The new ATP family – the optimum turbine for every application

Power station vendors are expected not only to have the product depth and know-how needed to supply complete plants and individual components but also to quote competitive prices and offer short delivery times whilst ensuring highest levels of flexibility and reliability. Over and above this, there is demand for compact turbine plants which can be run under a very wide range of service conditions. Industrial steam turbines are therefore optimized for specific production processes, requiring modifications which only a flexible, modular system can offer. To meet all of these requirements, ABB Power Generation Industry (PGI) developed the ATP steam turbine family for the power range of 2 to 100 MW. For unit ratings of up to approximately 40 MW, steam turbine packages designated ATP1 and ATP2, for frame sizes 1 and 2, are used. ABB Turbinen Nürnberg GmbH acted as project leader during the development of the packages.

German-based ABB Turbinen Nürnberg GmbH has been supplying complete turbine plants as well as individual plant components to the power industry for many years. During this time it has accumulated a wealth of know-how and experience in the combined cycle, steam and gas turbine power station sector, especially with plants having ratings of up to about 100 MW. The company's portfolio covers waste-to-energy and district heating power plants for communities and electric utilities, plus power facilities for companies in the chemical, petrochemical, metal processing, pulp and paper, foodstuffs and mining sectors. The installed plants supply these industries with process steam and energy or are used to drive their larger machines.

Compact turbine plants are in demand today which can be operated under a very wide range of service conditions. Customers expect short delivery times and competitive prices, high flexibility and absolute reliability. ABB's response to this challenge was to develop the modular ATP concept.

ATP stands for Advanced Turbine Program **1**, **2**, and is the new industrial steam turbine family of ABB Power Generation Industry (PGI) for plant ratings from 2 to 100 MW. The design of the ATP family is based on a future-oriented concept that unites innovative technology with proven components. It has allowed, for example, product costs and delivery times to be significantly reduced. The 14 to 18 months that were the norm for production of a steam turbine has been reduced with the ATP family to 12 months. Current efforts aim at a further reduction in the lead time to 8 months.

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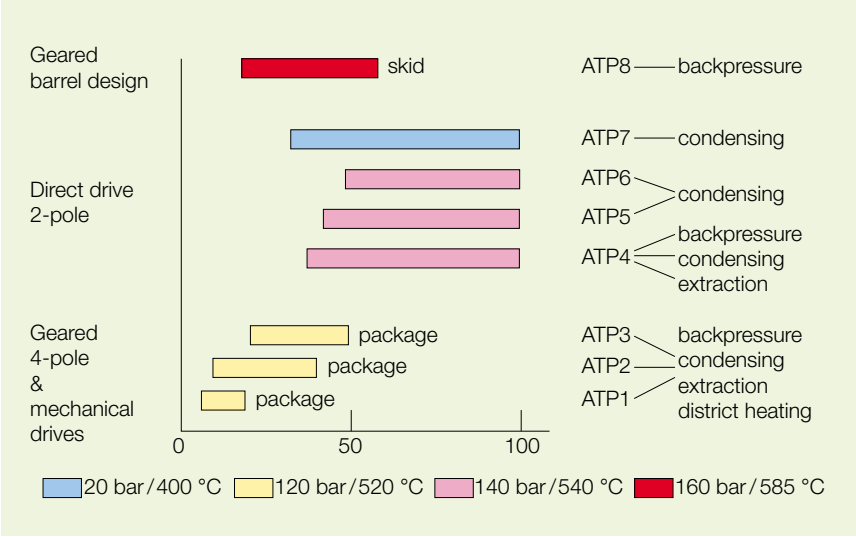
ABB Turbinen Nürnberg GmbH

The ATP1 and ATP2 series are preferably designed and built as complete packages rather than simply turbine units. Such a package consists of a baseframe with oil system, steam turbine, gearbox and generator, plus the option of a condenser. This arrangement allows ABB to offer complete solutions that can be customized to suit the special requirements of the plant operators. Precise definition of the interfaces between the ATP packages and the plant (eg, a combined cycle facility) avoids unnecessary project engineering work. At the same time, the modularity of the package allows considerable flexibility in the layout and combination of the components.

