SQUEEZE PLAYERS

More than 100 years after its invention, the diesel engine is finally beginning to make inroads in the recreational performance-boat market.

PHOTOS BY TOM MOBLEY

More mention of a diesel engine ignites a number of connotations among performance enthusiasts—good and bad.

Sluggish acceleration, egregiously heavy engines and billowing clouds of acrid black smoke top the list of the negative aspects. On the other hand, diesel fuel typically costs less than gasoline, the engines consume far less of it, comparatively speaking, and the lifespan of a properly maintained diesel engine is as much as five times that of a naturally aspirated gasoline engine.

But the smoke is clearing, the engines are shedding weight and the performance gap is closing fast, thanks to new technology emerging in the diesel-engine market.

Manufacturers are introducing engines with far more sophisticated fuel-delivery systems. Why? Well, because they had to. The U.S. Environmental Protection Agency's Tier II emissions regulations, which affect recreational inboard gasoline and diesel engines in January 2006, have forced their collective hand. To comply, manufacturers either have to clean them up or stop selling them. Use of "common-rail" fuel injection, a system in which each injector is supplied by the same fuel rail, is one of the emerging technologies in the marine-diesel market.

"The common rail is really a key component to the new clean diesel technology," said Pam Jones, West Coast representative for the Diesel Technology Forum. "This is because of the efficiency of how it atomizes the fuel into very small droplets. Upon compression, when they ignite, because of the small particles, there is less fuel left over. And it's the unburned fuel, largely, that creates emissions. So the ability to inject fuel in microfine particles into the combustion chamber makes for more fuel-efficient operation."

Common rail itself is nothing new. Port fuel-injected gasoline engines have had it for years. Diesels have traditionally used mechanical injector pumps and individual injector lines. Even with the old technology, the engines were still more miserly than gasoline engines. Development costs deterred engine manufacturers from introducing electronic-control systems. Existing technology wasn't broken, so it didn't need to be fixed—at least until the EPA enacted the emission requirements.

"You had a lot of diesel engine companies that had their own fuel-injection pumps that were all mechanical," said Adib Mastry, vice president and secretary of Mastry Engine Center in

A Viable Power Option

It's difficult not to like the longevity and reliability of diesel engines, their long oil-change intervals, closed cooling systems and decent fuel mileage. New technology is now making them more suitable for performance applications.

STORY BY BRETT BECKER

St. Petersburg, Fla., a Yanmar dealer. "Everybody waited until it was a necessity, and the necessity is basically the EPA with its Tier II emission requirements. That's why it took so long."

New electronic systems make variable injection timing far easier. With this system, engineers can time the delivery of the fuel into the cylinder according to the engine speed and a litany of other conditions. For example, with variable injection timing, Mastry said engineers actually can cut off fuel to certain cylinders while at idle to make gear changes—and docking maneuvers—less abrupt.

Variable injection timing also benefits the engine at full throttle. The engine control module can measure parameters such as exhaust temperature to regulate the amount of fuel to the cylinders. Mastry said that it will be possible for the operator to monitor the timing of the fuel delivery to each cylinder from a display at the helm. Variable injection timing also helps cut noise levels of diesels—that bag-of-hammers rattling that many buyers find objectionable.

"You're getting a lot of valvetrain noise," Mastry said. "But the hammering noise is not so much the valves as it is the injectors firing. Injectors fire at up to 2,400 psi, and it's just loud. It sounds equivalent to a gasoline engine that's pinging.

"The way the common-rail fuel-injection works, the fuel is delivered in a much more precise mist," he added. "Rather than being a hard pop, it'll be a nice mist. That will quiet them down 30 to 40 percent."

There likely will always be a bit of that "hammering" noise associated with diesels, simply because of the way they ignite the fuel. There are no spark plugs in a diesel engine. Fuel is delivered on the combustion stroke and ignited by the heat of compression. To squeeze the fuel mixture that hard, the compression ratios range roughly from 14:1 to 22:1 depending on the engine. Individual cylinder pressures in a diesel are typically as much as 400 psi. For gas engines, cylinder pressures usually register at just more than 100 psi.

