PROFILE

EURO VISION

A visit to Volvo Penta's on-water test facility reveals how, since building its first engine in 1907, the company maintains its focus on developing new marine engines and propulsion technologies.

Text and photographs by Steve D'Antonio (except where noted)

Above—Volvo Penta's on-water facility, located outside Gothenberg, Sweden, carries out year-round testing of a full range of products, using a variety of vessels in on-water and lab environments.

I took a seat in the helm chair and pushed the joystick to the right to move the boat off the dock, then twisted it to point the bow toward the mouth of the inlet. The boat dutifully complied with every command, as I, and anyone else in this industry, would expect it to.

While Volvo Penta didn't invent the joystick control for recreational vessels, it popularized the now-ubiquitous system released just over a decade ago. As I piloted the vessel, an *inboard* joystick model (more on page 63), among the rocky peninsulas and islets surrounding Volvo's on-water test facility at Krossholmen, Sweden, I thought back to my introduction to Volvo Penta when I was a young sterndrive mechanic hefting this manufacturer's beefy, seemingly overbuilt drives off and onto transoms. Back then, American engines, mostly Mercury, dominated my world. To my far less experienced gearhead mind, Volvo seemed alien; many of its manuals were multilingual and relied heavily on pictograms and translations, only augmented with drawings or photos.

Those judgments faded as I grew more experienced, and I developed a greater appreciation for the Swedish company's engineering and rugged designs. And with the addition of detailed descriptions, its manuals improved and are now among the best in the industry.

Fast-forward a couple of decades to when I traveled to Sweden to peek under the hood of Volvo's operations at its headquarters in Gothenburg, and to visit its famed on-water test facility and a nearby diesel-engine-manufacturing facility, in Vara (see the **sidebar** on page 61).

Early Engine

Volvo Penta dates back to 1868 and a mechanical shop and foundry, in Skövde, Sweden, that made a variety of metal products, such as cooking pots, stoves, boilers, brewery equipment, sawmill components, and agricultural implements. It introduced its first engine in 1907. Requiring two carburetors, the B1 was not a true compression-ignition diesel engine. The single-cylinder "paraffin" or diesel engine was started with gasoline and then switched to diesel or kerosene after it warmed up. Under the new name Pentaverken, the company began focusing on marine engines in 1916, extending its range to 2-, 3-, and 4-cylinder models.

Then came outboards. In 1922, it introduced the U2, one of Europe's early outboard motors, selling almost 8,000 through the remainder of the 1920s. With a few modifications and upgrades this engine remained in continuous production for the next 40 years. Pentaverken also manufactured four-stroke outboards as early as 1930.

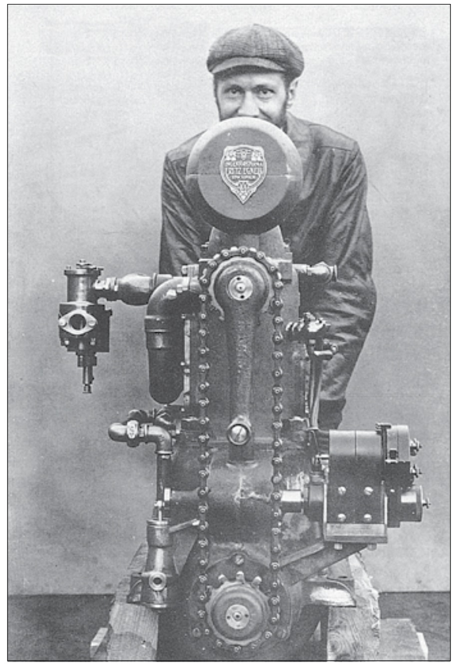
Concurrent with Pentaverken's rise, Assar Gabrielsson, the sales manager at Swedish bearing manufacturer Svenska Kullagerfabriken (SKF), and engineer Gustav Larson founded Volvo. In 1924, over a meal of crayfish in a Stockholm restaurant, they hatched the idea for a Swedish car that could endure the rigors of Scandinavia's rough roads and cold temperatures. With SKF's support, the first Volvo rolled off the production line in April 1927.

