BY SVEN DONALDSON

A NEW GENERATION OF MARINE DIESELS

VOLVO-PENTA HAS INTRODUCED SOPHISTICATED COMMON RAIL ENGINES TO THE BOATING INDUSTRY.

With diesels powering upwards of 40% of new cars sold in Europe, it's not surprising that Volvo Penta—headquartered in Sweden—has become the first engine builder to introduce so-called common rail engines in the marine sector. Most major car makers within the EU have switched from conventional unit fuel injection to common rail fuelling because the newer technology offers better efficiency, reduced emissions and substantially quieter operation.

Naturally, these advantages would be welcomed by mariners too. Nevertheless, until Volvo Penta revealed its new products last summer, there was no hint that the relatively small marine market would be seeing common rail engines anytime soon.

For Europeans, the financial motivation to "go diesel" is much stronger than here in North America because fuel prices generally are two-to-three times higher, and diesel costs about 25% less than gasoline. Nevertheless, there's growing interest in marine diesel power on this side of the pond, with converts citing longer engine life, higher resale value and extended cruising range. The latter is of particular interest to local boaters cruising up-coast, because declining fisheries and stiff environmental regulations have been forcing many fuel docks out of business.

In any case, Volvo Penta clearly believes that boaters are ready for a new generation of premium diesels which are compact, powerful, exceptionally quiet and ultra-clean. If so, 2003 could mark the beginning of a new era in more efficient, yet civilized marine propulsion.

Common Rail Basics

Unit injectors (as currently found on virtually all marine diesels except a few big ship engines) are compact piston pumps that each service an individual cylinder. To initiate a power stroke, an injector drives a spray of fuel into the highly compressed, super-heated air within the combustion chamber where it spontaneously "lights off" in an explosive fashion. Injection pressures are extremely high—typically around 1400 bar (21,000 psi)—because high pressure results in smaller fuel droplets and hence, more complete combustion.

In a common rail engine, a precision, gear-type pump supplies fuel, again at about 1400 bar, to a tubular reservoir—the common rail—which extends the length of the block. Each cylinder still has its own injector, but instead of being a pressure pump it now primarily acts as a fast-acting valve controlled by either a solenoid, or less commonly, a piezoelectric mechanism. The substantial volume of fuel within the common rail minimizes pressure fluctuations as injectors open and close.

With a common rail system, fuel can be injected in two or three closely-spaced pulses rather than all at once. Typically, an initial pilot injection triggers the burn, producing intense turbulence in the combustion chamber. Milliseconds later as more fuel is added, the violent swirling action already underway within the chamber ensures virtually 100% oxidation. Pulsed fuel injection also prevents cylinder pressures from peaking too sharply, reducing mechanical stress, while muting the percussive diesel sound we know so well. Moreover, valve-type injectors are themselves quieter than conventional unit injectors. Better yet, a more flexible injection protocol enables the common rail engine to operate at higher average cylinder head temperatures (for

better thermal efficiency), while avoiding excessive peak temperatures which lead to high nitrous oxide emissions. And last but not least, common rail systems are self-bleeding—no more troublesome re-start procedures after running out of fuel.

Volvo Penta D3

New Diesel Electronics

Obviously, any common rail engine requires electronic controls, but already such controls are commonplace on contemporary unit injected engines. Volvo Penta—like other major diesel manufacturers—has taken a conservative approach to ensure their electronics won't compromise engine reliability. Sealed, solid state components and waterproof connectors are the industry norm, while in many cases, redundant circuits operating in parallel back one another up.

Volvo Penta D4

To accompany their new crop of common rail diesels, Volvo Penta has debuted an integrated electronics platform based on the same sort of CAN-bus software-based technology that's become standard for the auto industry. The acronym stands for Control Area Network, and refers to a fully-integrated system that not only manages normal engine functions and diagnostics, but handles data for all onboard instrumentation including navigational electronics, autopilots and so forth. Mercury Marine has something similar with their SmartBoat system, while Teleflex Morse offers their competing MagicBus technology for non-Merc brands. Not surprisingly, there's some serious marketing manoeuvring involved, because once an owner is committed to a particular CAN-bus system including compatible instrumentation, it becomes much tougher to switch engine manufacturers should re-powering be necessary.

Volvo Penta's new system, known at EVM or Electronic Vessel Management, works with any of the company's electronic engines, both current and future models. The design of the EVC network permits multiple control stations and instruments to be daisy-chained together, greatly simplifying the task of wiring a large, complex yacht, or adding more functions to an existing boat.

First Look at the Common Rail Engines

In mid-June, I visited the Volvo Penta marine engine development centre on the island of Krossholmen in western Sweden, where I had the chance to inspect and drive a variety of planing powerboats equipped with the company's new engines. In one case, there was also a sistership available, equipped with the KAD 300 diesel, a popular, high-speed engine introduced in 2001 that will remain in the line-up for some time yet. Test boats were Euro brands, seldom seen in these parts, but spanning the range from fast sportboats to luxurious express cruisers.

