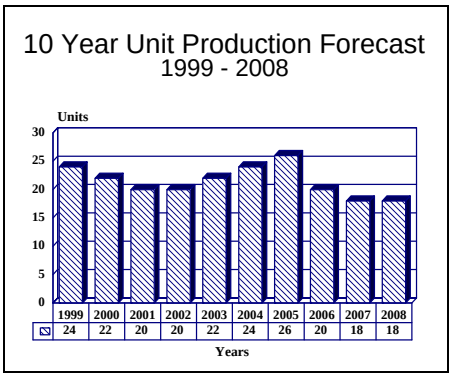
SEMT-Pielstick Diesels - Archived 12/2000

Outlook

- Bidding for US Coast Guard Deepwater Platform, spec'd for LPDs
- Strong reputation in naval and civil applications worldwide
- Solid sales expected to continue with buoyant surface ship market
- One of the flagbearers in the diesel market; despite growth in turbines, both types will continue to co-exist



Orientation

Description. Medium- and high-speed diesel engines for marine use.

Sponsor

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Company activities are located at three sites in France: Saint-Denis (Paris), Saint-Nazaire, and Saint-Germain.

Licensees. A notable feature of the company's marketing strategy is the granting of licenses to engine manufacturers around the world. In the naval field these include the following companies:

Blohm + Voss	Germany
Coltec Industries – Fairbanks Morse Engine	US
Diesel United, Niigata Engineering and NKK	Japan
Korea Heavy Industries & Construction	South Korea
Kirloskar Oil Engines	India
NEI-Crossley	Britain

Status. Production and service.

Total Produced. The grand total for all SEMT-Pielstick engines delivered presumably amounted to more than 14,000 units in 1998, with a total of 39 million kW in combined output. Of that figure, 1,360 engines were said to be in maritime service with 40 navies worldwide. In 1997, that comprised 550 warships.

However, that figure is believed to also include older engines of families other than PA and PC. In spring 1998, it was estimated that 275 of the PA6 range alone were in use on the ships of 12 navies worldwide.

Application. The SEMT-Pielstick engines are used as the main propulsion plant on all types of naval and Coast Guard surface ships as well as submarines, either independently or as part of combined systems incorporating gas turbines (in CODAD, CODAG or CODOG configurations).

Platform. SEMT-Pielstick diesels have been used, either on their own or as part of a larger machinery layout, in all types of surface ships, including destroyers, frigates, patrol vessels, amphibious warfare ships, oilers and under way replenishment vessels as well as submarines and cutters.

Price Range. Due to the manufacturer's very broad scope of products even in the two program groups concerned, it is difficult to place an average unit price for a diesel engine of either PA or PC series.

However, a typical cost of a naval diesel in this category can be stated as roughly US$750,000, including a service contract for technical support, spares supply and maintenance expertise. Once again, though, this price has been chosen only for the purpose of establishing a baseline, not representing an average or median price for these product classes.

Technical Data

(The following characteristics apply to the PA6-280 series engines, these being taken as representative of the latest generation of the company's products.)

Specifications

Number of cylinders:	12, 16, 18 or 20
Cylinder configuration:	In line or V; max 6 cylinders per line
Continuous rating:	295-440 kW/cylinder
Speed:	1,050 rpm

	Metric	**US**
Dimensions		
Bore:	280 mm	11.0 in
Stroke:	290 mm	11.4 in
Swept volume:	17.8 l/cylinder	1,086 cu in/cylinder
Weight:	14-37 tonnes	13.7-36.4 tons

Design Features. In a typical installation, the two engines on each shaft are in one compartment, mounted rigidly on a resiliently suspended common bed. The reduction gearbox is also rigidly mounted on the same bed. This rafting solution reduces noise emissions and vibration transmitted to the ship's structure. Where the mission profile requires long runs at low output, one engine is declutched and the ship proceeds using only one engine per shaft.