Short site-assembly times and low assembly costs are among the benefits of the package design. The use of standardized components provides the basis for economical solutions and short delivery times. Fully assembled in the factory, ATP plants are installed and commissioned on the customer's site in a very short time. Since the plants are designed primarily for installation at ground level, there is no need for costly foundations. In addition, the smaller space taken up by the equipment reduces the cost of the civil works.

In spite of the considerable cost reductions that are made possible by the new steam turbine family, the high quality and reliability of the plants remain unimpaired. Proven components are the guarantee of a high level of acceptance by customers and ensure that the plants will



Power ranges of the ATP steam turbine family **1**

also exhibit excellent reliability and availability in the future.

The ATP packages are designed to be used in steam turbine, combined cycle and district heating power plants, and also as mechanical drives. They are suitable for applications with maximum live-steam conditions of approximately 100 bar and 520˚C and, as an option, controlled steam extraction at a pressure of between 2 and 16 bar.

Customized plants of modular design

Thanks to the modular design principle that has been adopted, the ATP1 and ATP2 steam turbines cover the full power range with only two sizes of casing. By combining them with other turbine parts, a total of 30 turbine types can be offered. In all, 7 backpressure, 7 extraction-backpressure, 8 condensing and 8 extraction-condensing units are available **3**, **4**.

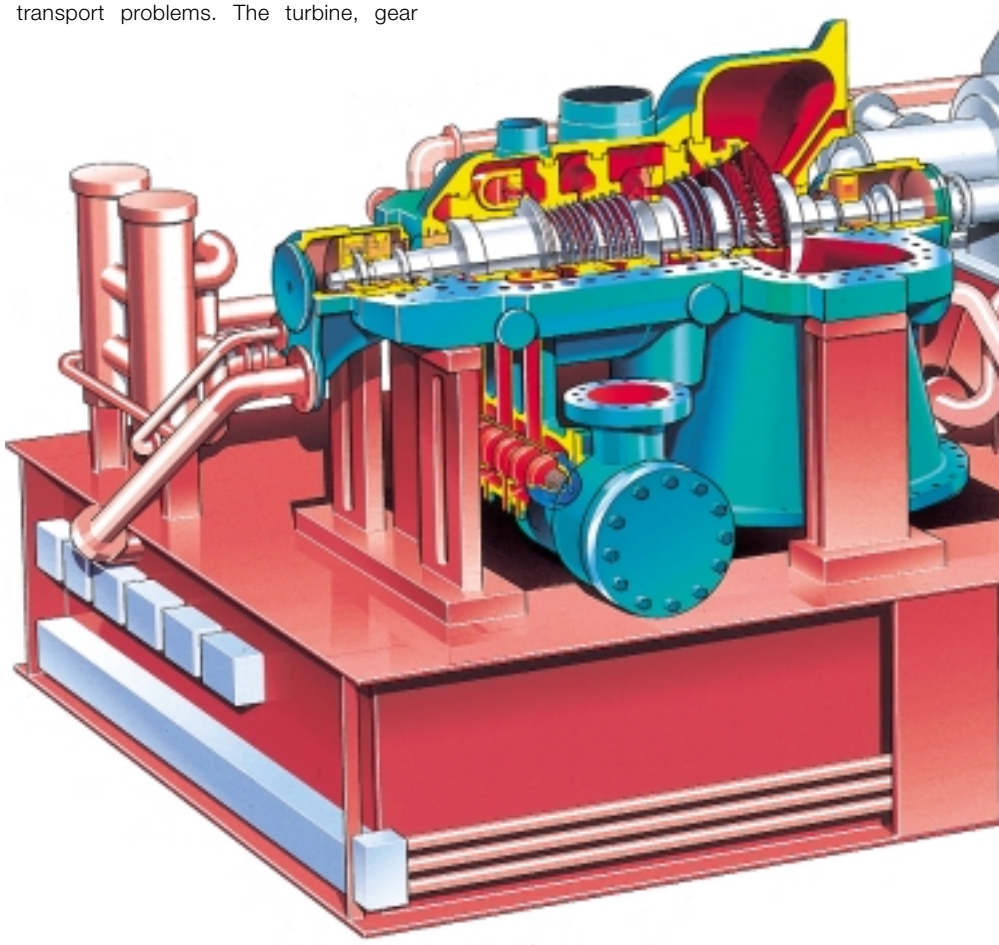
ATP combinations

The ATP turbine family in the power range from 2 to 40 MW features three different designs: ATP1 packages (approximately 2–16 MW), consisting of a baseframe (with integrated oil tank) on which the turbine, gear unit, generator and oil plant components are mounted already in the factory.