Given the high pressures and the violence of the explosions within the cylinders, the components of a diesel engine must be far more stout. That's where the weight comes from.

"Because of the high compression, the cranks are all forged steel and there's a lot of mass in them," Mastry said. "A six-cylinder has seven main bearings. They (Yanmars) have a bridge that goes underneath the crank for block strength and added support for the connecting rods. I think they're overbuilt quite a bit."

In addition to forged cranks, the materials used in the engines often bump up the weight. The blocks are cast from a harder metal—harder equals denser equals heavier—and the pistons can be forged aluminum or even steel. With all that mass and a heavy flywheel, it's no wonder diesels don't turn high rpm—not that they need to. Some of the engines you'll read about create more than 1,000 foot-pounds of torque at less than 2,000 rpm.

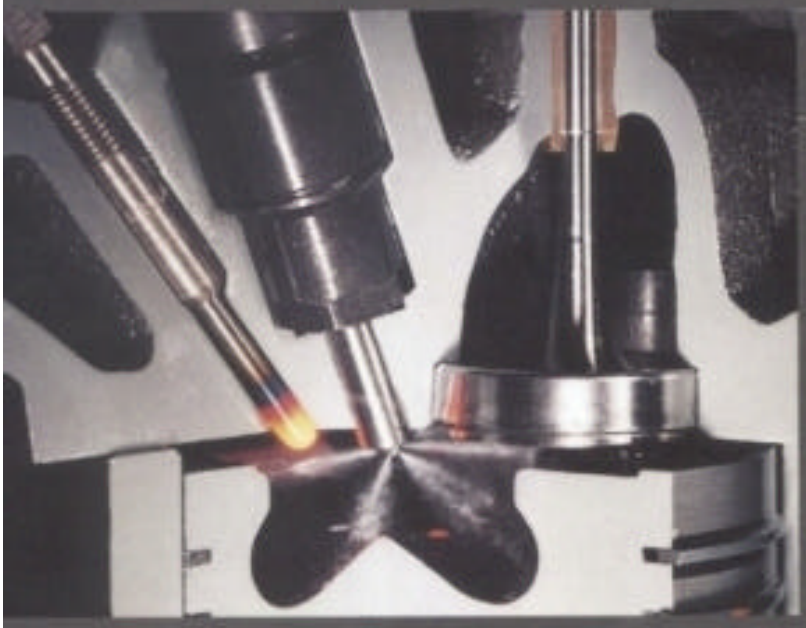

PHOTO COURTESY OF BOSCH

Left: Since diesel fuel is ignited by the heat of compression, diesel engines don't have spark plugs, but they do have glow plugs to initiate the process at startup. Once the engine is fired, it will run until its fuel supply is cut off.

"A diesel just wouldn't stay together at any kind of high rpm," Mastry said. "Number one, they don't make bolts strong enough to hold the head on to turn them that fast. You couldn't make a crankshaft strong enough with that kind of compression. Engine wear would be unbelievable."

But diesels have proven that they do last.

Lots of factors contribute to the engines' long life. Many engines use two oil pumps, one to lubricate the turbo and feed the spray nozzles that cool the underside of the pistons. The other pump feeds the bottom end and the valvetrain. Diesels typically have a much higher oil capacity. Some take as many as 20 quarts to fill, and the oil cooler contributes greatly to engine life and a longer oil-change intervals.

"In a 440 (Yanmar) at full throttle for an hour, the oil temperature never goes over 170, 180 degrees, where you'll see well over 200 degrees in a gas motor," Mastry said, adding that blower motors can push oil temperatures even higher.

Since diesels turn fewer rpm when they're running, they turn fewer rpm over their lifespan. Crankshaft and piston speeds are slower, and therefore wear is decreased.

Properly maintained, a diesel engine can last as long as 10,000 hours, compared with, say, about 1,800 for a well-maintained naturally aspirated gas engine, according to Mastry. If you consider that the average recreational boater uses his boat about 50 hours per season, you can begin to see why people would find diesel engines attractive. Your boat might be dust by the time a diesel is due for a rebuild.