Pentaverken became the exclusive supplier of engines to Volvo until the automobile manufacturer took control of Pentaverken in 1935, relocating all Pentaverken sales and design to Volvo's home city of Gothenburg. Today, Volvo Penta is the marine and industrial engine division within the larger Volvo Group.

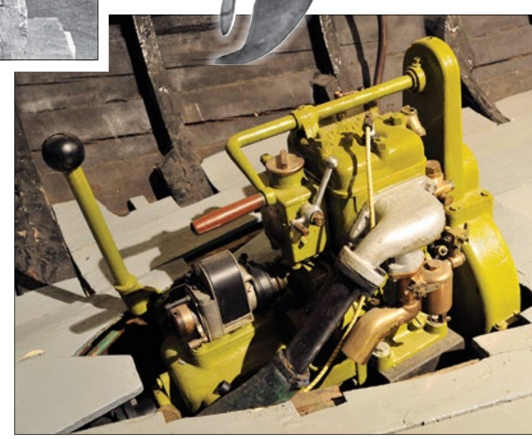
For the auto market, innovations included the Hesselman engine in 1935—one of the first multi-fuel engines that could run on gasoline, kerosene, and even heavy oil. The 6-cyl "crude-oil engine," as it was called, could idle on three cylinders, and was the first spark-ignition engine for automotive use that relied on direct injection of fuel into the cylinder.

After WWII, Volvo Penta manufactured its first true diesel engine, an in-line 6-cyl design noted for its comparatively quiet, smooth operation. Following that development, in 1949, Harald Wiklund became CEO. For the next 28 years he oversaw an unprecedented era of business growth and technological development.

PBB Read more about the Volvo name on ProBoat.com.



Introduced in 1922, the U2 was one of Europe's earliest outboards. With various upgrades and modifications, it would be produced for nearly four decades.



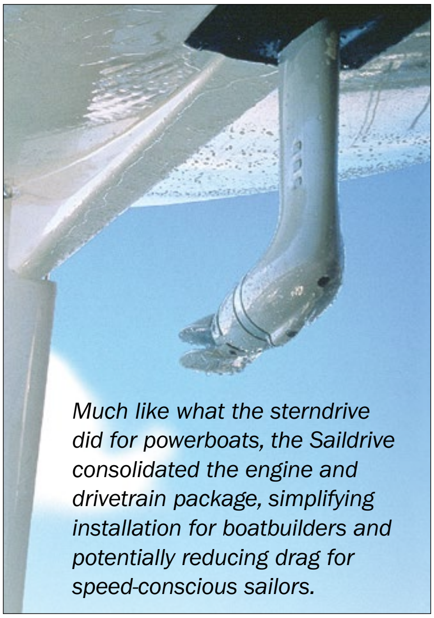
Above—*The Pentaverken B1 engine, with its designer, Edvard Hubendick, was more a multi-fuel engine than a true diesel; it was started on gasoline but then ran on kerosene or diesel.* ***Right***—*The MD1 would become a familiar fixture to many boat owners. Once the world's smallest direct-injection diesel, it included another innovation for the time, a reverse gear.*

From the MD1 to the IPS

In the 1950s, Volvo Penta's diesel innovations paralleled the rise of production-built boats. In 1954–56 came the world's first production turbocharged- and then turbocharged-intercooled-diesel engines. The MD1, the world's smallest direct-injection diesel, included a reverse gear, revolutionary for its time. In 1959 the company introduced one of the most profound changes in modern marine propulsion with the introduction of the Aquamatic sterndrive, a technology that altered how small powerboats, custom and production, were designed, built, and operated. Sales soared.

More Volvo Penta firsts followed. Introduced in 1971, the Saildrive remains extremely popular for dramatically simplifying sailboat propulsion systems and their installation. In 1982 Volvo introduced the DuoProp, a set of counterrotating propellers sharing the same shaft of its already popular Aquamatic sterndrives; this arrangement improved fuel economy and vessel handling, while eliminating the undesirable steering torque found in conventional single-propeller arrangements.

