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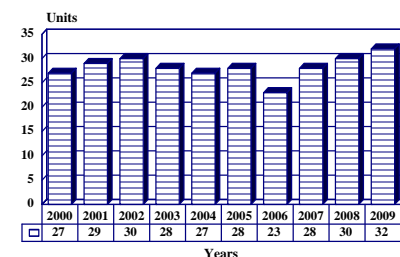
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Rolls-Royce Allison 570/571/572-K - Archived 8/2001

Outlook

- New model 572-K expected to boost sales overall
- Less complexity, cost and NOx emissions than in 571s
- All market applications will remain active for the next decade
- Power generation in cogen, combined-cycle systems particularly buoyant market for this engine type
- Marine sales expected to pick up in the longer term

10 Year Unit Production Forecast
2000 - 2009



Orientation

Description. Two-shaft, simple-cycle, axial-flow, aviation derivative, industrial and marine gas turbines with a cold front drive output shaft, in the 4.5-6.5 MW class.

Sponsor. The industrial and marine models 570/571/572-K were privately developed by the prime manufacturer.

Contractors/Manufacturers. The prime manufacturer is Allison Engine Company; Indianapolis, Indiana, US (Allison Engine Company was previously known as Allison Gas Turbine Division of General Motors Corporation).

Allison Engine Company is a wholly owned subsidiary of Rolls-Royce plc (London, UK).

OEMs: Marine Drive. Current OEMs for marine drive include the following:

- Cincinnati Gear Company; Cincinnati, Ohio, USA. (OEM)
- Kawasaki Heavy Industries Limited; Kobe, Japan. (OEM)

Distributors/EPSS: Generator Sets. Current Distributors/EPSS for generator sets include the following (distributors, unless otherwise noted):

- CEC-STR Distribuicao de Turbinas; Rio de Janeiro, RJ, Brazil.
- Centrax Limited; Newton Abbot, Devon, UK.
- Detroit Engine & Turbine Company; Adelaide, SA, Australia.
- Tominaga & Company Limited; Tokyo, Japan.
- US Turbine Corporation; Maineville, OH, USA.

Power Class. The approximate power output of the Rolls-Royce Allison 570/571/572-K series machines is as follows (see **Technical Data** section, "Performance" subsection, below, for more detail):

<u>Machine</u>	<u>Power Output</u>
Model 570-K	6350-6540 hp (4,735 - 4,877 kW).
Model 571-K	7630-8350 hp (5,689 - 6,226 kW).
Model 572-K	8675-11,000 hp (6,470 - 8,200 kW).

Status. In production.

Total Produced. As of the beginning of 2000, an estimated 220 Model 570/571/572-K I&M gas turbine machines and engines combined had been built.

Application. Mechanical drivers (prime mover for oil and natural gas pumping systems); electric power

generation (including cogeneration installations); marine propulsion.

Price Range. \$1.8-\$2.9 million, depending on variant (estimated in 2000 US dollars).

Competition. The Model 571-K faces competition largely from the 5.2 MW Nuovo Pignone PGT5 and the 5.0 MW Solar Taurus 60. The Model 572 faces competition from the Ruston Tornado at 6.7 MW and Tempest at 7.7 MW, as well as from the 6.8 MW Solar Taurus 70 and Kawasaki M7A at 7.0 MW.

Technical Data

Design Features. Design features of the Allison I&M Model 570/571/572-K series include the following:

Intake. Annular intake with six support struts; cast aluminum. Radial air inlet is an option for both engine models.

Compressor. Thirteen-stage axial compressor with variable stators in Stages 1-6. Variable inlet guide vanes. Stator Stages 1-5 are variable. Compressor blades are of 17-4 PH steel, stator vanes are made of Carpenter 450 material, casing of 410SS. Pressure ratio is 12.1-12.7:1; air mass flow of 41.79-44.17 lb/sec (18.96-20.04 kg/s). Compressor blades (steel alloy), stators, and cases are made of materials selected for corrosion resistance and long life. Design speed is 14,281-14,879 rpm (range is 11,000-15,450 rpm).

