PW Power Systems ST18/ST40

Outlook

- Sales over last 20 years marginal
- Majority sold for Norwegian Skjold class of six ships
- No future prospects discernable at this time

Orientation

Description. Multishaft, axial-centrifugal-flow, aeroderivative industrial and marine gas turbine machines in the 2- to 4-MW class.

Sponsor. The ST18A and ST40 were privately developed by the prime contractor.

Power Class. The power output of the ST18A is 1,961 kW; the power output of the ST40 is 4,039 kW.

Status. Available for production

Total Produced. At the start of 2015, approximately 30 machines had been produced.

Application. The ST18A/ST40 gas turbine machines have been made available for electrical generation (including cogeneration), mechanical load drives, and marine propulsion/power. One machine is being used for train propulsion/drive.

Price Range. For marine propulsion, $1.3 million for an ST18A gas turbine and $2.2 million for an ST40 gas turbine.

Competition. In the marine power market, competition for the ST18/ST40, at 4,000-5,100 hp, comes from the Rolls-Royce MT-7, GE LM500, and Zorya-Mashproekt UGT-3000.

Contractors

Prime

PW Power Systems, a subsidiary of MHI	http://www.pwps.com, 628 Hebron Ave, Ste 400, Glastonbury, CT 06033 United States, Tel: + 1 (860) 633-2616, Fax: + 1 (860) 368-5535, Email: lucia.maffucci@pwps.com, Prime
Ebara Corp	http://www.ebara.co.jp/en, 11-1 Haneda Asahi-cho, Ohta-ku, Tokyo, Japan, Tel: + 81 3 3745 6111, Fax: + 81 3 3745 3356, Licensee

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Subcontractor

Allen Gears	http://www.allengears.com, Atlas Works, Station Rd, Pershore, Worcestershire, United Kingdom, Tel: + 44 44 1386 552211, Fax: + 44 1386 554491, Email: sales@allengears.com (Generator-Mounted Compound Star Gearboxes)
Continental Controls Corp	http://www.continentalcontrols.com, 8845 Recho Rd, San Diego, CA 92121 United States, Tel: + 1 (858) 453-9880, Fax: + 1 (858) 453-5078 (Fuel Valves)
Meggitt Control Systems	http://www.stewart-warner.com, 3 Industrial Dr, Troy, IN 17601 United States, Tel: + 1 (812) 547-7071, Fax: + 1 (812) 547-2488, Email: infotroy@meggitt.com (Fuel Heater)

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data

Dimensions

	Length	Width	Height	Weight
ST18A	5.0 ft/1,532 mm	2.2 ft/670 mm	2.7 ft/807 mm	772 lb/350 kg
ST40	5.6 ft/1,700 mm	2.2 ft/670 mm	3.2 ft/965 mm	1,157 lb/525 kg

Performance

	Output (ISO)	Heat Rate	Turbine Speed	Pressure Ratio	Mass Flow	EGT
ST18A						
Generation	1,961 kW	11,922 kJ/kWh	18,900 rpm	14.0:1	7.97 kg/sec	532°C
Marine	1,960 kW	8,425 Btu/hp-hr	18,900 rpm	14.0:1	17.5 lb/sec	990°F
ST40						
Generation	4,039 kW	10,878 kJ/kWh	14,875 rpm	16.9:1	13.9 kg/sec	544°C
Marine	4,040 kW	7,688 Btu/hp-hr	14,875 rpm	16.9:1	30.6 lb/sec	1,011°F

SWIFTPAC 4

Output (ISO)	Heat Rate	Pressure Ratio	Mass Flow	EGT
3,880 kW	11,325 kJ/kWh	16.9:1	13.9 kg/sec	544°C

Design Features

Intake. Radial intake duct made of aluminum casting.

Low-Pressure Compressor. Single-stage LP centrifugal compressor driven by a single axial-flow LP or gas generator turbine.

High-Pressure Compressor. The ST18A and ST40 have a single-stage, centrifugal compressor that follows the LP stage, and is driven by the first-stage gas generator or high-pressure turbine. Compression ratio is in the range of 14:1 to 16.9:1.

