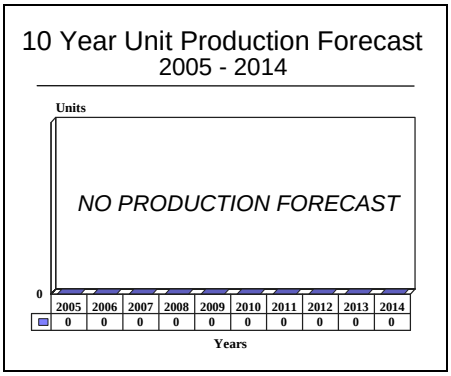
Volvo VT4400 - Archived 6/2006

Outlook

- VT4400 has been offered as part of a turnkey CHP or mechanical drive installations, built to customer specifications; machine's small overall size lends itself well for CHP, power generation, and mechanical load drive applications
- Engine program is currently on hold



Orientation

Description. The VT 4440 is a two-shaft, centrifugal-flow, industrial gas turbine machine in the 4-5 MW class. The high-efficiency three-stage power turbine is arranged to provide a cold-end drive.

Sponsor. Development of the DC-990 and, later, the DR-990 (the predecessor to the VT4400) was partially underwritten by the U.S. Department of Defense through the U.S. Navy.

Power Class. 4,400 kW (ISO base rating).

Status. New production of the VT4400 is on hold for the near term. Volvo Aero is focusing on the aftermarket for the machine to develop improved solutions for the machines in the fleet.

Total Produced. At the start of 2005, at least 96 DR-990/VT4400s had been installed. Recent production focused solely on the VT4400.

Application. Applications include electrical generation (including cogeneration installations) and mechanical load drive (especially in the oil and gas industry).

Price Range. The machine's price is estimated in 2005 U.S. dollars at $1.7-$1.8 million for an electrical generating gas turbine equipped package, and $1.5-$1.6 million for a mechanical drive gas turbine package.

For electrical generation, the price in 2005 calendar year U.S. dollars is for a basic electric power skid-mounted generator package including one simple-cycle (open cycle) single-fuel gas turbine, air-cooled electric generator, skid and enclosure, air intake with basic filter and silencer, exhaust stack, basic starter and controls, and a conventional combustion system.

For mechanical drive gas turbines, the price in 2005 calendar year U.S. dollars is for a natural gas-fired skid-mounted simple-cycle (open cycle) gas turbine prime mover (without driven equipment) with gearbox, skid, enclosure, inlet and exhaust ducts and exhaust silencer, a conventional combustion system, fire protection and starting systems, standard engine controls, basic auxiliaries needed for an operational installation and a conventional combustion system.

Competition. In the electrical generation arena, the chief competitors to the VT4400 have been the Solar Centaur 50 and the UTC Pratt & Whitney Power Systems (PWPS) ST40.

In mechanical load drive arenas, the chief competitors to the VT4400 have been the Rolls-Royce 501-KC5 and the Solar Centaur 50.

Contractors

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Technical Data

General. The Volvo VT4400's design owes much to the earlier DR-990 and, even earlier, to the DC-990.

Design Features. Among the design features of the Volvo VT4400 are the following:

Intake. Screened inlet plenum. Air intake module roof-mounted. Air intake filter, air intake silencer, and ducting components are standard options.

Compressor. Two-stage centrifugal compressor with a pressure ratio of 12.2:1 to 12.4:1. Stage 1 material is Ti-6Al-4V (17 blades); Stage 2 material is Ti-6Al-2Sr-4Zn-2Mo (15 blades). Mass flow is 20.0 to 20.1 kg/sec. Design speed is 18,115 rpm, and the speed range is 12,500 to 18,000 rpm. The casing is made of ASTM-A536, and stator vanes are of AISI-316L, AISI-410, and ASTM-439. Shafts are of IN718.

Combustor. A single annular, reverse-flow combustor with 18 fuel nozzles uses liquid or gaseous fuel. An automatic changeover dual-fuel system is offered as an option. Combustor chamber is made of Haynes Alloy 188 sheet. Liner and duct are Haynes 188. Dual exciter ignition is standard. The combustion system is designed for operation on natural gas, liquid fuel, and dual-fuel.

Gas Generator Turbine. The compressor section is driven by a two-stage axial turbine. The Stage 1 nozzle is of MAR-M509, while the first turbine rotor consists of 59 IN792 blades fitted to a Waspaloy disc by fir-tree roots. The gas generator rotates at 17,866 rpm. The second nozzle is also of MAR-M509, with the second turbine composed of 59 IN792 blades in a Waspaloy disc. TIT is 1,052°C.

Power Turbine. A three-stage axial-flow Dresser-Rand power turbine drives the output shaft at 3,000 to 7,200 rpm (100 percent speed is 7,200 rpm). Blades are of U-500, and fastened by fir-tree roots to the IN718 discs. Vanes are HS-31. Blades have Z notch shrouded tips. EGT is 482°C.

