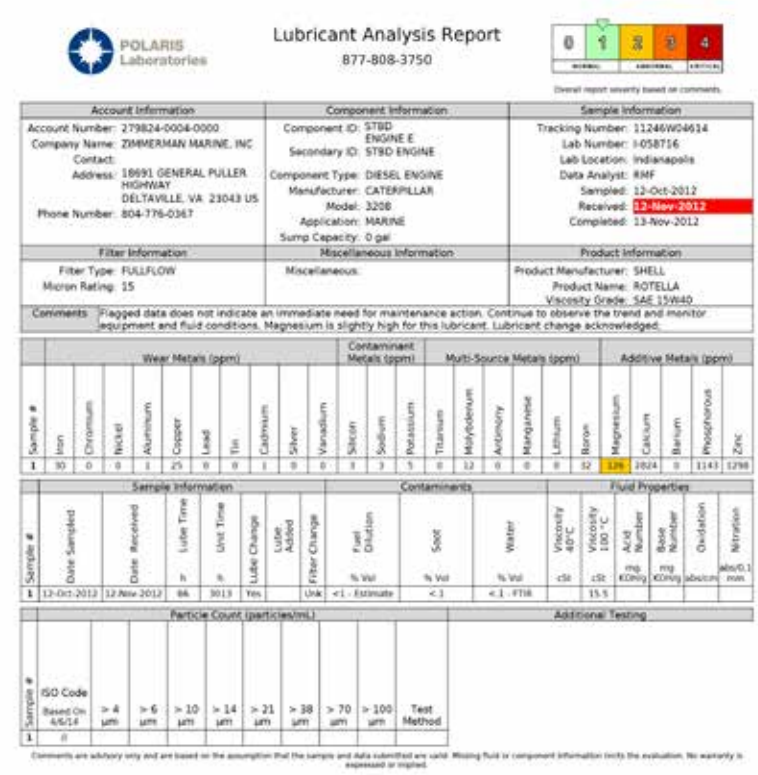
Oil samples must have a minimum of 50 engine hours to provide useful data, and more hours increase the accuracy. Samples taken over time (annually for a number of years) produce the most meaningful results. Coolant samples provide additional and potentially helpful information. Each analysis lab utilizes a different reporting format, but most will indicate severity levels with color coding or a numerical scale.

Oil samples can provide critical information about engine wear, but a one-time sample has limited value.

Before wrapping up, have a look at those absorbent pads that you placed under the engines before getting underway. Check for any discoloration, which indicates leaks. A final look at the engine for any fluid stains will close out the process.

On a cruising boat, the engines and generator can represent a substantial portion of the total vessel value. In addition, an engine failure at a critical time can be dangerous. For these reasons, whether you're buying a previously owned boat or preparing your own boat for an adventure, it pays to invest the time and money in a thorough mechanical survey.

Steve Zimmerman *is the president of Zimmerman Marine, which operates five boatyards in Maryland, Virginia, North Carolina and South Carolina. Zimmerman has been building and repairing boats for more than four decades.*



POLARIS Laboratories

Lubricant Analysis Report

877-808-3750

0 1 2 3 4

Overall report severity based on comments.

Account Information	Component Information	Sample Information
Account Number: 279824-0004-0000 Company Name: ZIMMERMAN MARINE, INC Contact: Address: 18691 GENERAL PULLER HIGHWAY DELTAVILLE, VA 23043 US Phone Number: 804-776-0367	Component ID: STBD ENGINE E Secondary ID: STBD ENGINE Component Type: DIESEL ENGINE Manufacturer: CATERPILLAR Model: 3208 Application: MARINE Sump Capacity: 0 gal	Tracking Number: 11246W04614 Lab Number: I-058716 Lab Location: Indianapolis Data Analyst: RMF Sampled: 12-Oct-2012 Received: 13-Nov-2012 Completed: 13-Nov-2012
Filter Information	**Miscellaneous Information**	**Product Information**
Filter Type: FULLFLOW Micron Rating: 15	Miscellaneous:	Product Manufacturer: SHELL Product Name: ROTELLA Viscosity Grade: SAE 15W40

Comments: Flagged data does not indicate an immediate need for maintenance action. Continue to observe the trend and monitor equipment and fluid conditions. Magnesium is slightly high for this lubricant. Lubricant change acknowledged.

	Wear Metals (ppm)										Contaminant Metals (ppm)			Multi-Source Metals (ppm)						Additive Metals (ppm)				
Sample #	Iron	Chromium	Nickel	Aluminum	Copper	Lead	Tin	Cadmium	Silver	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Antimony	Manganese	Lithium	Boron	Magnesium	Calcium	Barium	Phosphorous	Zinc
1	30	0	0	1	25	0	0	1	0	0	8	3	5	0	12	0	0	0	32	126	2824	0	1143	1298

	Sample Information							Contaminants			Fluid Properties					
Sample #	Date Sampled	Date Received	Lube Time h	Unit Time h	Lube Change	Lube Added	Filter Change	Fuel Dilution % Vol	Soot % Vol	Water % Vol	Viscosity 40°C cSt	Viscosity 100 °C cSt	Acid Number mg KOH/g	Base Number mg KOH/g	Oxidation abs/cm	Nitration abs/0.1 mm
1	12-Oct-2012	12-Nov-2012	86	3013	Yes		Unk	<1 - Estimate	< 1	< 1 - FTIR		15.5				

	Particle Count (particles/mL)									Additional Testing
Sample #	ISO Code Based On 4/6/14	> 4 µm	> 6 µm	> 10 µm	> 14 µm	> 21 µm	> 38 µm	> 70 µm	> 100 µm	Test Method
1	//									

Comments are advisory only and are based on the assumption that the sample and data submitted are valid. Missing fluid or component information limits the evaluation. No warranty is expressed or implied.