The Model 572-K has an all-new, variable geometry 12-stage axial compressor. A bleed valve is also installed. Model 572-K11 includes a two-stage booster module, which increases the pressure ratio of the new machine from 15:1 (in the 572-K9) to 20:1 in the K11.

Combustor. Annular, through-flow combustor has 16 fuel injectors. Cast steel diffuser. Inner wall of combustor supports the center bearing package. Casing is made of cast 410SS; liner and transition duct are of Hastelloy X. Ignition by two spark igniters.

The Model 572-K includes a dry low-emissions system of three combustor cans taken from the RB211 aviation turbofan engine.

Compressor Turbine. A two-stage, air-cooled axial turbine drives the compressor spool. Stage 1-2 nozzle vanes made of MAR-M509 and IN792, respectively, are

impingement cooled. Blades are of MAR-M246 with Stage 1 also impingement cooled. Stage 2 blades are tip shrouded and are convection cooled by compressor discharge air. Disc material is IN718.

Power Turbine. A two-stage power turbine (for 570-K) or a three-stage power turbine (571-K) drives the output shaft at 11,500 rpm. Both stages are tip shrouded. Rotor speed vanes from 6,000-12,000 rpm.

Seventy-eight Stage 1 blades and vanes are made of MAR-M246. Stage 2 blades of Waspaloy, Stage 2 vanes of IN792. Discs in IN718, casing is Hastelloy S.

Power turbine of 572-K is redesigned three-stage unit providing final drive to cold-end output shaft.

Bearings. Gas generator rotor is supported at the front by a roller bearing and at the rear by ball thrust bearing. Power turbine rotor is rear-supported by a roller bearing and the front by a working spline on the shaft. Rolling element bearings are AFBMA Grade 5.

Controls. A Continental Controls Corporation integrated solid-state electronic control system provides automatic starting and shutdown sequencing, electronic fuel control, speed governing, and fuel limiting. Malfunction monitoring and automatic variable geometry control are provided. The starter drive pad is located on the underside of the inlet housing.

Accessories. The two engine models come with a dual-fuel system switchable under load. Model 572-K features electric motor driven pumps for the accessory drive and fuel and oil pumps, though a simple accessory gearbox remains available.

Dimensions. Approximate dimensions of the Model 570/571-K for genset/compression application (burning gaseous fuel) are as follows (first figure is the Model 570-K; second figure is the Model 571-K):

	<u>Metric Units</u>	<u>English Units</u>
<i>Length^(a)</i>	1,768/1,872 mm	69.6/73.7 in
<i>Width</i>	914 mm	36.0 in
<i>Height</i>	955 mm	37.6 in
<i>Weight^(a)</i>	715/789 kg	1,557/1,740 lb

^(a)Axial Inlet Configuration.

Approximate dimensions of the Model 570/571-K for marine application (burning liquid fuel) are as follows (first figure is the Model 570-K; second figure is the Model 571-K):

	<u>Metric Units</u>	<u>English Units</u>
<i>Length</i> ^(a)	1,768/1,872 mm	69.6/73.3 in
<i>Width</i>	792 mm	31.2 in
<i>Height</i>	916 mm	36.1 in
<i>Weight</i> ^(a)	733/807 kg	1,617/1,780 lb

^(a) Axial Inlet Configuration

Performance. Approximate performance parameters of the Model 570/571/572-K series machines (Model 572-KC is mechanical drive) are as follows (ISO Continuous, S/L, 15°C, nominal) (data supplied where available):

	<u>Fuel Type</u>	<u>Output (kW)</u>	<u>Heat Rate (kJ/kWh)</u>	<u>SFC (kg/kWh)</u>	<u>Gas Flow (kg/sec)</u>	<u>EGT (°C)</u>
570-K	G ^(a)	4,877	12,167	0.284	18.96	565
570-K	L	4,735	12,167	0.284	18.96	565

^(a) G = Gaseous Fuel; L = Liquid Fuel.