Volvo Penta has chosen to debut their latest engine technology in the planing boat sector because fast hulls respond more dramatically to improvements in power-to-weight ratios, and because the company believes these new diesels can woo buyers away from big outboards and gasoline stern drives. Two series of common rail diesels were developed from scratch, specifically

for marine applications. The D-4 and D-6 are inline four and six cylinder engines displacing 3.7 and 5.5 litres respectively. They feature four valves per cylinder, replaceable wet sleeves and cast-iron construction with separate ladder frames between block and crankcase for maximum rigidity.

These new engines are noticeably more compact than previous-generation diesels of equal displacement, allowing them to achieve exceptionally high power densities without resorting to high rotational speeds. For example, the D-6 is almost identical in size to the KAD 300, yet has 30% more swept volume. The D-6 delivers 730 nm (537 ft-lb) of torque at 2000 rpm, and 310 hp at 3500 rpm. By contrast, the KAD 300—an engine that was state-of-the-art only two years ago—produces 567 nm (417 ft-lb) torque at 3500 rpm and 285 hp at 3800 rpm.

The D-6 weighs 560 kg (1,232 lb) without transmission, while the KAD 300 weighs 539 kg (1,186 lb), so in terms of power-to-weight, the D-6 is well ahead. More impressively, the D-6 achieves similar output at an R4 rating (light duty commercial up to 800 hours per year). By contrast, the KAD 300 is an R5 engine (pleasure only to 300 hours per year) which combines mechanical supercharging and turbocharging to coax extra output from smaller displacement. For the future, it's likely that an R5 turbo/ supercharged version of the D-6 will top 350 hp. Currently, as R4-rated engines, the D-6 and D-4 are engineered to go 5000 hours between overhauls, which for most recreational boaters means at least 15 years service.

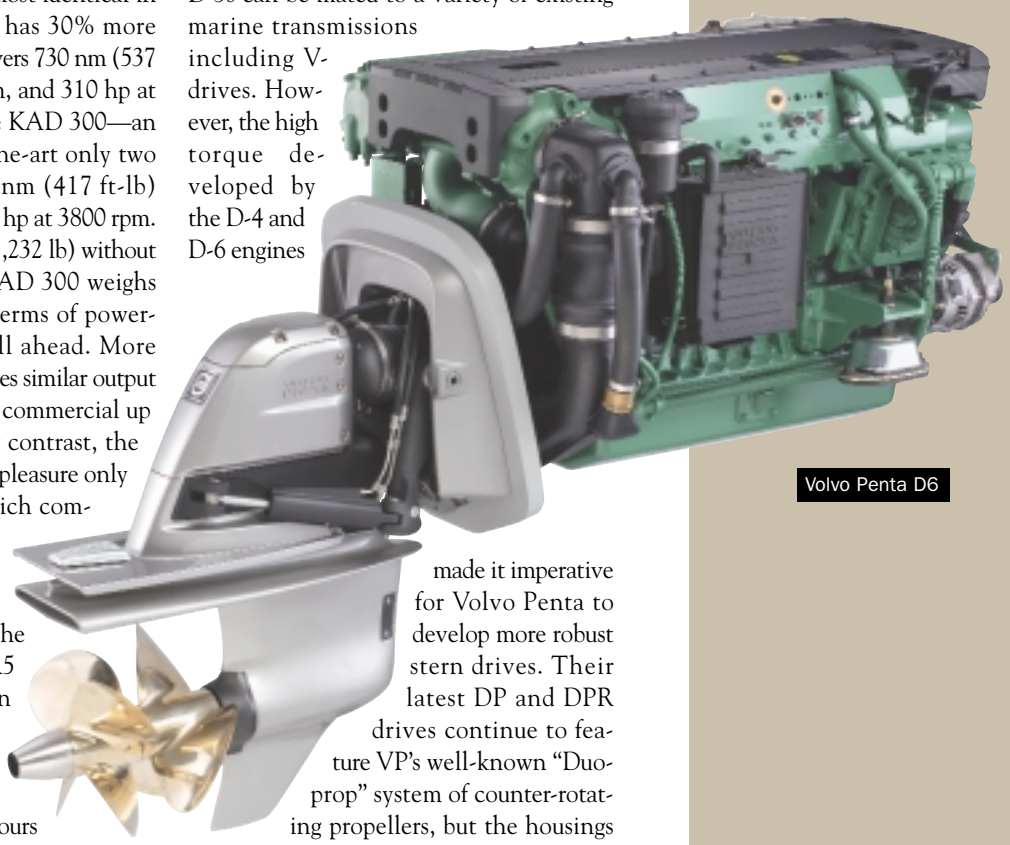
Volvo Penta is simultaneously debuting a third series of common rail engines based on an advanced, all-aluminum block developed for Volvo diesel cars. Called the D-3, it's an inline, 5-cylinder design displacing 2.4 litres and weighing just 215 kg (473 lb). Prices have yet to be announced, but high manufacturing volumes for the base engine should ensure they are quite competitive.