Operational Characteristics. To meet the long-range/low-power requirement while saving fuel through the high efficiency of a new type of turbocharger, SEMT-Pielstick developed for its PA6 STC (sequential turbocharging) model an air-charging system using one or two turbochargers, depending on the output required from the motor. Only one turbocharger is used for up to 60 percent of the maximum power of the engine, while two are used for 60 percent up to 110 percent (corresponding to an hourly overload of 4,270 kW).

The STC system increases the operating range of the diesel at slow and intermediate speeds, allowing the controllable-pitch propeller to be driven at its the normal pitch setting through most of the range. This also helps achieve increased efficiency and reduced underwater noise.

Variants/Upgrades

The PC range of medium-speed engines includes the following two types:

PC2-400. These engines are rated from 3,300 to 12,600 kW (4,490 to 17,136 hp), with engine speeds from 500 to 530 rpm. The PC2 range has a cylinder bore of 400 mm. This type is offered in two versions:

- PC2-6-400: 550 kW (747 hp)/cylinder
- PC2-6B-400: 630 kW (857 hp)/cylinder (500 mm stroke, 6-18 cylinders; a major innovation is the use of cast-iron)

This series is widely used in heavier combat ships, landing ships, refueling tankers and other vessels, where

the power requirement is generally from 6,600 to 15,000 kW, with engine speeds of 520-600 rpm.

PC4-570. The PC4 line is particularly suited for refueling tankers, with outputs from 12,150 to 23,850 kW and engine speeds generally at 400-430 rpm. This engine type is used by the US Navy on its series of 20 T-AO refueling tankers and five T-AKR fast Military Sealift Command Ships. These engines are rated from 6,625 to 23,400 kW (9,000 to 31,825 hp), with engine speeds from 360 to 430 rpm. They are offered in three versions:

- PC4-2-570: 1,215 kW (1,650 hp)/cylinder
- PC4-2B-570: 1,300 kW (1,768 hp)/cylinder (430 rpm, 570 mm bore, 660 mm stroke, 10-18 cylinders)
- PC40 L570: 1,325 kW (1,800 hp)/cylinder

The PA range of high-speed engines is suited for submarine applications, having been optimized for snorkeling mode operation. This features the use of a compound supercharging system with a low-pressure air centrifuge compressor which is driven by a turbine. The turbine receives its rotating power from the exhaust gases. The system also comprises a high-pressure air compressor which is driven by the engine.

The PA range includes the following types:

PA4-185. These engines are rated from 590 to 2,215 kW (800 to 3,000 hp), with engine speeds of 1,200 to 1,500 rpm.

PA4-200. These engines are rated from 1,060 to 2,650 kW (1,440 to 3,600 hp), with engine speeds of 1,200 to 1,500 rpm.

Both PA4 types feature a variable geometry combustion chamber. According to the manufacturer, a total of 180 of these types are at use on 92 submarines in France, the Netherlands, Pakistan, Portugal, South Africa, Spain and Sweden.

PA5-255. These engines are rated from 1,050 to 3,960 kW (1,430 to 5,385 hp), with engine speeds of 900 to 1,000 rpm.

PA6-280. These engines are rated from 1,745 to 7,920 kW (2,375 to 11,000 hp), with engine speeds of 720 to 1,500 rpm and a cylinder bore of 280 mm. These engines are used in CODAD, CODAG and CODOG configurations. The following sub-versions are available:

- CL: a long-stroke version
- BTC: low-compression version
- B: a higher-performance version

Low-pollutant-emissions versions of all engines are available through special matching, according to the manufacturer. Many of these engines are favored by operators of frigates, corvettes and OPVs, with power requirements between 3850 and 8100 kW, at 1,050 rpm. These include the La Fayette class of France; its close relative, the Sawari II class in Saudi Arabia; Bangladesh's new Ulsan class frigate; and a number of other similar platforms (see **Worldwide Distribution**).

STC. Sequential turbocharging feature for the PA6 engine, using a single supercharger for up to 50 percent of load and using the second supercharger only for the higher end of the load.

STC improves engine performance at low loads, offering more running flexibility at every load and enabling the engine top run at low load for long periods without fouling of cylinders. It also cuts fuel consumption and smoke emissions while improving transient performance ratings. The Colt-Pielstick PC2-5 dual-fuel configuration offers low emissions and high efficiency, meeting modern requirements for little pollution and use of energy resources.