Though the diesel is a viable power alternative, it's clear that the high-performance marine market will always favor gasoline engines. They're lighter, spool up more quickly when throttling in big seas and a pair of monstrous 14-71 blowers sticking through the hatches will always be cool.

For this roundup, we tried to pick engines that produced more than 400 horsepower, yet weighed less than 2,000 pounds. Finding engines that can make that kind of power was no problem. Weight was a more difficult criterion. For all but two examples in this roundup, we were able to meet the weight requirements.

All horsepower figures are listed in metric figures, which is the industry standard for diesel engines. For the engines in this roundup, the difference between metric ratings and those from the Society of Automotive Engineers is no greater than about 10 horsepower. Metric figures are a bit higher than SAE.

CATERPILLAR ▸

C-9 was introduced to the public at the Fort
rnational Boat Show in October 2002, but pro-
gin until roughly a year later. Caterpillar has long
to the marine industry and its heavy-duty 3306
the company's workhorse. But its design dated
0s and the engine wouldn't be able to pass foeth-
emission, performance and weight requirements that the 3306 couldn't meet," said Wes Hohulin, global pleasure-craft marketing manager for Caterpillar. "But what's selling the engine is its performance."

Hohulin said the C-9 operates virtually smoke free and that many initial customers have commented on how quiet the engine is. The engine produces 510 metric horsepower at 2,500 rpm and more than 1,300 foot-pounds of torque at 1,800 rpm.

The 8.8-liter engine uses Caterpillar's HEUI-B control system. The weighty acronym means the injectors are actuated hydraulically and electronically controlled. Caterpillar touts the engine's hardened mid-supported wet cylinder liners, which allow for a higher top piston ring position for better fuel economy and reduced emissions. The design, according to a Caterpillar release, is also responsible for the engine's virtually smoke- and soot-free operation.

You will need a lot of boat to float a pair of these engines. Weighing in at 2,088 pounds, the engines measure
by 37.94 inches wide, with a height of 38.69 i
Mercury Racing's HP900SC weighs 1,614 poun
and a No. 6 dry-sump drive, and measures 50 in
Huber transmission and shaft, 39 inches wide an

The Caterpillar C-9 features a 250-hour oil-
standard transmission cooler and optional fu
comes with an automatic poly-V belt-tensioniq

The Series 60 is available in numerous configurations from 385 horsepower to 825 horsepower, depending on the application.

"We have a basic engine block for the Series 60 we can use for, say, a pleasure application, and we can bump it to 800 horsepower," Noble said. "But if I'm going to put it in a tug boat that runs all day every day, it won't last. So we can use the same Series 60 platform to create an engine (less horsepower, longer life) specific to the application."

Highlights of the Series 60 include electronic fuel injection. The engine also features top-liner cooling, a patented design that allows engine coolant to circulate all the way to the top of the cylinder liner, which continuously draws heat from the hottest part of the cylinder.

The Series 60 also features steel pistons with top rings located lower on the skirt to protect them from high combustion temperatures. The pistons are cooled with passages drilled in the connecting rods and spray nozzles mounted in the block. Naturally the turbocharged engine is intercooled. It uses a copper and nickel intercooler to cool the incoming air charge.

Detroit Diesel's electronic control system receives input from 12 sensors, then uses the data to operate each fuel injector accordingly. Injection timing can be widely varied. The system also allows for user options such as variable idle speeds programmed by the owner and ultra-low idle speeds for maneuvering in tight marinas.

SPECIFICATIONS

Model	Series 60
Engine type	inline six-cylinder
Horsepower	825 at 2,100 rpm
Torque	1,884 foot-pounds at 1,600 rpm
Compression	14.7: 1
Engine weight	3,503 lbs.
Max fuel consumption	NA
Retail price	See dealer for pricing

Florida Detroit Diesel, 4141 S.W. 30th Ave., Fort Lauderdale, FL 33312, 954-327-4440, www.fdda.com, www.detroitdiesel.com.