At that time, diesel engines suffered from performance issues; their sluggishness was notorious. The turbocharger improved performance but did little for off-the-line performance,

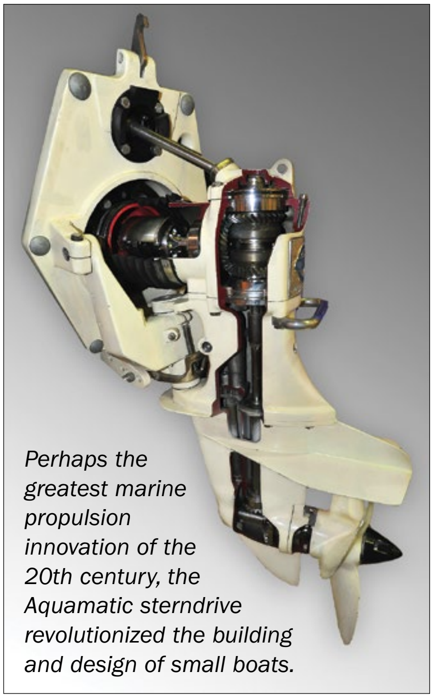


Much like what the sterndrive did for powerboats, the Saildrive consolidated the engine and drivetrain package, simplifying installation for boatbuilders and potentially reducing drag for speed-conscious sailors.

and "turbo-lag" persisted. Volvo overcame this problem by adding a belt-driven, clutch-operated supercharger to an otherwise conventional turbocharged diesel. The supercharger forced air into the engine in much the same way a turbo does; however, it worked when the engine was started and through its acceleration phase, where the turbo suffers from lag. Once the engine was up to speed, the supercharger's electromagnetic clutch disengaged, allowing the turbo to carry on adding power. (Though it sounds complicated, this is the same system used on automotive and marine air-conditioning and refrigeration compressors.) The Volvo KAMD super- and turbo-charged series engine was creative, relatively simple, and worked well. (See the Vara sidebar for more on this engine's development.)

Further improvements in diesel efficiency, performance, and fuel economy followed in 1991 with the EDC (electronic diesel control) system, the first dedicated electronically controlled diesel engine. Electronic control of engines and other automotive systems was a trend that had taken root by the late '80s and '90s. Volvo Penta capitalized on its association with the mother company, the Volvo Group—which manufactures technologically advanced automobiles, trucks, and stationary power-generation platforms—by integrating this technology into its marine-diesel and gasoline-engine lines. With more than 1.7 million units sold in the past 10 years the Volvo Group is among the top producers of heavy-duty diesel engines worldwide.

In 2005 Volvo Penta introduced the biggest thing in marine propulsion systems since the Aquamatic sterndrive. The IPS pod drive was the result of a five-year multimillion-dollar investment, drawing once again on the Volvo Group's advanced-technology sector. Next, Volvo introduced its joystick control system. Though joysticks were on Hinckley Picnic boats long before the Volvo version (see "Joystick Evolution," in PBB No. 146



Perhaps the greatest marine propulsion innovation of the 20th century, the Aquamatic sterndrive revolutionized the building and design of small boats.

and on ProBoat.com), Volvo pioneered its mass production, making it available to any boatbuilder who wanted to integrate it and IPS into its product. Today there's also a stand-alone

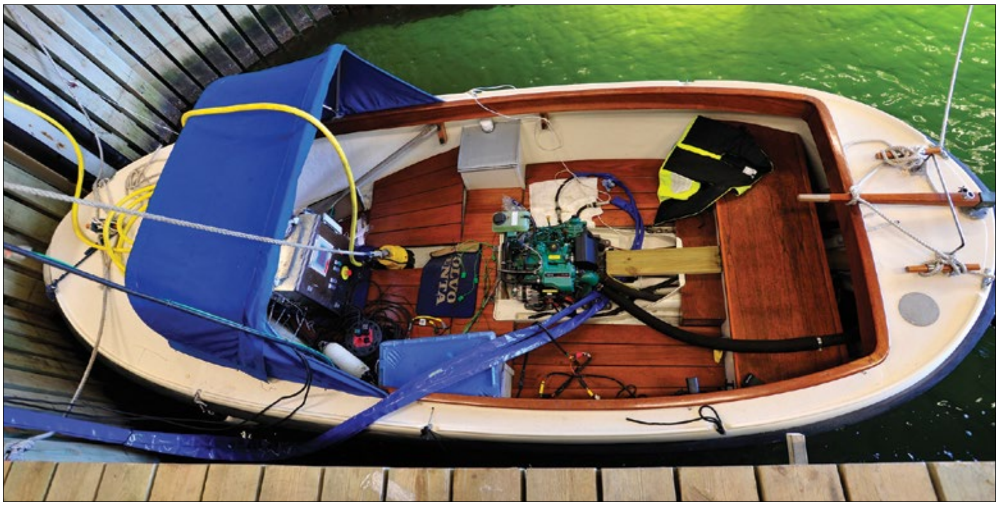
joystick-control system designed to be used with standard Volvo-drive systems (see page 63 for the test drives). The current high-output production version of the IPS is designed for vessels up to about 100′ (30m) with as many as four propulsion units.