	<u>Fuel Type</u>	<u>Output (kW)</u>	<u>Heat Rate (kJ/kWh)</u>	<u>SFC (lb/hp-hr)</u>	<u>Gas Flow (kg/sec)</u>	<u>EGT (°C)</u>
571-K (genset, mech. drive)	G	5,910	10,625	0.372	19.9	582
571-KF (marine)	L	5,735	10,747	0.417	19.7	585

	<u>Fuel Type</u>	<u>Output (kW)</u>	<u>Heat Rate (kJ/kWh)</u>	<u>Efficiency (%)</u>	<u>Gas Flow (kg/sec)</u>	<u>EGT (°C)</u>
572-KC9	G	6,710	10,515	33.7	23.6	529
572-KC9	D ^(a)	6,470	10,655	33.3	23.3	532
572-KC11	G	8,200	10,460	34.0	30.1	504
572-KC11	D	7,830	10,600	33.5	29.4	507

^(a) D = Diesel Fuel

Variants/Upgrades

Among the major variants of the Allison I&M Model 570/571/572-K series machines are the following:

570-K. The Model 570-K variant forms the basis for the majority of installations to date. The Model 570 is offered in KA form for electric power generation, KC for mechanical drives, and KF for marine propulsion.

571-K. The Model 571-K is an improved Model 570-K, utilizing a three-stage power turbine design. Stage 1 blades are IN792, Stage 2 blades are MAR-M246 and Stage 3 blades are Waspaloy. Vanes are IN792 and discs are IN901. Power turbine blades and vanes are uncooled. The Model 571-K is available in several model designations (see "Performance" section above).

572-K. Allison launched the Model 572-K in 1996 with plans to offer at least two models: the 6.7 MW (9,000 shp) Model 572-K9, and the Model 572-K11 at 8.2 MW (11,000 shp). Both new offerings are to be

made available for generation (KB9 and KB11), mechanical drive (KC9 and KC11), and marine (KF9 and KF11) applications.

The engines have three-can Dry Low Emissions (DLE) combustors as standard equipment. These are taken directly from the Rolls-Royce RB211. The engines will also be available with effusion-cooled, annular combustion systems for marine and non-DLE applications.

The 572-K features an all-new, 12-stage compressor with variable geometry for improved part power performance and operational flexibility, with axial blade attachments, individual stacked wheels, a modern variable geometry system and the addition of a compressor bleed valve. Rated speed at the output shaft is 11,500 rpm for all variants. Exhaust temperatures range from 940° to 990°F (504° to 532°C). See "Performance" section, above, for more ratings.

Major risk and revenue sharing partners on the 572-K program are Industria de Turbo Propulsores, SA, of Spain; Aero industry Development Center of Taiwan; Ishikawajima-Harima Heavy Industries, of Japan; and Kobe Steel Limited, of Japan.

Field evaluations of the Model 572-K9 began in the fourth quarter of 1997, at which time the Model 572-K11 entered testing.

572-KB9. Electrical power generation variant of the 572-K design.

572-KC9. A mechanical drive variant of the 572-K.

572-KF9. Marine propulsion variant of the same.

572-KB11. A higher performance “boosted” version of the KB9 electrical power generation variant.

Program Review

Background. The Allison Industrial and Marine (I&M) Model 570-K is an extrapolation of the 501-M62/XT-701 turboshaft engine, developed under contract to the US Army for its since-canceled Heavy Lift Helicopter program. The aviation derivative industrial and marine turboshaft engine utilizes the experience of the GMA 300 gas generator developed under the US Air Force’s Advanced Turbine Engine Gas Generator (ATEGG) program, the extensive production experience with the predecessor Model 501-K, and advanced cooling techniques from the GMA 100 ATEGG program.

Development History. The 570-K predates the XT-701 by virtue of its unofficial program initiation in 1971; the official program commenced in 1976. However, the first prototype unit was installed and operating in 1973, and very shortly the advanced features such as variable geometry and cooling led to impressive part load SFC and overall thermal efficiency.