MAN ▸

▸ With marine engine offerings for recreational and commercial use, MAN builds everything from 1,800-horse V-12s to one of its most recent models, which is also its lightest and smallest: the 450-horsepower D0836LE401, an inline six-cylinder introduced in October 2002.

Weighing in at 1,606 pounds, the 450-horse MAN measures a fairly compact 44.5 inches long by 29 inches wide by 36.4 inches in height. For comparison, Mercury Racing's HP500EFI weighs 1,113 pounds with a Bravo One drive and measures 39.5 inches long by 34 inches wide with a 22-inch height.

MAN built the engine with 1,000 annual hours of operation in mind, with 50 percent of those hours spent at average load and 20 percent of those hours at full throttle. That MAN's intended duty cycle mirrors that of a typical performance boat is convenient. What is more convenient—and more significant—is the total number of hours the engine can be run before it needs an overhaul or repower.

Depending on how the boat is used and maintained, owners can expect between 5,000 to 10,000 hours of use before it needs replacement, according to Dennis Spencer, regional sales manager for MAN.

"That doesn't mean it won't break and you'll never have to fix it, but it does mean you can expect that kind of life out of it," Spencer said. "The guys who get the most hours out of them are the guys who use them every day. So much of it depends on how a boat is used. If they sit very much, they get corrosion built up inside the cylinders and it shortens the life of the engine."

Spencer said that the company hasn't done much in the performance-marine market, but engines like the new 450-hp six-cylinder could present new opportunities.

The 450-horse six features an intercooled turbocharger with an optional transmission oil cooler. Boasting a 15:1 compression ratio, the engine comes with water-cooled exhaust that is insulated on the inside, which reportedly improves thermal efficiency and acceleration.

The engine also comes standard with an electronic diagnosis and monitoring system, which collates data such as rpm, oil pressure, boost pressure and air-charge temperature, and coolant level and temperature. If the system detects a critical engine condition, it stores data for later access by service personnel and sounds an alarm in the engine compartment, and at the helm. The system also reduces power output by 25 percent until the condition is repaired.

SPECIFICATIONS

Model	MAN D0836LE401
Engine type	inline six-cylinder
Horsepower	450 hp at 2,600 rpm
Torque	944 foot-pounds at 1,800 rpm
Compression	15:1
Engine weight	1,606 lbs.
Max fuel consumption	23 gph
Retail price	See dealer for pricing

MAN USA, 591 S.W. 13th Terrace, Pompano Beach, FL 33069, 800-MAN-2642, www.man-mec.com.

◂ MARINEDIESEL USA

GOING FAST WITH DIESEL POWER

Go to the Miami International Boat Show often enough and you will see diesel applications in high-performance boats. In 2003, Mastry Engine Center of St. Petersburg, Fla., displayed a 36' Spectre catamaran with a pair of Yanmar diesel engines. According to Adib Mastry, who has worked on projects with Hustler, Fountain, Nor-Tech, Cigarette and Skater, the boat's top speed was 108 mph. Here's how he he did it.

Mastry went with Yanmar's 440-horsepower six-cylinder, a two-speed transmission and a Bmax drive. The engines were stock Yanmars, but the transmission was a piece co-developed—and eventually patented—with ZF Marine. It featured a 1:1 first gear and a .778:1 overdrive second gear. Mastry used a 1.19:1 Bmax drive, which resulted in a final drive ratio of .925:1, or 7.5 percent overdriven.

With that setup, the engines would spin 3,450 rpm at full throttle, which translated to a prop speed of 3,750 rpm. For comparison's sake, a Mercury Racing HP525EFI engine at 5,250 rpm and a 1.35:1 Bravo One drive would produce a prop speed of roughly 3,900 rpm. On the chalkboard, the 36' Spectre would be a few mph faster with the HP525EFIs, even though each engine used 34"-pitch props.

"In a catamaran, you've got to remember once you hit that transition, the boat keeps getting lighter," Mastry said. "And the diesels carry so much torque, you can't bog them."

The benefits of the diesel include high cruise speeds and fuel mileage that boggles the mind.