No pod-drive manufacturer has yet matched the IPS's market penetration. To date, more than 20,000 IPS units have been sold worldwide. Most

Volvo Penta's theory that more people would buy boats if boat handling could be made as easy as driving a car was proved by the company's Joystick Maneuvering System.

recently, in early 2016 Volvo Penta introduced the IPS 800 and IPS 900 in two versions, coupled to D8-550 and D8-600 engines. Volvo's IPS numerical designation system rates equivalent (to an inboard engine) horsepower, taking into account the design's improved efficiency.

This sustained innovation and market success, decade after decade, is no accident; it's the result of consistent and substantial investment in research and development, and a commitment to efficient high-quality production. I managed a glimpse into how Volvo maintains the necessary creativity, standards, and momentum during my brief visit.



This "yo-yo" vessel is used to trial the durability of drivetrain shift mechanisms at Krossholmen, Volvo's waterfront testing facility.

Krossholmen Test Center

Krossholmen, Volvo's waterfront test facility, is about an hour north of Gothenburg. Despite its gate and security cameras, the facility is unassuming and slightly reminiscent of a New England boatyard, complete with cottages—former summer homes now used for conferences. The work carried out here is among Volvo Penta's most important, and secretive. During my visit, photos were prohibited in several areas.

Located on a peninsula at the mouth of the Göta älv River and opened in 1968, the Krossholmen Test Center operates year-round with large heated indoor work bays, a crane for launching small vessels and changing engines, a 70-ton lift, a fuel station (the facility averages 264 gal/1,000 liters of fuel per day), and ample dockage. Boat-handling equipment quickly moves vessels in and out of heated work areas to prevent freezing of systems. While winter temperatures are routinely well below freezing, according to facility director Johan Wästeräng, the water freezes only every third or fourth year; when that occurs, on-water testing is moved to ice-free fjords in Norway. On occasion he has had to rent an icebreaker to move larger vessels from the facility's basin to open water.

The primary goal of the facility is to thoroughly evaluate and prove Volvo products, from components, engines, sterndrives, and pods to electrical and electronic vessel-control systems and entire driveline packages, which will be marketed by boatbuilders using Volvo propulsion systems. Wästeräng said, "If it's going to fail, we will make it fail here."

The company's philosophy was not to push technology to the market simply for the sake of introducing new technology. "We try to spend time understanding what is the feature we'd like to deliver, how we support it and maintain it in a good way," said Johan Carlsson, senior vice president, head of R&D, and chief technology officer. "We try to take it step by step, and we're testing out a lot in our own laboratory. We have all the facilities we need to test how we operate this boat. Combining the technology development with the deep understanding of the boating needs of the user as well as the owner, I think that's what helps us pace innovation in a good way. When you see us launching something, we've also proofed it."

To accomplish this, the staff of 25 at Krossholmen, including six test engineers, manage upward of 35 vessels, the largest of which is 72′ (22m). The boats are a mix of late-model designs mostly from European manufacturers that used them for product demonstrations for press and boatbuilders. As well as rugged boats in both FRP and aluminum, test boats include a former sea rescue vessel, ones with enclosed helm stations, and smaller, simpler FRP vessels without cabins that Krossholmen staff call "mules." Wästeräng says he prefers the highest possible horsepower and drive combinations to maximize the strain placed on them, thereby revealing flaws and demonstrating the highest capabilities of every system or option.