Initial 570-K Program Objectives. Allison outlined the following program objectives at the outset of the 570-K in 1976: maximize efficiency over a wide operating range, especially part load; ensure 30,000 operational life for industrial use; ensure provision of internal and external corrosion resistance in marine environments; complete the development of Full Authority Digital Electronic Control (FADEC); optimize combustor starting and life for diesel fuel (marine); ensure full compliance with emission and noise dictates; and provide a low-cost gas turbine. All these goals were met, and full production began in 1979.

571-K Uprate Program. The Model 570-K, being essentially a derated engine from the 8,000+ horsepower of the aviation XT-701, was seen as being capable of easy uprating to the 7,500 shp power class for industrial applications. Allison uprated the 570-K to the new-designation 571-K by replacing the two-stage power turbine with a new three-stage unit. Each new power turbine incorporates a new case, redesigned blades and vanes, and overall redesigned blade and vane geometry. While the original 570-K is optimized for

part-load conditions, the 571-KC is re-optimized for power requirements above 50 percent load. Gas generator features remain the same, with firing temperature and overhaul times also remaining unchanged. Approximately 7,925 horsepower ISO is available for continuous operations as opposed to the 6,500 shp of the 570-K. Nova Corporation, Alberta, Canada, uprated its two 570-K units employed in gas compression at its Knight compression station. Winter peak load demand increases, forecast for the near term, dictate such increases in power. Nova’s 570-Ks were brought into an approved Allison overhaul and repair facility during the fourth quarter of 1983.

Major Licensees, Distributors, Packagers, OEMs and EPSs. Major firms currently working with Allison on the Model 570/571-K are the following (**Note:** Allison’s Engineered Product Suppliers [EPSs] combine aspects and responsibilities of the Allison traditional distributors and OEMs; EPSs supply the same product and service as the K distributor, along with providing a mechanical driver for compressors and pump applications):

Detroit Engine & Turbine Company. In mid-1990, an order was placed with Detroit Engine & Turbine Company in Australia for a gas turbine generator package for the Jamuna fertilizer plant in Bangladesh. Detroit Engine designed the overall generator package, using a single 571-KA and a Leroy-Somer generator. The package was delivered in the fourth quarter of 1990.

Centrax. The UK-based firm is the licensed European distributor and packager for Allison’s industrial engines. Its packages reportedly range in output from 2.5 to 6 MW (i.e., including other engines besides the 570 series). Centrax-packaged 570 gensets are used in a variety of applications, supplying electrical power, and are being sold for cogeneration installations.

IHI. Ishikawajima-Harima Heavy Industries is a licensee of Allison Gas Turbine Division in Japan. The company builds the aero T56 turboprop for the P-3C, also built under license in Japan. It has been a producer of the industrial variant of the I&M Model 570-K,

under the designation IM600. It is also a major risk and revenue sharing partner in the Model 572-K program. IHI offered both stationary and mobile configurations of the IM600. According to Allison, IHI is no longer an active licensee of the I&M Model 501-K.

Stewart & Stevenson. Stewart & Stevenson (S&S) has long been an innovative packager of gas turbines and driven equipment products; it can act as a single-source for the prime mover, driven equipment and, when desired, heat recovery and combined-cycle apparatus.

General Electric acquired Stewart & Stevenson's Gas Turbine Products division in 1998. All production is going to Allison in Indianapolis.

Stewart & Stevenson did note that the cold-end drive design of the 571-K makes it an ideal candidate for applications with space limitations. According to S&S, the machine can be turned down 60 percent of rated power with only a 5 percent increase in specific fuel consumption.

Tominaga. Tominaga & Company Limited of Japan has supplied 501-K and 570-K series to Hitachi Zosen for packaging, as well as performing total service on its own.

US Turbine Corporation. Powell Industries Incorporated's US Turbine Corporation offers a full range of gas turbine and engine generating sets in the 660-51,180 kWe range for gas turbine-powered gensets, and in the 354-2,677 kWe range for reciprocating engine-powered gensets. While it has offered the 570/571-K in its generator set product line, the current offering is limited to the 571-KA, under the designation UST5700.