Program Review

Background. In 1947, French diesel manufacturers formed a consortium known as Societé d'Etudes de Machines Thermiques (SEMT). The most promising line of development proved to be the Pielstick series, based on German technology available as war reparations, and therefore costing nothing to acquire. Subsequently, SEMT-Pielstick became the Engine Division of shipbuilder Chantiers de l'Atlantique, but the company is now part of the MTU-MAN group.

A typical product of the group is the two-shaft sets of four diesels, used to power the six Floréal class patrol frigates in a Combined Diesel and Diesel (CODAD) arrangement. Their required output was relatively low, and thus the 6PA6L (1,620 kW at 1,000 rpm) was chosen. This has a considerable logistic advantage, sharing many parts with the 16PA6V line, which has been used for some years as the cruise propulsion unit in the seven George Leygues class frigates. If the supercharged PA6 BTC units in the two Cassard class

air defense destroyers (DDGs) are included, the French navy has 60 PA6 units at sea or on order.

The propulsion of the La Fayette class light frigates, also twin-shaft CODAD, consists of four 12PA6 V280 diesels (3,880 kW at 1,050 rpm). The first three of the class have been commissioned and a fourth was launched in May 1997, with commissioning due in December 1999. The fifth and the last of the series will be launched in March 1998, with an estimated commission date in 2002. The installation is similar to that of the two Cassard class destroyers.

The French navy also ordered a missile trials and range telemetry ship, to be used by the Rockets and Missiles Directorate of the Delegation Générale pour l'Armament. The FS *Monge* was completed late in 1992, following sea trials and installation of its tracking and measurement systems. It has a single-shaft controllable-pitch propeller driven by two medium-speed 8PC2.5L diesels (3,825 kW at 520 rpm). Many of the components are identical to the 16PC2.5V diesels in the five Durance class oilers. The ship also needs a high output of electrical power for its mission. This is supplied by six 60 Hz generating sets driven by 6PA6L280 engines (1,280 kW at 900 rpm).

The nuclear attack submarines (SSNs) of the Rubis class are fitted with an emergency get home 450 kW generating set powered by a single 8PA4V185SM diesel. While this class was under construction, work started on a new class of strategic missile submarines (SSBNs) known as the Triomphant class. Being much larger, their emergency power requirements were met by two emergency generating sets powered by one 8PA4V200SM diesel. Within the same dimensions, this unit develops an output of 500 kW.

The Walrus class submarines, now in service with the Royal Netherlands Navy, are powered by a diesel-electric propulsion system comprising three generating sets, each powered by a 12PA4V200SM set developing 960 kW.

The Canadian navy Halifax class frigates have a Combined Diesel or Gas turbine (CODOG) propulsion system which uses a single 20PA6V280 diesel (maximum continuous rating 6,480 kW at 1,050 rpm) for cruising. Output is split on the two controllable-pitch propellers through a mechanical drive. These ships recently experienced problems regarding cracking of their diesel engine mounts.

The Indian navy and coast guard have both decided to continue using PA6 series diesels for new construction. The last two of the eight Khukri class corvettes are under construction, driven by two 18PA6 V280 engines (5,300 kW each). Seven Sukanya class offshore patrol vessels (OPVs) and three Samar class Coast Guard patrol vessels have been delivered. These ships are propelled by two 16PA6V280 diesels (4,700 kW) each, as are the nine coast guard OPVs of the Vikram class, built in 1979-1992. The first 40 diesels for these three groups of ships were made in France by SEMT-Pielstick, but the rest of the order is being completed by the company's Indian licensee Kirloskar Oil Engines Ltd.

The Indian navy has also redesigned the engine room configuration of its Tarantul class FAC-M to a triple-screwed configuration with diesels driving the outer shafts. This program has been delayed due to fiscal problems. However, similar modifications have been proposed by other operators of Tarantul and the older Osa classes as a way of extending the operational life of those craft.