ATP2 partial packages (approximately 6–40 MW) are designed to overcome transport problems. The turbine, gear unit and oil plant components are mounted on a baseframe with integrated oil tank in the factory, while the generator is mounted on a separate frame or on a concrete foundation. Partial packages are transported separately and joined together on the site **5**.

As a third variant, all of the individual components can be installed separately. This variant is available for all types and outputs within the total power range.

Computer-aided means are used at an early stage of the tendering to determine the combination of turbine, gear unit, generator and oil plant, plus a condenser where necessary **6**. This defines the variant that will be used – package, partial package or separate installation. Packages and partial packages are delivered to the plant site preassembled and ready-to-install. The information concerning the connections to external systems and the other in-house instal-



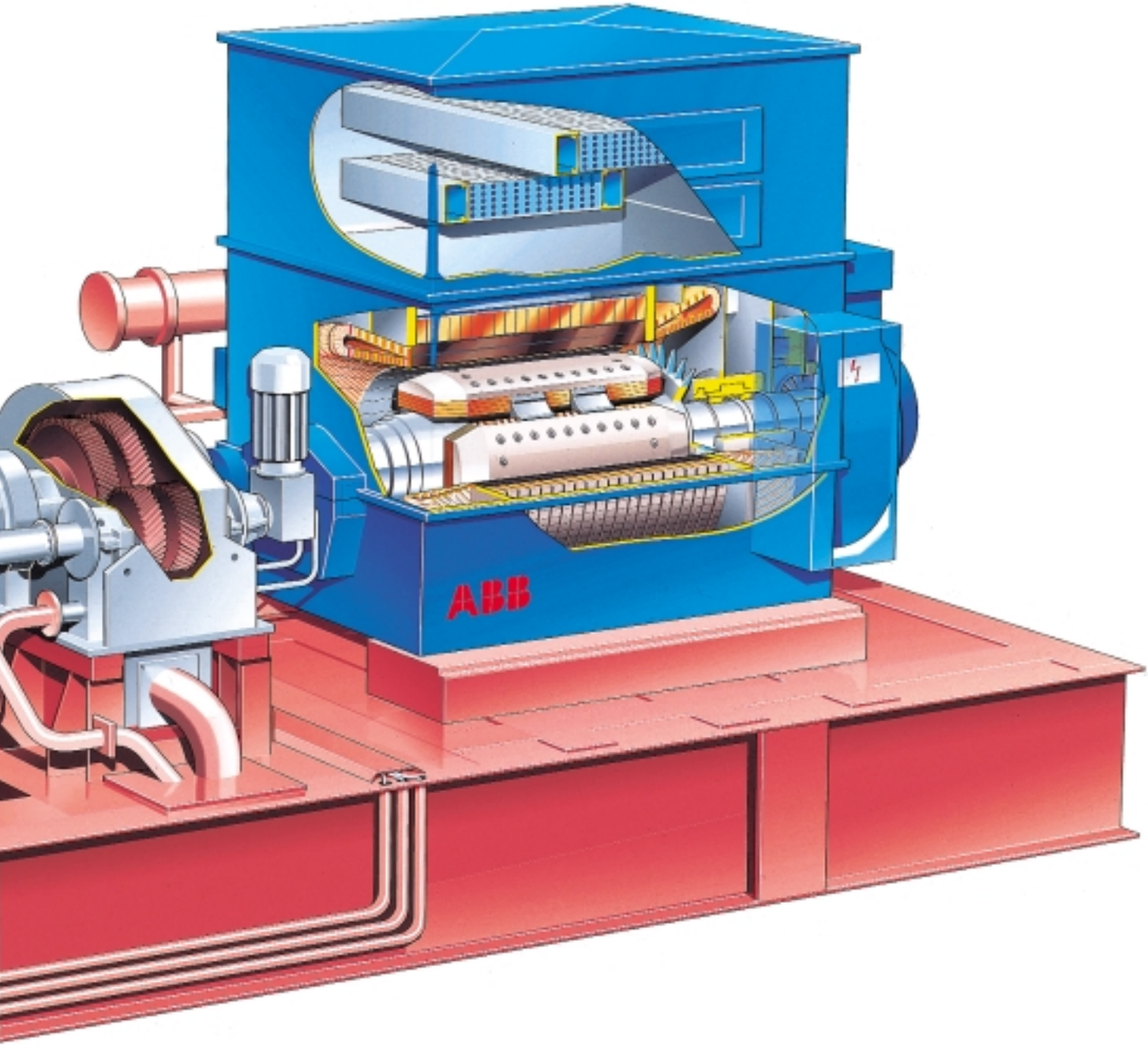
lations is taken from the interface definition and the project engineering documentation.