Combustor. Single annular reverse-flow combustor design, with 12 or 14 piloted airblast fuel nozzles and one or two spark igniters. Ceramic coating is used extensively as a thermal and oxidation barrier. Catalytica Energy Systems has provided XONON Cool Combustion Systems for the ST18A and ST40.

High-Pressure Turbine. Single-stage, axial-flow HP turbine, with cast blades mounted in forged discs by fir tree-shaped roots. Blades are internally air cooled.

Low-Pressure Turbine. Single-stage, internally air-cooled LP turbine drives the LP compressor via concentric shafting. Cast blades are mounted in forged discs by fir tree-shaped roots.

Power Turbine. Engine power is extracted by a two-stage, axial-flow, free power turbine and delivered to the cold end of the engine by concentric shafting. Cast blades, with fir tree-shaped roots, are set in forged discs.

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Accessories. Optional equipment includes a dual-ignition exciter system, a P3 Venturi adapter, a fuel heater, a liquid fuel pump and fuel-control system, a 1,200-rpm output reduction gearbox, marine materials / coatings, and a starter (or starter generator). Labyrinth seals are used exclusively in the turbomachinery train. Anti-friction bearings (roller and ball) are used throughout. Continental Controls Corporation provides AGV liquid-fuel valves for the ST18.

Gearbox. Generator-mounted compound star gearboxes are supplied to PW Power Systems by Allen Gears. The gearboxes are used with the ST40 in power-generation duty.

Operational Characteristics. The ST18A has an output speed of 18,900 rpm and the ST40, a speed of 14,875 rpm.

The ST18A and ST30 make use of Catalytica's XONON combustion system with NOx-reduction technology in order to increase the marketability of the machines in the U.S. and Europe.

Variants/Upgrades

ST18. The ST18 is a free turbine I&M turboshaft engine derived from the Pratt & Whitney Canada PW100 series of aviation turboprop powerplants. This I&M model's turbomachinery consists of three independent rotating assemblies mounted on concentric shafts. The compressor is made of one LP and one HP centrifugal impeller, each driven by a single-stage axial turbine. Power is extracted by a two-stage axial (power) turbine and delivered to the front of the engine by concentric shafting. Each of the four turbine stages comprises cast blades mounted in forged discs by fir tree roots; the Stage 1 blades and the two compressor turbine vane rings are air cooled. The combustion system is composed of a reverse-flow annular combustion chamber, 14 fuel nozzles, and one spark igniter; the engine can burn gas or liquid fuel. The ST18's thermal efficiency is about 30.2 percent.

A tower shaft, driven by the HP compressor rotor, provides connection to an accessory gearbox mounted on top of the engine. This gearbox transmits power for engine starting, and provides a connection for driving an integral air/oil separator and other engine-mounted accessories.

This model has a radial air intake that also provides the interface to the reduction gearbox or other driven load.

The version of the ST18 currently available is designated ST18A by PW Power Systems.

ST30. The ST30 was a free turbine I&M turboshaft engine derived from the Pratt & Whitney Canada PW150 series of aviation turboprop powerplants. This model's turbomachinery consisted of three independent rotating assemblies mounted on concentric shafts. The model had a three-stage axial compressor followed by a single high-pressure centrifugal impeller, each driven by a single-stage axial turbine with separate blades and discs. All LP and HP turbine blades were internally air cooled. Power was extracted by a two-stage turbine and delivered to the front of the engine by concentric shafting supported by three rollers and one ball bearing. The combustion system was composed of a reverse-flow annular combustion chamber, 12 fuel nozzles, and one spark igniter; the engine could burn gas or liquid fuel.

This model had a radial air intake that also provided the interface to the reduction gearbox or other driven load.

The ST30 designation has not been used in PWPS documentation since January 2003.

ST40. The ST40 is an uprated version of the ST30. It is a free turbine I&M turboshaft engine derived from the Pratt & Whitney Canada PW150A aviation turboprop powerplant. This model's turbomachinery is composed of three independent rotating assemblies mounted on concentric shafts. The compressor is made of a three-stage axial unit followed by a single centrifugal impeller, each driven by a single-stage turbine. Power is extracted by a two-stage turbine and delivered to the front of the engine by concentric shafting. The combustion system is composed of a reverse-flow annular combustion chamber, 12 fuel nozzles, and one spark igniter; the engine can burn gas or liquid fuel.