Japan's Maritime Safety Agency uses a range of SEMT-Pielstick engines for its patrol vessels. The PC2.5V400 (7,645 kW) is used in the HIJMS *Shikishima* (16-cylinder version), the two Mizuho class vessels (14-cylinder version), and the eight Soya class and two Izu class vessels (12-cylinder version). In addition, a new class of patrol boats is driven by one 12PA4V200VGA unit and two 16PA4V200VGAs, all made under license by Niigata.

The Republic of Korea's Navy (RoKN) switched to SEMT-Pielstick diesels in the late 1980s, starting with the first of two Chun Jee class replenishment ships laid down in 1989 and delivered in 1990, and two tank landing ships ordered in 1990. The *Chun Jee* is driven by two-shaft 12PC2.5V400 diesels (5,750 kW), while the new LSTs have two-shaft 16PA6V280 units (4,700 kW). These engines are made locally under license by Korean Heavy Industry Company (KHIC) and Hyundai Heavy Industry's Engine and Machinery Division (HHIEMD).

The Royal Navy has built two large replenishment ships (AORs), the Fort Victoria class RFAs. They are propelled by two 16PC2.6V400 diesels, one coupled to each shaft (8,800 kW each at 520 rpm). These 85 tonne units are manufactured under license by NEI APE Crossley Engines, part of the Rolls-Royce Group.

The five Peacock class patrol vessels built for Hong Kong in the early 1980s were driven by twin-shaft 18PA6V280 diesels. Nine oilers of the Royal Fleet Auxiliary were engined by Crossley-Pielstick diesels, the Leaf class with two 14PC2.2V400s, and the five Rover class reengined with two Crossley-Pielstick 16PA4185s. The Irish navy has two of the former Peacock class patrol vessels bought from Britain, with the three others being sold to the Philippines.

Additionally, Ireland has three of the Deirdre class OPVs driven by twin 6PA6V280s.

The US Navy built nine transport oilers (AOTs) in the early 1970s, propelled by two 14PC2V400 diesels coupled to a single shaft. The 18 Henry J Kaiser class large oilers (AOs), built since the early 1980s, are driven by two 10PC4.2V400 units (12,150 kW each at 400 rpm). Eight Whidbey Island (LSD-41) class dock landing ships (LSDs) have been commissioned since 1985, and the four slightly modified Harper's Ferry (LSD-49) class are also in service. They are all propelled by four 16PC2.5V400 units (7,650 kW at 520 rpm) coupled to two shafts. Like the PC4 diesels in the oilers, they were manufactured locally under license by Coltec Industries.

One of the biggest export successes for SEMT-Pielstick was acceptance by the Chinese People's Army-Navy (PLAN) in the mid-1960s. The Type 065 Jiangnan class frigates (1965-68) were driven by two 12PA6V280 units. The same units were selected for the 29 Type 053 Jianghu design, built since the mid-1970s, the Type 053K Jiangdong class, and the latest design, designated Jiangwei by Western intelligence.

Two of the former Federal Republic of Yugoslavia's Split class frigates have two-shaft CODAG plants, with twin 12PA6V280 diesels providing cruise drive. These ships are now in Serbian service but are not thought to be operational. They are therefore not included in this report's **Worldwide Distribution** section.

Oman specified the SEMT-Pielstick diesels for all its recent construction, including the two Project Muheet class corvettes (two Crossley-built 16PA6 V280-STC engines each) and three Project Mawj OPVs (2 SEMT-Pielstick 16PA4 V200 each).

SEMT-Pielstick is one of the major players in the maritime diesel market and is expected to remain so, despite the corporate reorganization of the field and the periodic predictions that diesel engines will be extinct and will be replaced by gas turbines, much like in aircraft. In the long term, however, it is unlikely that gas turbines will take the place of diesels across the board. Although gas turbines do offer much greater power in proportion to their weight and volume demands, have lower manning requirements and, in theory, lower maintenance demands, these merits are offset by less tangible limitations for many markets.

Many navies are limited in their technical infrastructure and engineering capability. Diesels can draw upon skills readily available from the civilian sector, while gas turbines cannot. Spares for naval diesels can be produced from civilian plants designed, for example, for truck production. These sources are not available for gas turbines.

