# Power Trip

## A tour of MAN Engines' Nuremberg facility unveils the proficiency behind 250 years of mechanical innovation.

**Text and photographs by Steve D'Antonio**

"The manufacturer of the world's first diesel engine." It's a claim guaranteed to capture any gearhead's attention. It caught mine. I didn't find out about MAN's affiliation with Rudolf Diesel until I visited the company's facility in Nuremberg, Germany.

Hold that thought.

### Starting in Seattle

My introduction to MAN Engines started with a visit to its U.S. West Coast dealer, RDI Marine, through my work with Fleming Yachts (see "Fleming: An Asian Pacific Venture," *Professional BoatBuilder* No. 151). RDI opened its shop in the historic Ballard neighborhood of Seattle, Washington, in 1991, and cut its teeth supplying the highly competitive Alaska salmon gill-net fishing fleet and its professional mariners, who rely on high-power density engines. The season lasts only five to six weeks, so the pressure to perform is intense, and RDI leaves nothing to chance, stationing personnel with parts and tools in Naknek during the fishing season to support its customers.

The pressure cooker of salmon fishing prepared RDI for another market, one that also places emphasis on high horsepower and reliability in small packages: builders of planing recreational vessels. Bayliner, Offshore Yachts, Cabo Yachts, and West Bay all became regular RDI MAN Engines clients. In 2005, RDI supplied a pair of MAN 6-cylinder engines to Fleming Yachts, which used them to repower hull No. 1 of the 65 series. This was an experiment of sorts; hull No. 1 was owned by Tony Fleming, and he was unhappy with the noisy idling characteristics of the original engines. The repower was a success, and since that time, MAN Engines, through RDI, has powered every Fleming 58, 65, and 78 (17.7m, 19.8m, and 23.8m).

Yet another RDI speciality is what engine folks refer to as "in frame" rebuilds of MAN engines. The company averages 10 to 12 of these per

***Above**—The main engine-assembly hall at MAN Engines, in Nuremberg, Germany, is where all off-road models of MAN diesel and natural gas engines are assembled.*

year. In 2014, in addition to its full roster of domestic service and repairwork on marine, stationary, diesel, and natural gas engines, RDI personnel carried out rebuilds in Mexico, Okinawa, and on the Japanese mainland.

In an effort to ensure maximum reliability, RDI test-runs every new and rebuilt engine in its shop long before it ever gets near an engineroom. For new builds, RDI works with the builder before and during the installation to ensure it complies with MAN's and the builder's installation requirements. Finally, vessels are seatrialed with an RDI technician aboard, running the engine through its range of load and rpm, recording data, and confirming, once again, that it meets all the installation requirements. This is included in the sale price of the engine, and it's reviewed with boatbuilders at the time of sale.

***Above**—When MAN engines arrive at the company's dealer RDI Marine, in Seattle, Washington, they are carefully inspected before being prepared for finish painting. RDI prefers to paint in-house rather than ordering already-painted engines from the factory. **Left**—RDI will also partially disassemble and meticulously prepare the engines before installing custom gear and transmissions.*

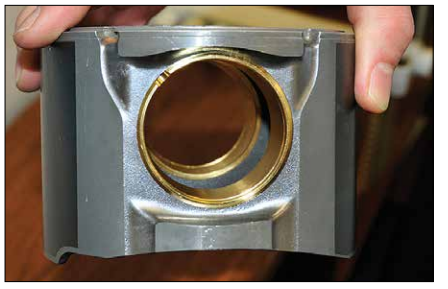
Besides RDI Marine, the RDI Group also comprises RDI Service and RDI Energy, which sells and services biogas- and natural-gas-powered gensets, all powered by MAN engines. That led to further expansion into servicing cranes and other MAN engine-powered industrial equipment.

As a former marine diesel mechanic, when I toured RDI's shop I couldn't ignore its prevailing features: operating-room-like cleanliness, focused technicians, and row upon row of new buff-colored (MAN Engines' primer color) engines. Brand-new engines were being partially disassembled and meticulously prepared, including the application of paint filler. The shop then installs custom gear such as brackets for alternators and remote filters, as well as transmissions. Rather than rely on the manufacturer, RDI prefers to paint in-house the engines it sells. All painting is to customer specifications, usually white but sometimes red, blue, or even British Racing Green. Those who purchase MAN engines from RDI have come to expect, among other things, their long-lasting paint finish.

Then there's the plethora of custom fixtures, brackets, mounts, and other hardware, most of which was machined and welded, some of it in-house. Thanks to Seattle's thriving aviation industry, a cadre of machine shops with available capacity is happy to make parts for firms like RDI, often during the night shift.