This model has a radial air intake that also provides the interface to the reduction gearbox or other driven load.

The power increase over the ST30 was achieved in part by improving hot section coatings. In addition, some gas path components were modified to optimize performance at the higher rating.

XONON. In April 1998, PWPS (then P&WC) selected Catalytica Combustion Systems' XONON Cool Combustion System for use on the PWPS ST18A and ST30 gas turbine machines. The XONON system essentially eliminates NOx and certain other harmful emissions in gas turbines.

With the use of the XONON system, PWPS became the first turbine manufacturer to offer a family of commercial engines that emit less than 3 ppmv NOx.

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ENT 400. In 2002, DTE Energy Technology and Pratt & Whitney jointly developed the ENT 400 package, which included a bottoming cycle and provided 40 percent efficiency using an Organic Rankine bottoming cycle and recuperator. At that time, the goal was to develop improved silicon nitride ceramic cores for these gas turbine engines to provide a highly efficient and low-emissions mini-turbine package at a cost of $500/kW.

SWIFTPAC 4 Mobile Power Plant. The PWPS SWIFTPAC 4 mobile power plant, at 4 MW and 32.3 percent efficiency, is the smallest in the PWPS mobile power series. It is a complete power plant package in one shippable container, capable of generating power within 24 hours of arrival. The total package weighs less than 70,000 pounds (31,750 kg) and is 40 feet (12.2 m) long (ISO-certified stackable shipping container). Its emissions output is NOx, 25 ppmv and CO, 50 ppmv.

Program Review

Background. As part of its ongoing product line evolution, PWPS (then United Technology Pratt & Whitney Canada) developed the ST18A, a machine derived from the aero PW100 series of aviation turboprop engines. The ST18A was previously referred to as the SPW127.

PWPS decided to base the new ST18A machine on the highly efficient and popular PW127 aviation turboprop, already selected for several applications. More important, the ST18A powerplant is seen as a commitment by the company to remain active in the industrial marketplace over the long term.

Train Propulsion/Drive. In October 2002, in Washington, DC, Bombardier Transportation unveiled the JetTrain locomotive, a high-speed passenger train powered by an ST40 gas turbine machine. The JetTrain marked the first application of ST40 engine technology in a train.

The train/high-speed rail solution was designed specifically for the North American market.

Marine Propulsion. In January 2004, Pratt & Whitney Marine Systems entered into a contract with Norwegian shipyard Umoe Mandal to supply gas turbine propulsion systems to the Royal Norwegian Navy for six 260-ton Skjold class fast patrol boats.

The vessels have a maximum speed of 57 knots (105 kmph) and a range of 800 nautical miles (1,482 km) at 40 knots. Each gas turbine propulsion system has two ST18 marine gas turbines (designated ST18M) and two ST40 marine gas turbines (designated ST40M).

The Norwegian Navy based its decision on a comprehensive evaluation of operational, technical, and maintenance requirements. Specifically, the Navy performed a detailed study of competing turbine configurations. PWPS's COGAG configuration was better suited for the Skjold applications than the CODOG configurations offered by others.

The six Skjold class vessels were launched in 2007-2008 and commissioned in 2010-2012. The first vessel was evaluated by the U.S. Navy and Coast Guard in 2001-2002, but was found to be unsuitable for Navy service. The ship was also viewed as a candidate for the U.S. Navy's Littoral Combat Ship program but was discarded early in the selection process.

In mid-2016, Norwegian Defense Minister Ine Eriksen Søreide put forward a long-term plan for defense that envisions closing down the Coastal Ranger Command and Naval Home Guard, and phasing out the coastal corvettes of the Skjold class. This plan has been accepted and the ships of the Skjold class are likely to be scrapped in the near future.