Design of packages and partial packages

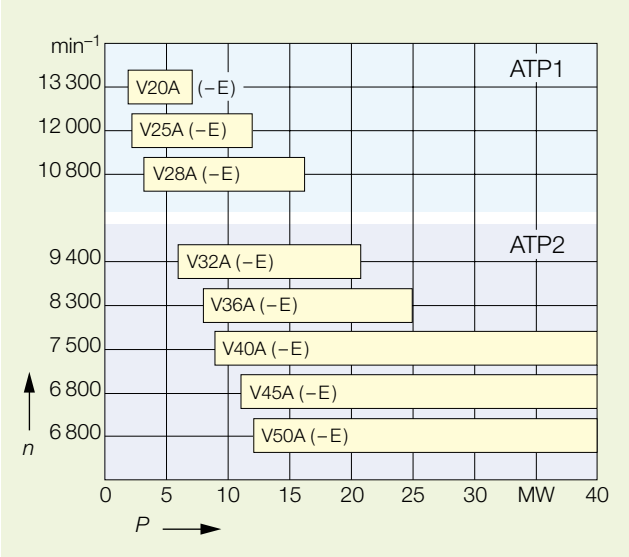
The ATP packages and partial packages largely comprise standardized basic components, the main ones being the baseframe, turbine casing, blading, gear unit, generator, oil plant, control valves and emergency trip valve as well as other key components, such as the TURLOOP® control system, that are necessary for safe and reliable operation of the turbine-generator installation.

Baseframe

The baseframe is constructed with I-profile beams, strengthened by bracing and extra supports at the component locations. An oil tank is integrated in the frame, which is designed for floor installation or for mounting on a table slab foundation.