"We'll do pretty much what the owner requests if at all possible," said Brian Cook, who runs RDI with his wife and business partner, Janet. "We make all the engine and gear feet, mount the hydraulic pumps, extra electrics and alternators, fire/bilge pumps, raw-water dump pipes, fuel and hydraulic coolers, and we also keel-cool some engines [which requires custom-fabricated plumbing]. Basically, if it's possible, we'll do it."

Picking up a beautifully CNC-machined aluminum remote oil-filter housing, made locally to RDI's specifications, I let out a low whistle and said, "This is a work of art, and it must cost a fortune." I didn't record the price, but it seemed ridiculously low, a tenth of what I would have expected.



***Left**—Customization is an important part of RDI's business; it supplies a range of options, utilizing components made in-house or by Seattle's well-established machining and fabrication industry. **Above**—Only original-equipment MAN engine parts are used in RDI's rebuilds, a number of which the company performs each year.*

Cook, Klaus Schwientek, vice president of sales, and several other RDI staff have traveled to MAN Engine's facilities in Germany for training and product education; and they recommended I do the same. They made the introduction, and within weeks I had an invitation to visit MAN Engines' Nuremburg production facility.

## Touring the Nuremberg Facility

On the way to the company's main building, the industrial equivalent of a lawn ornament is impossible to miss. A massive replica of Rudolf Diesel's 1908 "MAN" diesel engine stands roughly 12′ (3.7m) tall, complete with huge flywheel, a reminder for visitors and employees alike of the company's roots and the role MAN Engines played in the development of the diesel engine.

The Nuremberg plant is an impressive spread, and neat as the proverbial pin. Established in 1841 as (in English) the Klett and Company Iron Foundry and Engineering Works, this site has been home to MAN Engines since 1897. Today, with a staff of 4,300 in this 1-million-plus square-foot (93,000m$^2$) location alone, MAN Engines refers to this entire facility as the International Competence Center for Engines (this probably sounds better in German). Its full description: "International competence center for the development, production, and sale of diesel and gas engines with a power spectrum from 37 kW to 1,324 kW [50 hp to 1,800 hp]."

All MAN's off-road models are assembled here, including straight 4- and 6-cylinder, V8, V10, and V12 diesels as well as gas (these are compressed natural and biogas rather than gasoline) engines for on-road, off-road, marine, and power-generation applications. Precision components such as cylinder heads are cast and machined at MAN's on-site foundry, while other casting is done elsewhere, with all assembly completed here. Clean and orderly are understatements in describing this shop floor, where employees wear traditional twill coveralls (much like those preferred by Rudolf Diesel himself), and during my visit none was dirty. Automated electric trolleys transport engines between assembly stations, while technicians attach components with cordless electric tools. The plant produces about 90,000 engines per year, using 8,700 tons of castings.


*For an assembly plant, it is uncharacteristically quiet and immaculate inside the company's 1-million-plus-square-foot (93,000m$^2$) Nuremberg facility.* ***Top—****Employees wear traditional twill coveralls, much like the ones from Rudolf Diesel's day.* ***Center—****Automated trollies move engines and parts to and from assembly stations.* ***Bottom—****At those stations, technicians attach components with cordless electric tools.*

In addition to assembling engines here, the Nuremberg facility also conducts advanced diesel research and development (a new R&D laboratory was opened in 2010, and a materials testing lab has been located here since 1996). Other divisions include engineering, design, alternative-fuel development, rail, agricultural, materials technology, and parts-supply management. On-site test cells and dynamometers are used to test current engines and new designs. In 2014, MAN Engines began producing its latest iteration of the ultralow-emissions D38 diesel engine. Currently employed for over-the-road trucks, it meets the latest and most stringent Euro 6 emission standards for nitrogen oxides and hydrocarbon emissions (see "Taking the Measure of Emissions," on page 40).

While the production building is impressive, the undisputed jewel of the Nuremberg plant is the MAN Engine Academy. I've been to scores of training facilities, and all the good ones are much the same: classrooms, blackboards, and PowerPoint projectors, along with static and running engines. The MAN Engine Academy has all this and more. My host, Florian Schaffelhofer (MAN's marketing person), and I were met at the door by one of the academy's "professors," who proudly showed us the facility, in recess during our visit.