Gearbox. Main drive gearboxes are available in both epicyclic and parallel offset types with speeds of 1,500 to 22,800 rpm. The output gearboxes are integral with the turbine and accessory gearbox assembly.

Controls. A Dresser-Rand/Woodward governor controls gaseous/liquid fuel flows, respectively. Dresser solid-state microprocessor controls are standard. Optional accessories for alarm, automatic shutdown, surge signal output, and monitoring are available. Starting is by air/gas expansion turbine or hydraulic starter.

Dimensions. Approximate dimensions and weights of the Volvo VT4400 gas turbine machine in a packaged generator set are as follows:

	Metric Units	English Units
Length	8.2 meters	27.88 feet
Width	2.5 meters	8.20 feet
Height	3.3 meters	10.82 feet
Weight	34,000 kg	74,956 pounds

Performance. Nominal performance parameters of the Volvo VT4400 gas turbine machine at ISO conditions are as follows:

ISO Base Rating	Heat Rate (LHV)	Pressure Ratio	Mass Flow (Base Load)	TIT	EGT
4,400 kW	12,370 kJ/kWh	12.4:1	20.5 kg/sec	1,052°C	482°C
5,900 shp	8,350 Btu/shp-hr	12.4:1	45.19 lb/sec	1,925°F	900°F

The VT4400 with 4,400 kW shaft power output at ISO conditions, in a typical CHP plant, has the following performance parameters (data allow for 60 mm H_2O inlet pressure loss and 150 mm H_2O output pressure loss):

VT4400 TYPICAL CHP PLANT PERFORMANCE

4,123 kW gross electrical output at 6,000-13,800V, 3-phase, 60 Hz
7,120 kW (approx 10.5 tonnes/hr) steam generation at 9 bar(g) saturated
7,800 kW hot water generation (100°C/75°C)
Natural gas, liquid fuel, and dual-fuel systems available

Variants/Upgrades

DR-990. The designation DR-990 applies to the gas turbine machine produced and marketed by Dresser-Rand until October 1997.

VT4400. The designation VT4400 applies to the Volvo Aero-produced and Volvo Aero-marketed version of the DR-990, to which Volvo Aero acquired the rights in October 1997.

Program Review

Background. The VT4400 has been produced by Volvo Aero Corporation, Land and Marine Gas turbines, in Malmö, Sweden.

The following firms have been affiliated with the DC-990/DR-990/VT4400 program:

- Dresser-Rand; Olean, New York, USA.
- Dresser-Rand A/S; Kongsberg, Norway.
- Hibiya Engineering Limited; Tokyo, Japan.
- Onan Corporation; Minneapolis, Minnesota, USA.
- Stewart & Stevenson Services Incorporated, Houston, Texas, USA.

Development of the Volvo Aero Corporation VT4400 gas turbine machine began earlier with Dresser-Rand and its DR-990 (formerly the DC-990), begun in 1973 under a U.S. Navy contract awarded to (then) Garrett Corporation for a marine propulsion gas turbine with a hot-day rating of 6,000 shp. Borrowing much from the IE 831 and ATF3 engines, Garrett aimed for a compact, high-performance design in its new IE 990, using a scaled-up IE 831 compressor section. Turbine component design included technology derived from aviation's ATF3. The centrifugal compressor design was selected because of its resistance to damage by foreign objects, and because it had suffered few losses due to tip seal wears. The production 990, incorporating optional marinized materials and coatings, is derived from the Navy's prototype GTPF 990. Aluminized coatings are incorporated in the hot section for oxidation and sulfidation resistance. The overall DR-990 design features the modular concept, allowing rapid on-site serviceability to maximize the machine's availability.

The first Navy prototype was built in 1978 and the initial production variant entered service the same year.

DR-990 Applications and Uses. Dresser-Rand offered generation and compressor packages built around the DR-990. Dresser centrifugal compressors are used in the production of ammonia, urea, ethylene, methanol, and LNG; in oil refining, in air separation and oil production including gas lift and injection; in gas production including gas injection and gathering; and in various refrigeration, storage, and transportation modes. The DR-990 is offered with both 1,500-rpm (50 Hz) and 1,800-rpm output gearboxes for generator sets, and the company offers complete cogeneration packages as well as more traditional power equipment.

Cogeneration Use. The DR-990's first sale in that burgeoning portion of the electrical generation marketplace was made in 1985 when (then) KHD of Germany purchased a complete cogeneration set based on the DR-990 for use in an FRG municipality for power generation and district heating. In Europe, several DR-990 gensets have been installed to comply with strict environmental legislation. The package complied with the NOx limit of 150 mg/m^3 then in effect in Germany.

Volvo Carries On with the DR-990. Just when most industry followers believed that the DR-990 program was at the end of its production life cycle, Dresser announced in October 1997 that it had sold to Volvo Aero Corporation of Sweden the rights not only to manufacture the DR-990 but also to further develop it. Volvo redesignated the machine the VT4400.