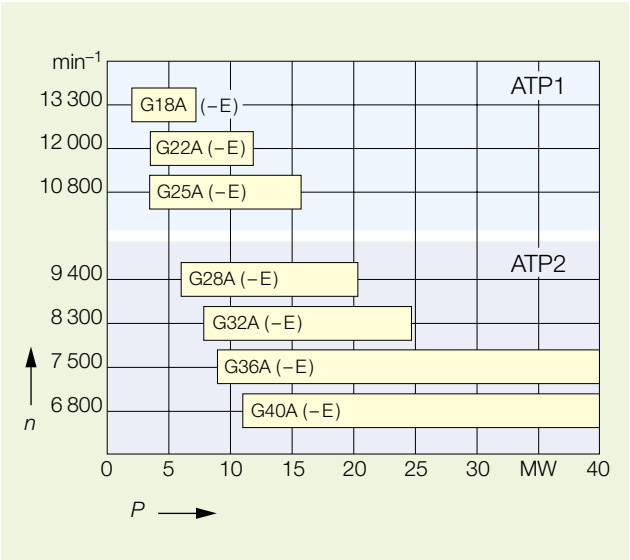


ATP1 steam turbine package (condensing turbine) **2**



Condensing turbines (V) with controlled extraction (–E) 3

n Rev/min *P* Power output



Backpressure turbines (G) with controlled extraction (–E) 4

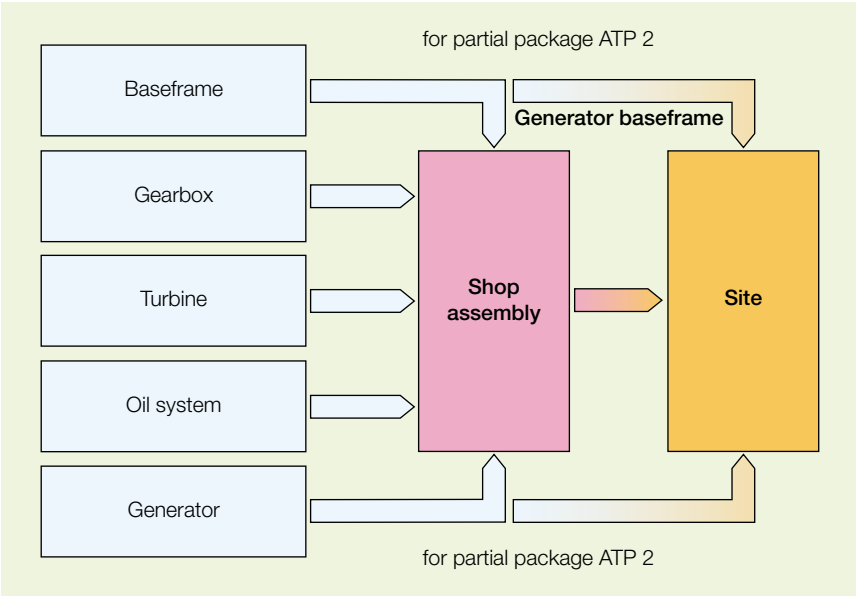
n Rev/min *P* Power output

Turbine design concept

The turbines feature well-proven, highly reliable blading. Their rugged, compact design and their low steam consumption allow high efficiencies to be achieved. The turbine unit is located at the front, on the right-hand side of the baseframe; below it is an opening for the exhaust steam exit. Also on the right-hand side are the steam and drain connections. (The direction of rotation is to the left when viewed from the turbine-gear unit.)

The layout conditions determine the choice of component modules, although in principle the basis for each layout is either the ATP1 or ATP2. The use of proven, standardized components ensures a high design standard and secures reliable operation for the operator. What is more, standard components combine the advantage of efficient, cost-effective production with broad flexibility in the design and layout of the plants.

Assembly of packages (ATP1) and partial packages (ATP2) 5



The steam turbine 7 is essentially defined by the following design features:

- Axial-flow, single-casing construction.
- Live-steam admission is possible from above, below, or the front end.
- Inlet and nozzle casings are joined by pipe nozzles with piston ring seals to reduce the stresses caused by thermal expansion.
- Thermoelastic suspension of thermally stressed parts, such as the guide blade carriers and nozzle casing, in the turbine casing.
- Steam exhaust can be directed upwards or downwards.
- Rotor constructed as a monoblock.
- Turbine is fixed by means of flexible supports.

- Turbine runs at high speed, being connected to the driven machine via a gear unit.
- Hot parts are insulated by means of asbestos-free mats.
- Guide-blade carriers have grooves into which the stationary blades are inserted.

Gear unit

The gearbox, with a double helical toothed spur gear offset to the left, is mounted in the middle of the baseframe 8. An enclosed oil sump, mounted in a self-supporting frame, is fitted as standard. Since the sump's sag is minimized, the oil can drain into the package through a pipe. The high-pressure oil infeed is on the left (on the drive side), and the oil exits downwards. The rotor turning unit and a force-driven main oil pump are coupled to the gearbox.