Opened in 2012, the academy offers weeklong sessions in German and English for MAN staff, dealers, and customers. Subjects include the use of diagnostic tools and equipment, fault simulation, commissioning, maintenance, troubleshooting, repair and rebuilding, monitoring, and operation of training engines. Instructors can

## Early MAN

MAN, developing before and in the midst of the industrial revolution, seems never to have stood still. The firm's engineers were responsible for pioneering the first high-speed printing press, steam turbines, and one of the world's first monorails. MAN also built early steel railway bridges, considered advanced feats of structural design and engineering for the time (Müngsten railway bridge, at one time the highest in Europe, is still the highest in Germany).

*A replica of Rudolf Diesel's 1908 diesel engine outside the main building in Nuremberg is a reminder of the company's impressive history.*

Company history dates back to the mid-18th century, when Franz Ferdinand Domherr von Wenge founded the Ruhr region's first heavy industry, the St. Antony Ironworks. The company was renamed Gutehoffnungshütte Actienverein für Bergbau und Hüttenbetrieb, or Good Hope Ironworks for Mining and Steel Mill Operation, shortened to GHH, in 1873. From there, and through a number of mergers and acquisitions, the company took a circuitous path while continuing to grow and innovate. MAN was born in 1898 from the merger of Maschinenfabrik Augsburg AG and Eisengießerei und Maschinenfabrik Klett & Company, in Nuremberg, into Maschinenfabrik Augsburg-Nürnberg (M.A.N.) AG.

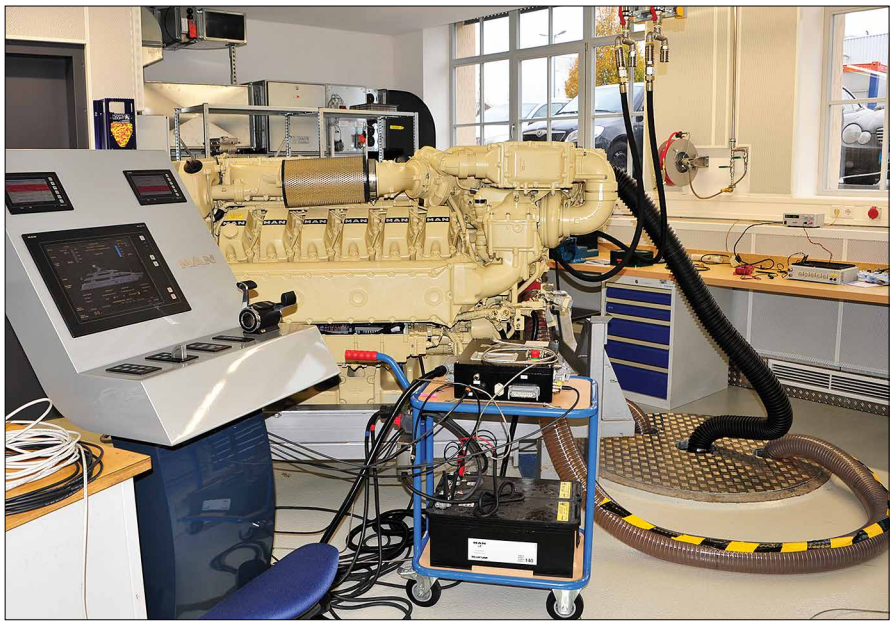
In this atmosphere of mechanical creativity and engineering was the workshop of, among many others, Rudolf Diesel, who developed the first practical diesel engine at the Augsburg Werks in 1895. The transition of Diesel's vision from drawing board to shop floor was initially unsuccessful, and there was also no shortage of detractors. Many experts of the day believed compression ignition simply wasn't possible with the current state of metallurgy. Heinrich von Buz, the managing director of Maschinenfabrik Augsburg, wasn't among them. One of the few who believed in Diesel's potential, he had the patience and nerve required to see the vision through. He agreed to finance what would become four years of research and improvement as the design underwent six iterations and ultimately paid off in spectacular fashion. The first commercial diesel engine, a 20-hp (15-kW) model, built by MAN predecessor Maschinenfabrik Augsburg, was installed in a matchstick factory in Kempten in 1898, the same year the merger produced MAN.

Remarkably, in 1912, just 14 years later, powered by twin 1,050-hp (788-kW) engines (they stood about 15′/4.6m tall and 30′/9.1m long), the 370′ motor ship *Selandia* was launched in Copenhagen, Denmark. Manufactured by Burmeister & Wain shipyards, it was the first *large* diesel cargo ship (there's significant debate about the claim to first successful *diesel-powered* merchant ship; however, many maritime historians agree *Selandia* has earned the title of first oceangoing motor-powered vessel). Closing the diesel loop, B&W was acquired by MAN, becoming MAN B&W Diesel A/S, part of MAN B&W Diesel Group in 1980. Today, half the world's cargo ships run MAN engines, and the MAN B&W division produces ship diesel engines of more than 100,000 hp (75,000 kW).