Dresser-Rand's New Role with the DR-990. When the sale to Volvo Aero Corporation was made, Dresser-Rand retained the right and obligation to support all installed DR-990 and DJ-50 machines; it also secured the right to market any Volvo-developed improvements to all current and future customers. D-R was also obliged to continue to offer replacement parts, repairs and overhaul work, field engineering services, and lease and replacement machines.

Other Volvo Gas Turbine Machines. In addition to the VT4400, the Volvo Aero Corporation portfolio of gas turbine machines has included two other models: the VT600 and the VT2600.

VT600. The VT600 is a small machine rated at 655 kW shaft power output at ISO conditions and at about 635 kW gross electrical output (at 415V, 3-phase, 50 Hz) in a typical CHP plant. It is offered to the marketplace as part of a turnkey CHP installation built to customers' specifications. At least four VT600s have been delivered to customers in Latvia, Sweden, and the U.K.

VT2600. The VT2600, rated at 2,590 kW shaft power output at ISO conditions and about 2,250 kW gross

electrical output (at 6,000-13,800V, 3-phase, 50 Hz) in a typical CHP plant, was developed by Volvo together with its two partners as project EU159 in the European Eureka program. It is offered to the marketplace as part of a turnkey CHP installation, for offshore oilrig duty, or as a marine propulsion installation built to customers' specifications. The gas turbine machine is well suited for ferries and high-performance racing vessels. Nothing has been heard about this model in the recent past.

Funding

U.S. or Swedish government funding, if any, specifically pertaining to the Volvo VT4400 gas turbine machine has not been identified.

Recent Contracts

No major identifiable military contracts specifically pertaining to the Volvo VT4400 gas turbine machine have been awarded or received in the recent past.

Recent Sales

In December 2002, it was announced that Volvo Aero would deliver a VT4400 gas turbine to Ukraine for installation in a Zaporozhye city district Ushakovo central boiler house. The gas turbine is used to convert the boiler house into a gas turbine cogeneration plant. The renovated boiler house began commercial operation in late spring 2003.

Timetable

Month	Year	Major Development
Apr	1972	U.S. Navy contract for GTPF 990 prototypes awarded
	1977	IE 990 testing begins
1Q	1978	IE 990 machine made available; DJ-50A unit made available
	1980	Dresser agreement concluded to build and market IE 990
	1981	First machines installed
1Q	1982	DC-990 introduced
	1985	Kongsberg-Dresser agreement signed; first sale of DR-990 for cogeneration
Jan	1987	Dresser agreement with Ingersoll-Rand announced
	1990	DR-990 becomes standard designation
	1991	DR-990 Kongsberg overhaul facility becomes fully operational
Oct	1997	Volvo purchases rights to produce DR-990; machine redesignated VT4400
Late	2002	Sale of one VT4400 to Ukraine reported
Thru	2014	Continued production/availability of VT4400 by Volvo projected

Worldwide Distribution

At the start of 2005, at least 96 DR-990/VT4400 gas turbine machines had been installed, including early models by Garrett and Dresser-Rand. Among the major customer nations are **Australia** (18 machines), the **United Arab Emirates** (12) and the **U.S.** (17).

Forecast Rationale

It is without question that Volvo Aero Corporation saw potential in the DR-990 (which it redesignated the VT4400) for use in the electrical generation and mechanical load drives markets. Volvo has long had considerable expertise in thermal barrier and oxidization and corrosion-resistant coatings, and it had been eyeing the application of that technology to a new industrial gas turbine machine. Volvo also recognized that the 4.4 MW power output was ideal for the small/medium pipeline and distribution systems that should be built in

Northern Europe in the next 10 to 20 years, and that the machine was well-sized to provide offshore power generation and compression duties on medium-size platforms.

With a concerted movement worldwide to CHP/ cogeneration, the VT4400 generator should be eyed by potential customers for cogeneration applications. Regrettably, sales of the machine, few as they may be, have not been well publicized by Volvo, giving credence to the belief of many industry analysts that Volvo may not be giving the machine full emphasis sales-wise.

In the absence of sales activity for the VT4400 machine, Volvo has told Forecast International that new production of the VT4400 is "on hold" for the moment while Volvo focuses on the aftermarket to develop solutions for the machines in the installed fleet worldwide. It is eyeing solutions that will offer increased life and lower costs.

No forecast for the machine is provided.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

			High Confidence Level				Good Confidence Level			Speculative Level			
Engine/Machine	**Application**	**thru 2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total 2005-2014**
DRESSER-RAND (a)													
DR-990 SERIES	GENERATION	28	0	0	0	0	0	0	0	0	0	0	0
DR-990 SERIES	MECHANICAL DRIVE	66	0	0	0	0	0	0	0	0	0	0	0
Subtotal		94	0	0	0	0	0	0	0	0	0	0	0
VOLVO AERO CORPORATION													
VT4400	GENERATION	2	0	0	0	0	0	0	0	0	0	0	0
VT4400	MECHANICAL DRIVE	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal		2	0	0	0	0	0	0	0	0	0	0	0
TOTAL PRODUCTION		96	0	0	0	0	0	0	0	0	0	0	0

(a) No additional production will be done by Dresser-Rand.