Industrial Applications. The initial installation of the Model 570-K occurred at Dow Chemical in Freeport, Texas, in the US, as a process drive system. Stewart & Stevenson packaged the unit, which is incorporated in a liquid nitrogen and liquid oxygen production plant. The unit began operation in October 1979. Sales were rather slow in the beginning but gained momentum during 1980 and 1981. Since then, other sales have been made to Mexico, Chile, Egypt, and Canada. As with the smaller 501-K, the 570-K made its greatest penetration in the mechanical drive sector at an early date, but is now in greater demand as a generation set.

Combined Cycle. Combined-cycle units that include the Model 570/571-K have been made available by Stewart & Stevenson under the designations CC1-570-K and CC1-571-K; Sulzer Turbosystems Inc under the designations TG-80ACC (using the 570-KC) and TG-80BCC (using the 571-KC); and by Valley GM Power Products under the designations 7600 VCA and 15000 VTCA (using the 570-KA) and 8500 VCA and 17000 VTCA (using the 571-KA).

Marine Applications. The marine propulsion 570-KF version was also designed to provide low SFC at part power; for example, there is only a 20 percent increase in SFC at a 50 percent power rating. The Model 570-KF is rated up to 7,900 hp maximum continuous at a thermal efficiency of 32.4 percent. In the combined gas and steam cycle (COGAS), the engine produces 10,187 horsepower at an approximate thermal efficiency of 41.5 percent.

Stewart & Stevenson has been one of the world's foremost designers and packagers of marine auxiliary power and prime propulsion diesel and gas turbine modules for the last 20 years. It produces the 570-K propulsion module and has delivered several units for the Swedish Stockholm missile boat program.

Civil Marine Applications. Boeing considered using the 570-K for an improved version of the Jetfoil, but found that the redesign requirements exceeded the craft's projected sales potential.

One marine propulsion engine has been procured by France through Creusot-Loire for use in an experimental high-speed craft for military application. Initially, two 501-Ks were to be used, but a later decision focused on a single 570-K with diesel cruise engines.

Civil marine use of the 570-KF includes the 138 foot (42 meter), 230 ton private yacht *Sherger*, originally built for the Aga Khan. It features a CODOG propulsion arrangement, with diesels outboard and the turbine inboard. Another vessel is the 98 foot (29.8 meter), 77 ton private yacht *Fortuna* built for the King of Spain. A recent S&S-packaged Model 570-KF gas turbine is onboard the 71 foot (22 meter), 37.47 ton private yacht *Croupier*; the Allison engine is used in a CODAG arrangement with twin 8V-92TA Detroit Diesel diesels in conjunction with Cincinnati Gear epicyclic reduction gearing and ZF Model BW165 transmissions. The *Croupier's* price is estimated at \$8-\$8.5 million.

Military Marine Applications. Allison's first military marine application was the Swedish government, which ordered the 570-KF propulsion module for the Stockholm class guided missile patrol boats/frigates; the 335 ton class vessels were previously designated Spica III. Each of the two vessels in this class employs twin MTU 16V diesels in the cruise mode and one Allison/S&S 570-KF engine (in a CODAG capacity) developing 6,000 horsepower. The two boats were ordered in 1981, laid down in August 1982 and March 1983, and commissioned in the first half of 1985.

In other applications, the Model 570-KF was selected by the Canadian Navy as the cruise engine for its 5,100

ton Iroquois DDH 280 class destroyer refurbishment project, designated TRUMP (Tribal Update and Modernization Program), in which the vessels' original Pratt & Whitney FT12A-3 engines would be replaced with the 570-KFs (the project also called for the replacement of the original Pratt FT4A-2 boost engines with GE LM2500-30s). Modernization of the first vessel, an 18-month effort, began in October 1987, and

of the second vessel in October 1988. All modernization work was completed in 1993.

Both the Model 570-KF and 571-KF have been proposed for the British Hovercraft BH.7 Mk 20. The hovercraft is intended for mine hunting and destruction duties. The 570-KF would be specified for moderate climates, with the higher powered Model 571-KF for hot climates.

Funding

Funding specifically pertaining to the 570/571-K machines has not been identified.