As a side note, in 1903 MAN produced its first "marine" diesels for German submarines. By 1911, the French navy was operating 60 diesel-powered submarines with French diesel engines, and many credit the French with the production and implementation of the first marine diesel engines. In this era, MAN built a series of four- and two-stroke engines for use in German and Dutch submarines.

Another milestone occurred in 1924, when MAN manufactured the first direct-injection, diesel-powered truck, creating significant fanfare, equivalent perhaps to the introduction of today's first hybrid vehicles.

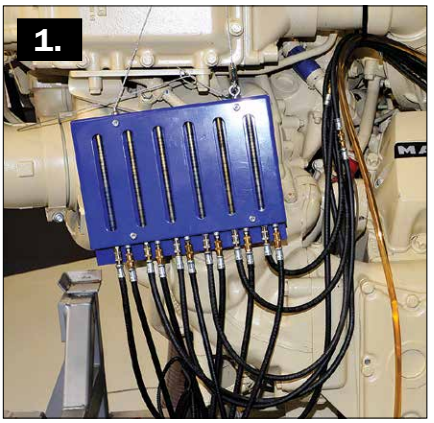
*—Steve D'Antonio*



*State-of-the-art education is the order of the day at the MAN Engine Academy. Subject matter covers all MAN engines from 12 liters to 24 liters, while classrooms include operational engines, as well as the latest test and monitoring equipment, including the MAN Monitoring and Diagnostic System for Marine Engines.*

induce faults and challenge students to find them with state-of-the-art training simulators, electronic whiteboards, and operational engines. The curriculum covers off-road, rail, power generation, natural and biogas, agricultural, and marine—for engines from 12 liters to 24 liters, R6, V8, and V12 blocks, including conventional mechanical injection and modern electronic common rail. MAN will tailor classes to a customer's needs as well as travel *to* the customer to provide training.

We stopped by a classroom with two fully operational, late-model engines, a V8 and a V12. These were wired to ECUs (electronic control units), shift and throttle controls, and full instrumentation, and plumbed to raw-water and exhaust systems, simulating what a technician would encounter aboard a vessel. It also included what MAN Engine Academy refers to as the MAN Monitoring and Diagnostic System for Marine Engines. This large board shows digital displays as well as the engine's entire electronic system, spread out over roughly a 4′ x 8′ (1.2m x 2.4m) panel, allowing students to trace systems, component by component, sensor by sensor, and






***1**—This fuel-injection diagnostic tool and other instrumentation hooked up to fully operational diesel engines at the MAN Academy allow students to simulate real-world conditions in a classroom environment. **2**—An instructor at the training center demonstrates the classroom Monitoring and Diagnostic System, which helps students troubleshoot MAN Engines using a field version of the program. **3**—A close-up of the monitoring equipment connected to one of the classroom diesel engines.*


*Actual marine engine displays are employed at the MAN Academy in teaching students how to access critical troubleshooting data.*

identify faults. We ran one engine and reviewed information as it was displayed on the interconnected displays. These engines are incredibly complex, as are all electronically controlled engines. The training facility drives home the point, and it embodies MAN Engines' commitment to training dealers and staff. As someone who works in this field daily, I know that one of the worst missteps a manufacturer can make is introducing an exceptionally complex product, regardless of how efficient or useful it may be, while giving short shrift to support, training, and education for its staff and dealer network. MAN Engines seems to understand this danger.

## High-Speed Systems

MAN offers a broad range of high-speed four-stroke diesel engines for commercial and recreational marine applications (MAN also manufactures larger slow-turning ship-propulsion plants through the Danish firm Burmeister and Wain, which it acquired in 1980 and coincidentally is the same firm credited with building the first large oceangoing diesel-powered ship in 1912). MAN offers an output range from 258 hp to 1,000 hp (195 kW to 750 kW) for heavy-duty applications requiring unlimited operating hours, and continuous full-load operation for tugboats, buoy tenders, and other work vessels. For medium-duty service (up to 4,000 hours per year, with full-load operation up to 50% operating time), such as ferries, fishing, and passenger vessels, the range runs from 400 hp to 1,400 hp (300 kW to 1,050 kW). And for light-recreational as well as lighter-duty commercial and municipal-use duty (up to 1,000 hours per year, with full-load operation not exceeding 20% of operating time), MAN's engine range includes straight 6-, V8-, V10-, and V12-cylinder engines providing 730 hp to 1,800 hp (548 kW to 1,350 kW).