D-3 stern drive packages rated at 130 hp and 160 hp are presently available, both equipped with a sophisticated variable-geometry turbocharger and charge air cooling (intercooling).

Also on the way is a 110 hp D-3 that's governed to 3000 rpm for use in big sailboats and other slower craft. But, even the high-output D-3s are engineered for 2000-3000 hours between overhauls, which for most users, should prove ample. It's a sad fact that many marine diesels succumb to under-use and indifferent maintenance, not major hours.

Matching Drives and Props

For inboard installations, D-4s, D-6s and D-3s can be mated to a variety of existing marine transmissions including V-drives. However, the high torque developed by the D-4 and D-6 engines made it imperative for Volvo Penta to develop more robust stern drives. Their latest DP and DPR drives continue to feature VP's well-known "Duoprop" system of counter-rotating propellers, but the housings and drive trains are substantially stronger with space for larger props. As well, there are bigger exhaust ports (to boost power by minimizing back pressure) and cooling water intakes with double the capacity of previous models. Installation still requires just a single transom cut-out, and the new engine packages are essentially direct replacements for earlier Volvo Penta stern drives.



Volvo Penta D6

The new DP drive will be mated to both the D-4 and D-6 engines for boats running up to 45 kts, while the DPR drive is used with the D-6 for 45 plus. For the DP, there's a new series of Duoprop propellers cast in high-strength bronze alloy, and available in progressive pitch increments to accommodate boats with top speeds from 25 to 45 kts. The DPR drive uses stainless props.

For now, the only D-3 stern drive package incorporates the SX single-prop lower unit originally developed for high-output gas engines. This was a marketing decision aimed at creating a diesel stern drive that performs on par with outboards and gas stern drives, for about the same price.

Another key measuring stick is the 1.7 litre diesel stern drive (and inboard) sold by Cummins Mercruiser. Based on a 4-cylinder block from Isuzu, this 120 hp engine is proving popular for runabouts and pocket cruisers. Thanks to common rail fuelling and a higher power-to-weight ratio, the D-3 looks to enjoy a technological edge, but the price wars may get fierce.

On-the-Water Testing

The combination of advanced engine architecture, common rail fuelling and CAN-bus electronic controls is immediately obvious when boats equipped with these new-generation engines head out on the water. First, all three new engines were extremely smooth and quiet—as revealed by low readings on the dB meter.

What impressed me most, however, was the difference in raw acceleration between two Norwegian-built Windy Oceancraft 850s (28'), one with a KAD 300, the other with the new D-6. Judging by rpms at full throttle, both were optimally propped, yet it was no contest. Every attempt at a drag race left the KAD 300 labouring far behind, while the D-6 almost jumped onto a plane. The KAD 300 produced light, but visible smoke during hard acceleration, while the D-6 was utterly smoke-free. For those who like numbers, VP's comparative test data shows the D-6 pushed the Oceancraft 845 to 30 kts in 12.1 seconds, while it took the KAD 300 16.1 seconds. Wide open, the D-6 delivered 41 kts at 3410 rpm, while the KAD 300 managed 38.2 kts at 3788 rpm.

Twin 210 hp D-4s did a very good job of propelling a Fairline Targa 35. This "bullet-proof" luxury cruiser weighed in at 8,400 kg (18,500 lbs), yet accelerated to 15 kts in just 6.3 seconds, and topped out at a hair under 30.

Aboard a 23' Nimbus 230R with a sophisticated dual-step hull, a single D-4 yields 40 kts. By the same token, the 160 hp D-3 with the SX drive delivers 34 kts in a Ryds 20 GTS runabout.

Although it might risk swamping certain aft-cockpit boats, it's impossible to damage an EVC engine by shifting violently from full throttle forward to full reverse. The control system delays changing gears until the rpm has dropped into the safe range.

Outlook Bright

Until now, the only common rail diesels available at a consumer level in North America come in heavy duty pick-up trucks from Dodge (Cummins engine) and GM (an Isuzu/GM joint venture). For 2004, Mercedes plans to start selling its E320 CDI sedans in Canada and the U.S., but there's little indication this technology is ready to take off here quite yet…at least on the automotive front.

Still, if Volvo Penta has read the cards right, progressive North American boaters will be at the vanguard when it comes to getting new-generation diesels out on the water. And while VP may have grabbed an early lead, it's a sure bet that other marine engine makers will be watching closely, and perhaps fast-tracking comparable products.