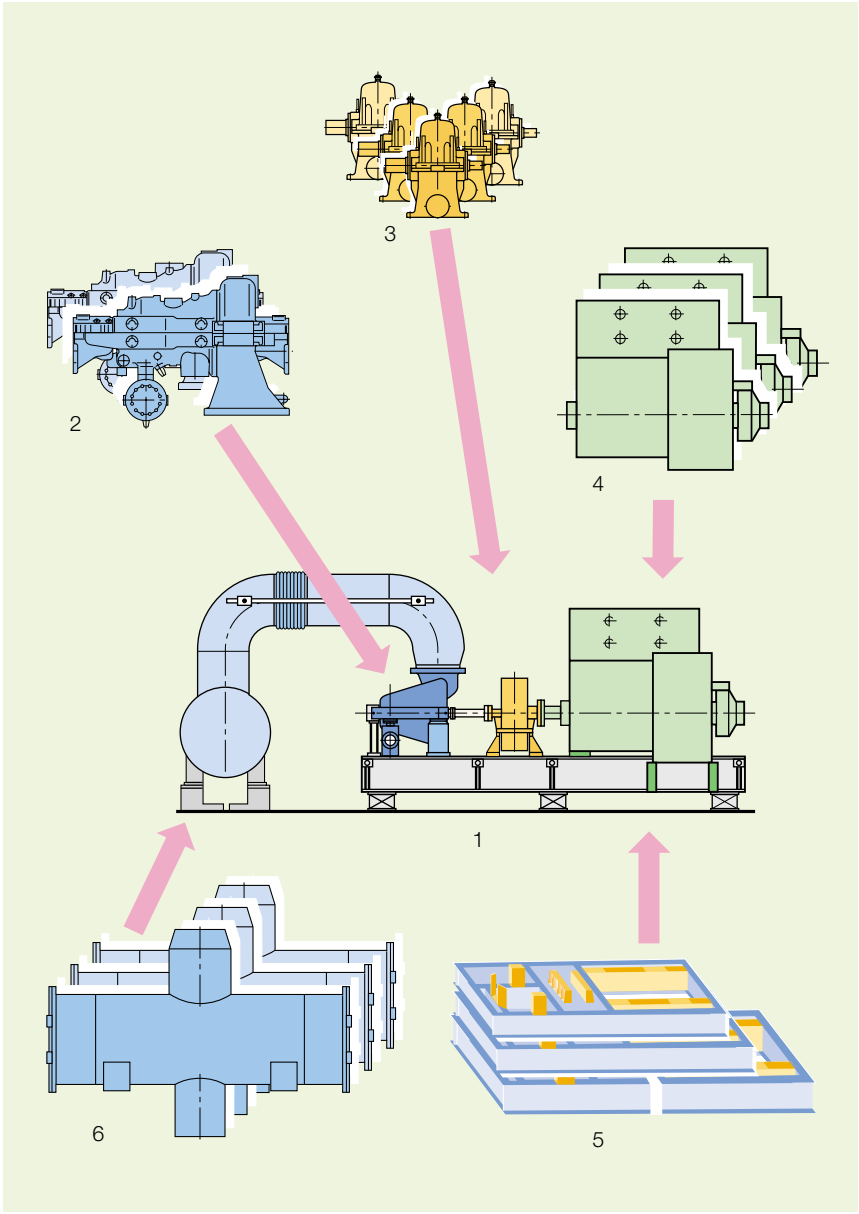
Generator

The generator is mounted towards the back of the baseframe (in the case of ATP2, in the middle) 9. A four-pole, three-phase synchronous machine [1] with end-shield bearing, the generator features built-on air/water coolers, salient pole rotors and a brushless excitation system. The main mechanical parts of the generator include the two-part casing with bearing and cooling system, the stator core and winding assembly, the rotor and the exciters.

The air/water heat-exchanger is located in the upper half of the two-part casing. As a rule, the generator cooling system is of double-flow design. The air for cooling the stator and the rotor is forced into the machine at both ends via two axial fans. The hot air exits radially at the center of the machine, being returned after it has passed through the air/water heat-exchangers. The lower half of the casing consists of the bearing support plates, side beams and a bottom plate.