All MAN Engines' recreational and commercial marine high-speed diesels

*A pair of MAN R6 800-hp (600-kW) engines supplied by RDI and installed aboard a 58' (17.7m) semi-planing recreational cruising vessel. MAN builds marine engines for the commercial- and pleasure-boat markets. Since the recession, the former has become an increasingly important, and more reliable, sector for the manufacturer.*

meet Tier III emissions requirements without resorting to after-treatment systems. Anticipating the upcoming Tier IV compliance requirements, MAN is researching after-treatment as a marine engine option. Its engines are rated to operate on up to 10% biodiesel; Germany is the largest consumer of biodiesel in the European Union.

On several occasions I've had boatbuilders and end users note MAN's oil-change requirements, some with skepticism and others with wonder. I inquired about this and received the official company line, which parallels the technical literature. Depending on the model, oil-change frequency ranges from 400 to 600 hours. That can be attractive for commercial operators, as well as long-distance recreational cruisers. I also posed the question to Brian Cook at RDI, and he emphasized the effect of high- versus low- or ultralow-sulfur diesel fuel on oil "health," with the

latter making these extended oil-change intervals more realistic. Cook also emphasized the importance of oil analysis when pushing up against the limits of these intervals (see "Lessons From the Oil Sump" in *Professional BoatBuilder* No. 143).

Time between overhauls, another subject I brought up with Cook and the staff at MAN, also varies from model to model, from a low of 5,000 hours for light-duty pleasure-craft applications, to 18,000 hours for heavy-duty commercial-application engines. RDI reports, again, 10,000–12,000 hours is typical for light-duty engines, and more than 20,000 is not unusual.

Features for marine engines include double-wall high-pressure fuel lines, individually removable cylinder heads, and wet-cylinder liners (making in situ rebuilds possible). Optional switchable fuel and oil filters can be replaced while the engine is running for critical applications. Turbo waste gates and variable and two-stage turbocharging, and free-floating turbocharger turbines are also available. All marine engines can be built to meet common classification society rules. ECUs in marine engines are based on those used in MAN on- and off-road applications, an area in which the company has extensive experience and high production numbers, making the engines exceptionally reliable.

Paralleling what I learned at RDI, MAN dealers offer inspections after engine installation, and certification to ensure that engines comply with installation requirements. Although most engine manufacturers offer inspections, MAN Engines' representatives at the MAN Academy placed an exceptionally high value on the practice. I got the impression they consider it nearly mandatory, and understandably so. I routinely see new-engine installations that violate a range of manufacturer installation protocols, jeopardizing engine performance, reliability, and warranty coverage—scenarios made less likely with inspections.

When I asked about examples of recent commercial marine engine installations (I saw the yacht and fishing side at RDI), I was shown a series of applications: a 140′ (43m) 570-ton buoy tender with twin 760-hp (570-kW) D2842 LE412 V12 engines on the Weser River in Bremerhaven; a 65′ (20m), 28-ton, 25-knot aluminum vessel equipped with twin 750-hp (563-kW) D2848 LE422 V8s for Austrian police patrol on Lake Constance; and an Alaska-based 155′ (47m) 14-knot landing craft powered by twin 900-hp (675-kW) D2862 LE424 V12s. Each of these applications is demanding in its own way, for load, duration, and reliability, yet they all rely on different power plants tailored to a specific use.

Having produced more than 4.5 million injectors, MAN's diesel experience runs deep. Its 53,000 employees work from 13 locations in Germany (Nuremberg, Munich, Salzgitter, Plauen), Mexico, Brazil, South Africa, Poland, Russia, Turkey, China, and India. When I asked my host how many diesel engines MAN had produced, he looked puzzled. "This year?" he asked. "No," I said, "in total,


*The Alaska salmon fishery, where customers demand high horsepower, superior support, and reliability in vessels like the one shown here, is a market RDI has aggressively pursued.*

from the beginning of MAN time." His eyebrows shot up, and he said, "I have to check." I have asked a few more times since my visit, and ultimately the answer I received was, "Too many to count." The most specific was, "Several million over the last decades."

After completing my review of the MAN Academy, my host and I left the building and returned to our car, where we found a note taped to the driver's side window, in German, of course. I assumed we'd parked in a restricted area. In fact, the note pointed out a mechanical deficiency—one of the vehicle's wheels was missing a lug nut. For an instant I pondered whether this was a brilliant piece of MAN showmanship, exhibiting to the press the staff's attention to detail. I quickly concluded that it was genuine; the folks here really do pay close attention to all things mechanical. 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 the technical editor of* Professional BoatBuilder*, and is writing a book on marine systems, to be published by McGraw-Hill/International Marine.*