"In the Spectre, I can cruise at 90 mph and burn 30 gph at 3 miles per gallon—and that's a real conservative figure—it's more like 4.5 miles per gallon," he said.

Mastry has since torn the boat apart again and begun filling in the notches on the transom so he can mount a pair of Arneson ASD-8 surface drives. The torque of a diesel has proven too much for stern drives.

"If you're out there running hard and the boat comes out of the water and lands, the motor doesn't slow down when it lands," he said. "You just watch the boost gauge on the turbo hit 40 psi. It doesn't slow down at all because of all that mass moving."

Mastry said using the Arneson drives will allow him to back the propeller pitch down to around 30 inches and still have 100-plus-mph performance.

"I've found that propellers seem to be optimum efficiency-wise somewhere around 30 inches of pitch," Mastry said. "When you get up into the 36 and 37, the prop isn't as efficient. You get too far out of square, the efficiency of the blade comes down because it's too much like a screw."—BB

▸ Unlike other engines in this roundup, MarineDiesel's supercharged 400-horsepower Tigershark V-8—and all the company's diesel Optimizer 6.500 V-8s for that matter—was designed specifically for repower applications. Based on the General Motors 6.5-liter diesel V-8 used in the military Hummer H1, the MarineDiesel engine is sized comparably to "porcupine" big-blocks and the later-model 496-based engines. It even uses the standard MerCruiser 9-pin connector.

"We want to illustrate to consumers that they can in fact consider a diesel engine when repowering their boats, without having to consider the excessive costs associated with rebuilding the stringers and engine compartment," said MarineDiesel's Andy Logan in a written statement. "A standard conversion with our product usually will not take any more than one additional hour as compared to a standard gas-engine replacement."

The engines are so close in size, in fact, that the MarineDiesel Tigershark will bolt into place where, say, a 502 once was, or even a small-block engine. The Tigershark 6.5-liter measures 30.7 inches long by 32.2 inches wide and stands 30.7 inches tall and weighs 948 pounds. Compare that with MerCruiser's small-block MX 6.2 MPI, which measures 32 inches long by 30 inches wide and 22 inches in height. Coupled with a Bravo One drive, the MX 6.2 MPI weighs 993 pounds.

What makes the 6.5-liter Tigershark ideal for repowering is its center-exit exhaust manifolds, which mean the tailpipe locations likely won't need to be changed.

If you don't want a supercharged engine, MarineDiesel also offers a 300-horse Hammerhead, a 250-horse Stingray and a 170-horse Barracuda, all based on the 6.5-liter engine.

The blown Tigershark produces 400 horsepower at 4,000 rpm. Part of that power stems from its cupronickel intercooler, which drops the temperature of the incoming air. It features high-pressure mechanical fuel injection with variable timing.

SPECIFICATIONS

Model	MD400SC Tigershark
Engine type	V-8
Horsepower	400 hp
Torque	NA
Compression	15:1
Engine weight	948 lbs.
Max fuel consumption	NA
Retail price	NA

MarineDiesel, 1414 S. Sangre Road, Stillwater, OK 74074 405-533-3833, www.marinedieselusa.com.

◂ VOLVO PENTA

▸ Introduced two years ago, Volvo Penta's TAMD75PEDC, known internally as the 75, came about because of market

demand. According to Jens Bering, Volvo Penta's diesel product manager, the company hasn't focused its efforts on the go-fast market because the numbers aren't there just yet, though he said the 75 could be used for performance applications.

"We have just not focused on that market in favor of supplying OEMs," Bering said, adding that the 75 often finds a home in 40' to 50' semiplaning hulls. "People are stuck on horsepower. Everybody wants to go faster and faster in their boats.

"In the 40' to 50' range, there had never been an engine that could elevate the speed to the 30-knot range," he added. "Boatbuilders have been pushing us for more and more horsepower. We sort of set the pace at 480 horsepower and boy did we get attention from the boatbuilders."