Finally, gas turbines are relatively fuel-thirsty compared to diesel engines. Admittedly, this gap is closing and skillful ship handling can dramatically reduce the fuel consumption of gas turbines, but the difference is still significant. This translates directly to ship operating costs and thus to days-at-sea. For a navy tasked with protecting maritime economic assets, this factor is critical.

SEMT-Pielstick is reportedly bidding for the US Coast Guard's deep water capability replacement project. The offer will concentrate around the PA6 and PA6B models, of which about 275 engines have been sold to 12 navies. It remains to be seen whether the USCG takes up this offer, since the Navy is seriously discussing going over to a fully electric fleet in the future. This would mean that the prime mover would be an electric motor, powered by either a gas turbine or diesel engine-propelled generator. The PC2.5 Pielstick diesel is already being installed on the San Antonio class LPD-17 ships of the USN, with the first one being launched in 2001. It is not yet known whether all the ships of the series will be powered by these diesels or whether all-electric propulsion will be applied on the future copies.

Funding

In principle, the engines are developed through private corporate funding. In many instances, however, the government does provide support for the R&D work, albeit in indirect form.

Recent Contracts

Contractor	Award ($ Millions)	Date/Description
Avondale Industries	12	Four engines for LPD-18, under subcontract to Coltec Industries Fairbanks Morse Engine Division. Includes options for over $100 million through 2006.
Chantiers de l'Atlantique	N/A	*September 1999* — Eight engines for Morocco's two Floréal class frigates, with deliveries in August 2000 and January 2001.

Additionally, a number of other contracts are won by the company on a regular basis, with some of the most notable ones including that for 12 engines of the 16PA6 STC type for Saudi Arabia's Sawari II (La Fayette) frigate program, and one for four 12PA6 STCs for Bangladesh's new Ulsan-derivative frigate being built by Daewoo in Korea.

The PC2.5 STC type has been selected by the US Navy for its new LPD-17 San Antonio class landing ship platform, with four engines on each. The first two of these ships are under construction.

One other recent contract announcement is that by the US Navy to buy the 10PC4.2 V570 engine for the propulsion source on the 20 T-AO refueling tankers and for five T-AKR fast Military Sealift Command Ships.

Timetable

Month	Year	Major Development
	1979	French order for Cassard destroyers
	1979	Ordered by India for Vikram OPVs
Jun	1981	Ordered by UK (Hong Kong) for Peacock OPV
	1982	Ordered by Saudi Arabia for F-2000 frigates
Jun	1983	Canadian order for 1st Batch Halifax frigates
Mar	1987	Indian order for Sukanya OPVs
Dec	1987	Canadian order for 2nd batch of Halifax frigates
	1988	French order for first group of La Fayette frigates
	1989	South Korea specifies SEMT Pielstick
	1989	French order for first two Floréal frigates
	1990	French order for second pair of Floréal frigates
	1991	French order for third pair of Floréal frigates
	1992	French order for second group La Fayette frigates
	1993	Omani order to equip corvettes and OPVs
Jun	1995	Additional French orders for La Fayette class
Sep	1999	Order for powering Morocco's two Floreal class frigates
	2000	Delivery of four engines for LPD-18 scheduled
	2001	Lead ship of LPD-17 San Antonio class to be launched

Worldwide Distribution

Canada: *20PA6 V280* (12 units on 12 Halifax class frigates)

China: *12PA6 V280 BTC* (72 units on five Type 065 frigates, 29 Type 053 frigates and two Type 053K frigates)