The test vessels are repowered over and over again with successively newer Volvo power plants and drives. They

Krossholmen includes sophisticated indoor stand-alone test bays to run and monitor engines through a range of operating conditions. Waste heat is captured to warm the buildings.

run 10–12 hours per day during summer months, and five to six hours in winter. In a year, technicians and engineers put 5,000 or more hours and 40,000 nautical miles of run time on these boats. I encountered a "yo-yo" test boat, in which a Volvo powertrain is shifted—full forward, neutral, full reverse—several thousand times over the course of 200 hours, replicating a lifetime of shifting. Full-time 24-7 drivetrain testing is also carried out on boats inside work bays, where they can be monitored and noise kept to a minimum for neighbors (waste exhaust heat is scavenged from the engines to heat the buildings). Outside some buildings, various components, including instrumentation, shift and throttle controls, and plastic and metal parts, are left exposed to the elements. No photos of these were permitted.

The Krossholmen facility also supervises field tests, which Volvo utilizes in cooperation with customers whose boats accumulate a minimum of 1,500–2,000 hours per year, operated for one to two years—primarily commercial applications. Demonstration vessels are replaced periodically, and are sourced from manufacturers who intend to use the latest Volvo products.

While at Krossholmen I met with Carlsson and Bjorn Ingamenson, Volvo Penta's president. I inquired about service and support, subjects I'm passionate about, and shared some experiences I've had with Volvo through my career, including the challenge of finding well-trained dealers and technicians. Though this is now less of a problem, there remains room for further improvement. In addition, at one time many Volvo parts were hard to get, and suppliers showed little sense of urgency; that, too, has changed significantly for the better with Volvo's expanded supply network-and-distribution system.

"We have come a long way in the U.S. and in the surrounding countries, in South America and [Central] America," said Ingamenson. "And the reason for that is, when we saw the export of Italian boatbuilders and some of the other European boatbuilders, they had put a high demand on us, and they definitely told us that your service people are not educated enough, and your service point is not covering where our boats are. In the last three years, we have been putting together working groups from our European team and our American team to work together in order to improve this when it comes to competency but also when it comes to location."

In regard to electric propulsion, he said, "I think we will see in the future, Volvo Bus is the leader within the Volvo Group in this field, and they have purely electrified bus lines today, and one here in Gothenburg, and they're in other cities as well. I think the future will be very much into hybrids, where you go low speed on electric power, and then you turn it to diesel and high speed. So of course we are having tests and all that, but also we have to see the demands there, and the pricing of those types of products must be there before you can commercialize it. We follow it closely, and we know that technology is ready when the market is there, and we'll want to be one of the leaders."

These comments were a refreshing departure from the familiar sentiments the marine industry is accustomed to hearing. The company seems to understand what's involved in properly supporting exceptionally complex systems across an expansive dealer network.