Tipping the scales at 1,896 pounds, the 75 produces 956 foot-pounds of torque at 1,600 rpm and all of its 480 horsepower at 2,600 rpm. Its length is 44.5 inches, its width 32 inches and its height just a hair under 37 inches. In contrast, the MerCruiser 496 Mag HO weighs 1,399 pounds with a Bravo One XR drive. It measures 35 inches long by 33 inches wide by 24 inches tall.

The turbocharged inline six-cylinder was developed specifically for semiplaning and planing hulls. Its Electronic Diesel Control system measures conditions such as operating temperature, air pressure and other factors to deliver a precise fuel charge through its six-hole direct-injector nozzles. The system also allows for drive-by-wire installations, automatic twin-engine synchronization and self diagnosis.

The smoke is clearing, the engines are shedding weight and the performance gap is closing fast.

Volvo Penta designed the engine, which has seven main bearings, to have as few moving parts as possible for maximum reliability.

As a marine diesel, it was designed for longevity, but Volvo Penta had the presence of mind to build the engine with replaceable wet cylinder liners, valve seats and guides. Its construction features two cylinder heads, freshwater cooling for the turbocharger and oil cooling for the forged-aluminum pistons. The engine package includes the transmission, controls and wiring harnesses.

"With the EDC system, we deliver a complete package," Bering said. "The engine, transmission and controls, and harnesses are developed, supplied and warranted by one company."

SPECIFICATIONS

Model	TAMD75P EDC
Engine type	inline six-cylinder
Horsepower	480 @ 2,600 rpm
Torque	956 foot-pounds
Compression	17:1
Engine weight	1,896 lbs.
Max fuel consumption	26 gph
Retail price $46,960, includes engine, transmission, harnesses and controls.	

Volvo Penta, 1300 Volvo Penta Drive, Chesapeake, VA 23320, 757-436-2800, www.volvopenta.com.

◂ YANMAR

Yanmar has long marketed itself as a leader in the diesel marine industry, and that marketing isn't without merit. The most power, with the smallest footprint and best-in-class power-to-weight ratios have been the company's stock in trade.

Yanmar engines are designed specifically for marine use, not a marinized version of a truck or industrial engine. The result is a line of compact, lightweight engines—when compared with other diesels on the market—that won't sink the back of your boat because of their weight.

"Put them (diesels) in a boat and weight becomes an issue. Size becomes an issue," said a Yanmar representative. "We've always designed engines for marine use, so they're purpose-designed products to meet a specific application."

For years, the 440-horsepower inline six was high on the list of power plants for performance boaters. Now Yanmar has introduced the new 6CX-GTE2, an entirely new inline six that makes 500 horsepower at 2,900 rpm.

According to company literature, the power increase stems from a longer stroke, a more aggressive turbo-intercooler and optimized tune settings. The engine also features four valves per cylinder and a high-pressure direct fuel-injection system.

"When we sell a diesel, it's designed to run for long periods of time producing most or all of its horsepower. It's not overstressed at those rpm," said the Yanmar rep, adding that rebuilding big-power blower engines after one season's use can get old quickly. "If you can get just twice the hours of a gas motor, which is absurdly low for a diesel engine, it pays for itself over and over again."

The 500-horse Yanmar weighs 1,815 pounds and measures 59.21 inches long by 32.44 inches wide by 35.63 inches high. For comparison, the Mercury Racing HP525EFI weighs 1,201 pounds and measures 39.5 inches long by 34 inches wide by 24 inches high.

"Our power-to-weight ratio is by far better than anyone else's," said Adib Mastry. "Also, our stuff works better in the performance boats, because it does turn a few more rpm than others." ●

SPECIFICATIONS

Model	6CXM-GTE2
Engine type	inline six-cylinder
Horsepower	500 at 2,900 rpm
Torque	+/- 1,200 foot-pounds at 1,700 to 2,000 rpm
Compression	NA
Engine weight	1,815 lbs.
Max fuel consumption	25 to 28 gph
Retail price	See dealer for pricing

Yanmar Marine USA Corp., 101 International Pkwy., Adairsville, GA 30103-2028 770-877-9894 www.yanmarmarine.com.