France: *16PA6 V280* (14 units on seven Georges Leygues class frigates); *18PA6 V280 BTC* (eight units for two Cassard (C70A/A) class destroyers); *12PC2 V400* (30 units on 15 d'Estienne d'Orves class frigates); *12PA6 V280 BTC* (two units for *Cdt l'Herminier* of the same class); *12PA6 V280 STC* (20 units on five La Fayette class frigates; *6PA6 L280* (24 units for six Floréal class); *8PA4 V200* (four units on two le Triomphant class ballistic

missile submarines, with two more to be launched); *8PA4 V185 SM* (six units on three l'Inflexible class SSBN, six units on six Rubis Amethyste class SSN); *16PA4 V185 VG* (six on three Agosta class SSK); *12PA1* (four units on two Daphné class SSK); *12PA4 V185* (four units on two other Daphné class SSK); *8PC2.5 L400* (two units on trials ship FS *Monge*); *16PC2.5 V400* (four units on two Foudre class LSD)

India: *16PA6 V280* (18 units on nine Indian Coast Guard Vikram class OPV; six units on Samar class OPV; 14 units on the navy's seven Sukanya class OPVs); *18PA6 V280* (16 units on eight Khukri class corvettes); *12PA6 V280* (four on two Magar class LSTs, with one more ship to follow)

Ireland: *18PA6 V280* (four units on two Peacock class PG); *6PA6 L280* (six units on three Deirdre class patrol vessels)

Morocco: *6PA6 L280* (est.; eight units for two Floréal class frigates)

Oman: *16PA6 V280 STC* (eight units on two Qahir class corvettes)

Philippines: *18PA6 V280* (six units on three ex-UK Peacock class patrol craft)

Saudi Arabia: *16PA6 V280 BTC* (16 units on four Al Madina class frigates); *12PA6 V280 STC* (four units going on two La Fayette class frigates)

South Korea: *16PA6 V280* (six units on three Chun Jee class AOR; four units on two Alligator class LSTs; *12PA6 V280* (18 units on three Mazinger class and six Sea Dragon/Whale class patrol craft)

Taiwan: *12PA6 V280 STC* (24 units on six La Fayette class frigates)

UK: *16PC2.6 V400* (two units on Ocean class LPH; four units on 2 Fort Victoria class AOR); *16PA4 185* (six units on three Rover class AOL); *14PC2.2 V400* (six units on three Appleleaf class AOT)

US: *10PC4.2 V570* (36 units on 18 Henry J Kaiser class oilers originally built – some transferred overseas; up to 48 units going on the 12 new Bob Hope class AKR); *16PC2.5 V400* (48 units on LSD-41 Whidbey Island and LSD-49 Harper's Ferry class dock landing ships; four units each on the LPD-17 San Antonio class landing ship platforms)

Forecast Rationale

The warship construction market slowed down for a few years after the end of the Cold War. However, now that the "honeymoon is over" and the navies worldwide are adapting to the new world order, diesel still remains the main form of naval propulsion. In fact, diesels are ideal for the ships likely to be built for the up-and-coming navies of the future.

Momentarily, the aftermath of the economic crash in Asia is still having an impact on defense investments there, but once the situation rebounds and begins to show sufficient signs of improvement, many of the nations in that region will need to re-up their defenses. Much of that will be based on procurement of ships propelled by diesel engines, which represent a known entity that is commonly serviceable, have wider tolerances than gas turbines and operate more efficiently over a wider power band than gas turbines, which are more geared for optimal performance in a narrow band only.

SEMT-Pielstick is in a relatively placid, well-defined market sector and enjoys a tremendously strong reputation in marine diesel engines. Its product line is also manufactured by a number of licensed producers around the world, which in themselves are already established brands with strong reputation. This makes distribution and marketing substantially easier, compared to a brand that would have to convince the market of its technical superiority and at the same time establish financial credibility. In short, SEMT has reached a level of world penetration that makes it one of the few "mega-brands" in the market. This is perhaps best illustrated by the degree of stability indicated in this report and the attached forecast.

The production figures indicated are estimates of what can be reasonably expected given the level of activity in both naval and civilian markets in Europe and North America at the moment. The pickup in Asia is expected to support the bullish outlook in the later years of the forecast window.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

			High Confidence Level			Good Confidence Level				Speculative			
Designation	**System**	**Thru 98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**Total 99-08**
SEMT-PIELSTICK DIESELS	MARINE ENGINES TYPE PA/PC (VARIOUS USERS)	510	24	22	20	20	22	24	26	20	18	18	214