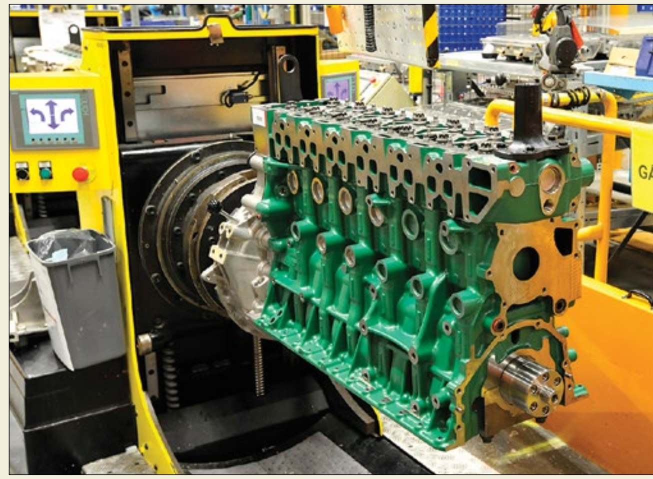
On-Water Testing

I spent an entire sunny spring day at Krossholmen testing a range of vessels: an Absolute 56, Atlantis 55, Cobalt 27, Cranchi 48 Atlantique, Four Winns 22, a Targa 44 (my personal favorite), and an XO 240. In addition to being crewed by knowledgeable captains and engineers, these boats were equipped with the full spectrum of Volvo products, including the new Volvo D8-550 and D8-600 IPS 800 and 900; D8-600 inboard; gasoline V8-300 and V8-350 Aquamatic sterndrive and Forward Drive (Volvo's new, for 2015, sterndrive with forward-facing propellers); Dynamic Positioning System (Volvo's station-keeping system for IPS drive systems); Interceptor System (a trim tab formerly known as Humphree, recently acquired by Volvo); EVC-E3 "eKey" (Volvo's Electronic Vessel Control System, which provides a common electronic platform that shares data via an automotive-like CAN bus network for trip computer and engine data via a chart plotter display); and


At Krossholmen, boatbuilders can run a range of late-model vessels, each equipped with different Volvo systems, giving potential clients an invaluable "try before you buy" experience.

VARA

Volvo Penta's Vara plant is a scenic hour-and-a-half drive northwest of Gothenburg in an agricultural district, and on the edge of a Viking archaeological site. It seems an unlikely location for a heavy-industry plant. The facility's manager, Tonny Tuveheim, explained that when it was founded in the 1970s, Sweden suffered a labor shortage: "Vara had no heavy industry at the time. The area is strictly agricultural land, and Volvo's thinking was that the farmers could be a good source of labor. The farmers are known to work quite hard. It's not an easy life; they always have problems on the farm which they must solve, and they are pretty stable. They don't move around, and they have no interest in going to urban areas; they don't shift jobs. So as a result we have a stable workforce here in Vara."

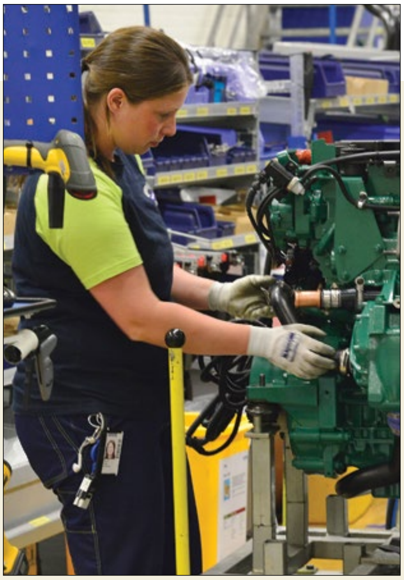

The world's smallest production diesel-engine-manufacturing plant, Vara is known for its efficiency and cost-effectiveness. Here, a D6 block undergoes finish machine work.

The plant's original plan to manufacture heavy-truck engines and light trucks barely came to fruition by the time the recession of the early '80s hit. Truck assembly was shelved, while engine production was established to build what became known as the series KAD30 and 40. Known as the "fence engine," it was developed by Lars Malmros of Volvo Truck Corporation and Harald Wiklund of Volvo Penta, who were neighbors and agreed during a discussion over the fence between their properties that a small 6-cylinder-diesel engine would serve both their interests—Malmros for his light trucks and Wiklund for the Aquamatic, which hitherto was available only with a gasoline power plant. From 1977 through 2002 Vara produced more than 250,000 of these engines in a range of variants, and they are acknowledged to be among Volvo Penta's most important engines, if not the most important.

Today, the 215,000-sq-ft (20,000m^2) plant produces approximately 5,000 engines per year, a total lifetime production of over 400,000, by a staff of just 215. Unlike competitors, who simply marinize existing engines, Vara, which is devoted to building marine engines, is the smallest complete-diesel-engine-manufacturing plant in the world and, Tuveheim pointed out, very efficient.

Efficiency is about more than just profits; if he can't demonstrate the cost-effectiveness of manufacturing engines here, in the relatively high-cost environment of Sweden, production will be shifted to other parts of the world where labor is less costly. Efficiency programs include Volvo Production System (VPS), the in-house "lean" manufacturing program; "First Time Through," a quality-control-measurement system; and a process for assembly that Tuveheim called "digital instructions."

"We have some 15,000 to 20,000 variables here on the 5,000 engines that we build per year, which makes them very difficult to assemble correctly, and most of the assembly is manual. It is, therefore, very difficult to assemble each engine the correct way, from the quality perspective, and to make sure that we do that, we have the recipe for the engines on screens, and just the ones that you need to know."