Recent Contracts

No major identifiable commercial or military contracts specifically pertaining to the Model 570/571-K have been awarded or received in the recent past.

Timetable

Among the major events in the 570/571-K series program are the following:

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
	1971	Development of Allison 570-K begins
	1976	570-K program official commencement
	1977	First preproduction engine operational
Feb	1978	Completion of 2,500 field demonstration hours
Oct	1979	Model 570-K production-standard units available
Mid	1983	First preproduction 571-K units operational
	1985	Production-standard 571-Ks available
	1985	570-K selected for Canadian DD 280 refurbishment project;
	1985	Sweden selects 570-K for Stockholm class vessels
Thru	2007	Continued production/availability of 570-K/571-K projected

Worldwide Distribution

As of 2000, about 220 Allison I&M Model 570/571/572-K Series machines had been built and delivered to customers in nine countries worldwide, including military (naval) customers. The major non-naval customer nations of the machines include the **US**, **Mexico** and **France**.

Forecast Rationale

Outside the electric generation marketplace, the mechanical drive activity of the 570/571 is presently at a low level, owing to low activity in its traditional oil and gas markets. A moderately priced, stable oil supply and the availability of alternative energy sources (natural gas in particular) are taking an increasingly large share of the petroleum market. This situation is limiting the requirement for additional pumping capacity.

With cogeneration becoming increasingly important in an effort to control overall costs, and with the availability of dual-fuel cycle configurations, production of the Model 570 and 571 machines for generation use is expected to remain relatively constant in the forecast period. The machines may even find use in such novel applications as prime movers for cogeneration systems in municipal waste disposal and landfill gas-fueled generation. Dual-fuel-cycle machines could boost sales in the latter part of the forecast period.

The new Model 572-K is following the developing market demand for CHP, marine and compressor duty machines in the 6-10 MW class. The engine is not an updated variant of the Model 571 but a largely new, simplified, less expensive machine developed to expand Rolls-Royce Allison's product range to 11,000 horsepower (8.2 MW) within the next few years. This is where the company believes the market is headed, and this new engine is expected to provide the power band previously lacking from the assortment.

The parent group is also addressing the increasing regulatory requirements for low NOx machines by

making a Dry Low Emissions (DLE) combustion system standard with the Model 572-K. With help from parent Rolls-Royce and the new revenue sharing partners (see Model 572-K, above), the Model 572-K machines have the potential to become fairly substantial revenue sources for Allison after the initial ramp-up period. Most of the growth in the following forecast is based on the anticipated success of the 572 model in its different variations, land and sea. The 572-K faces tough competition, however, from the Solar Taurus 70 and Alstom Tempest, both of which are also posting buoyant sales.

In the decade extending through the year 2009, an estimated 282 Model 570/571/572-K gas generators and engines are projected to be built and delivered, with virtually all of the final activity being relegated to the packagers. Of that total, an estimated 89 will find use in the mechanical drive marketplace, especially for compression and pipeline drives. An additional 147 machines will be for fixed-base power generation and generator sets, with most of them for cogeneration or combined-cycle/cogeneration service. Another 46 machines are expected to be built for the marine propulsion market, propelling new-build surface craft and one-of-a-kind luxury vessels. Some military applications are possible as well.

However, the competition is tough against the likes of Vericor's TF50 and TF40 (as was the case with Sweden's corvette reengining project in 1999), ASE-8 and others. Even the French-Norwegian Eurodyn may be considered a competing product when considering new installation (depending on the power requirement and the room available).

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

Engine	(Application)	thru 99	High Confidence Level				Good Confidence Level				Speculative		Total 00-09
			00	01	02	03	04	05	06	07	08	09	
ALLISON ENGINE COMPANY													
570/571/572-KB	PWR. GENERATION	100	18	18	18	16	14	14	13	14	12	10	147
570/571/572-KC	MECHANICAL DRIVE	78	6	7	8	7	8	9	8	10	12	14	89
570/571/572-KF	MARINE PROP.	42	3	4	4	5	5	5	2	4	6	8	46
Total Production		220	27	29	30	28	27	28	23	28	30	32	282