Related News

Corn Ethanol Production Accelerates in Brazil – Brazil's first plant to produce ethanol exclusively from corn is located in Lucas do Rio Verde, in the west-central agricultural state of Mato Grosso. The R$450 million industrial plant is powered by state-of-the-art technologies – and designed to generate zero waste. The plant substation power is supplied by 10 MVA dry transformers, while other transformers ranging from 300, 2,500, and 2,000 kVA are used for other plant processes. For the plant's cogeneration of energy, a package of electric equipment was installed,

including the main plant ST40, 22,500 kVA generator, which works together with certified medium voltage MTW-03 switchgear, control, protection, power import, and export panels, all of which are controlled by the automation system designed by WEG engineering. (*EngineerLive*, 4/18)

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Funding

No U.S., U.K., Canadian, or Norwegian government/military funding for the PWPS ST18A/ST40 gas turbine series has been identified.

Contracts/Orders & Options

Contractor	Award ($ millions)	Date/Description
PWPS	N/A	Jan 2004 – Contract with Norwegian shipyard Umoe Mandal to supply ST18M and ST40M gas turbine propulsion systems to the Royal Norwegian Navy for six 260-ton Skjold class fast patrol boats.

N/A = Not Available

Timetable

Month	Year	Major Development
Early	1987	P&WC announces work on SPW124-2 machine
Late	1995	Production of ST18 machine begins
	1995	Nedalo BV becomes ST18 distributor
	1996	P&WC report indicates five distributors/packagers
Apr	1998	ST30 announced
		P&WC selects Catalytica XONON combustion system for ST18A and ST40
Sep	1998	Kvaerner Mandal P 960 *Skjold* launched
	1999	ST40 made public; ST30 made ready for delivery
Nov	1999	Flowtronex becomes P&WC packager
Oct	2002	Bombardier JetTrain unveiled in Washington, DC
Aug	2002	DTE Energy Technology and PWPS develop ENT 400 package
Jan	2004	ST18M and ST40M chosen for Royal Norwegian Navy's six Skjold class vessels
	2007-08	Five Skjold class vessels launched
	2008-09	Five Skjold class vessels commissioned
May	2013	MHI completes acquisition of Pratt & Whitney Power Systems

Worldwide Distribution/Inventories

Country	Year of Installation	Total Number
ST-18M		
Canada	1998	1
Netherlands	1996	1
Norway	2010 (4), 2011 (2), 2012 (4), 2013 (2)	12
Total		**14**
ST-40M		
Brazil	2017 (1)	1
Norway	2010 (4), 2011 (2), 2012 (4), 2013 (2)	12
U.K.	2014	3
Total		**16**

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Forecast Rationale

There is only a limited market for propulsion based on the ST18 and ST40 marine gas turbines or, indeed, for any gas turbine in this power bracket. Gas turbines' thirst for fuel is a severe tactical limitation that deters most designers from adopting the systems. Turbocharged or supercharged diesels provide equal power output with significantly lower fuel consumption. Although diesels are heavier than gas turbines of similar power output, the reduced weight of the fuel needed to achieve a given operational radius more than offsets this factor.

Operationally, gas turbines have high exhaust temperatures and produce a heat plume that can be detected from considerable distance. This is not an important factor on large warships, since they have the weight and volume to carry exhaust cooling equipment. Small surface combatants, however, do not have such features. For all these reasons, gas turbine-powered small craft have proved to be a dead end, and the opportunities for gas turbines aimed at this sector are very limited.

A viable niche for the ST40 is the market for air-cushion and other surface-effect ships. In this case, the sensitivity of these craft to weight increases is such that the light weight and power density of gas turbines overcome their disadvantages. However, surface-effect ships are a small niche, and even there, advanced diesels are penetrating the market.

Modern warships are voracious consumers of electrical power and are helpless if that power is cut off. The instant response and high power density of gas turbines make them highly suited to emergency standby power generation, and even for the provision of routine power supplies. Currently, the Rolls-Royce MT-5 fills this requirement, but it peaks at around 4,000 kW. With electricity demands increasing, higher output is necessary. A very good argument can be made that an intermediate generator in the 8- to 12-MW range could be leapfrogged and that ships could jump to an electrical ship's service generator version of the LM2500. This would bypass the ST18 and ST40 completely.

The cold fact is that the ST18 and ST40 have achieved virtually no sales. Outside of the controversial Skjold program, only five gas turbines – one ST18 and four ST40s – are known to have been sold in 20 years. In that environment, no forecast can be justified. Unless there is a radical change in the situation over the next year, this report will be archived.

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