Originally sited in Sweden's farm country primarily to take advantage of the reliable workforce, the Vara plant remained operational throughout the recession, thanks in part to its savvy general manager.

Vara is the first Volvo manufacturing plant in Sweden to have achieved CO_2 neutrality, and it sells some of its waste, from metal shavings to cafeteria by-products.

While roaming the plant floor I noted a few differences from other engine-production facilities I've visited in the U.S. and abroad. In addition to being very clean, a given for most modern engine plants, it was also comparatively quiet. Ear protection is not required; and surprisingly, no one wears eye protection. Workstations have taken the place of the traditional assembly line. Engines remain in one place longer than in a traditional assembly line, so each worker carries out more tasks, essentially building almost an entire engine. I was certain this had something to do with job satisfaction and productivity; however, Tuveheim explained the setup was based on a study conducted by Sweden's National Health Service that found repetitive motion injuries were noticeably higher on an assembly line than in an environment where employees were doing more varied tasks.

One final notable difference: the food in the cafeteria included salmon and reindeer. Delicious!

—Steve D'Antonio

joystick maneuvering for pods as well as shaft drives (the latter includes integration of thrusters).

Of course, operating all these vessels, and returning to any vessel if I wished, made it possible to quickly evaluate the various control systems. In a comparison of joystick maneuvering for IPS pod drives versus conventional inboards, for instance, I found that while IPS drives have a well-earned reputation for extreme maneuverability, the shaft-drive version worked extremely well. From my perspective, the shaft-driven joystick system proved to be the most interesting and rewarding to pilot. Many boat buyers are under the impression that accessing the ease and operation of a joystick requires purchasing a boat with a pod drive. To a large degree that has been true, but the shaft joystick system changes this equation. A boatbuilder considering adopting any of these systems would be well served by spending time at Krossholmen.

Two products that debuted during my visit were the Volvo Battery Management System (BMS), a modular product designed to integrate, simplify, and automate a vessel's batteries, DC supply, and engine functions via a remote key fob; and Glass Cockpit, a collaboration with Garmin offering integrated flat-screen displays for navigation and driveline control. The common theme is an automobile-like experience. Boats are complex and getting more so each year, while users are becoming more accustomed to simplification in the interfaces with smartphones, computers, cars, and homes. In these apparently diverging trends Volvo Penta has identified an opportunity to simplify selection, installation, and operation, if not design, of its marine product range.

It's clear that a great deal of design and testing effort has gone into this program. Nevertheless, integration of electrical, navigation, and propulsion

Designed to be easy to install and operate, Volvo's Battery Management System gives boaters an experience similar to operating a luxury automobile, something the company knows more than a little about.

systems is an ambitious undertaking, especially in the limited—and thus, decidedly non-automotive-like—production environment of recreational yachts. However, the company was successful in making a similar transition of electronic engine control from the automotive and over-the-road truck worlds to marine applications,

Another goal with these systems is to offer one-stop shopping for boatbuilders, offering as much plug-and-play product as possible, with faster installation, lower cost, and claims of greater reliability compared to a complete driveline package. Indeed, the BMS greatly reduces the number of connections, battery switches, and length of cabling, and Volvo claims it's about the same cost as a similar conventional system.

Volvo Penta refers to this program as "Easy Boating." Using the BMS's eKey fob, for instance, a user can essentially turn on the boat's DC electrical system from 328′ (100m) away. With the press of a button, user-programmed systems are activated, not unlike starting a car and turning on its lights as you approach it—a commonplace technology today. On the water it's not old school yet, but neither is the next generation of boat owners. And, who better to understand and implement a system of this sort than an organization that has built hundreds of thousands of luxury automobiles, trucks, and buses? PBB

About the Author: *For many years a full-service yard manager, Steve now works with boat builders and owners and others in the industry as Steve D'Antonio Marine Consulting. He is an ABYC-certified Master Technician, and sits on that organization's Engine and Transmission, and Hull Piping Project Technical committees. He's also the technical editor of* Professional BoatBuilder.