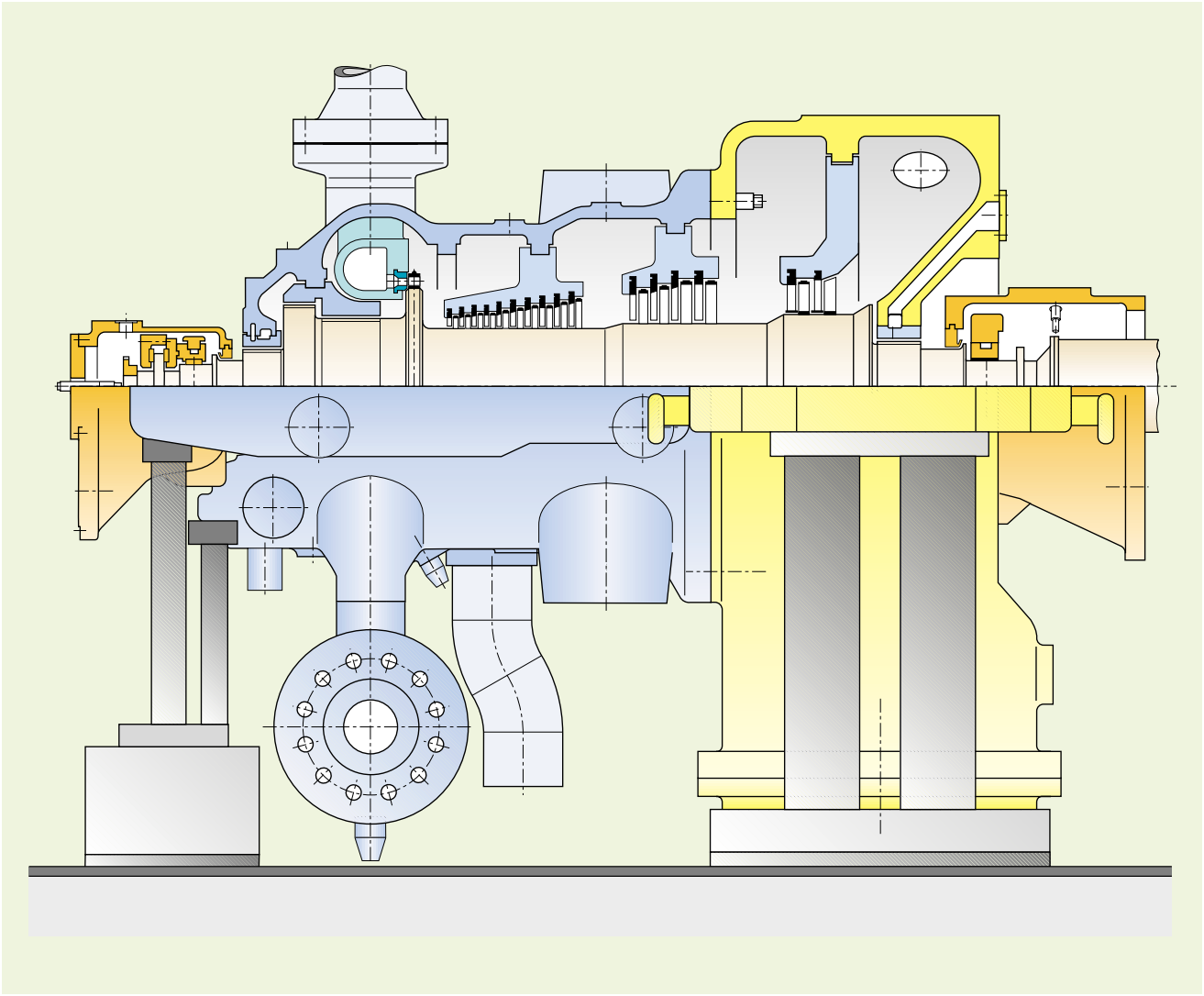
The stator core and winding assembly is designed as a separate unit and is inserted into the bottom frame-half. The stator core is pressed between two end plates and fixed with rectangular steel bars which are welded to the back. Very good rigidity is achieved by bolting the end plates to the side beams of the frame. Dynamic and static forces are transmitted to the foundation direct by feet located in the end-plate area. The double-layer, preformed winding is insulated using the proven MICAREX method. The entire stator core and winding assembly is vacuum-pressure impregnated (VPI) after the coils have been inserted, fixed and wired.

The rotor is of the salient pole type. Its shaft is manufactured in one piece from high-grade forged steel. Each pole is surrounded by a single-layer coil made of heavy copper bar. The coils are pressed

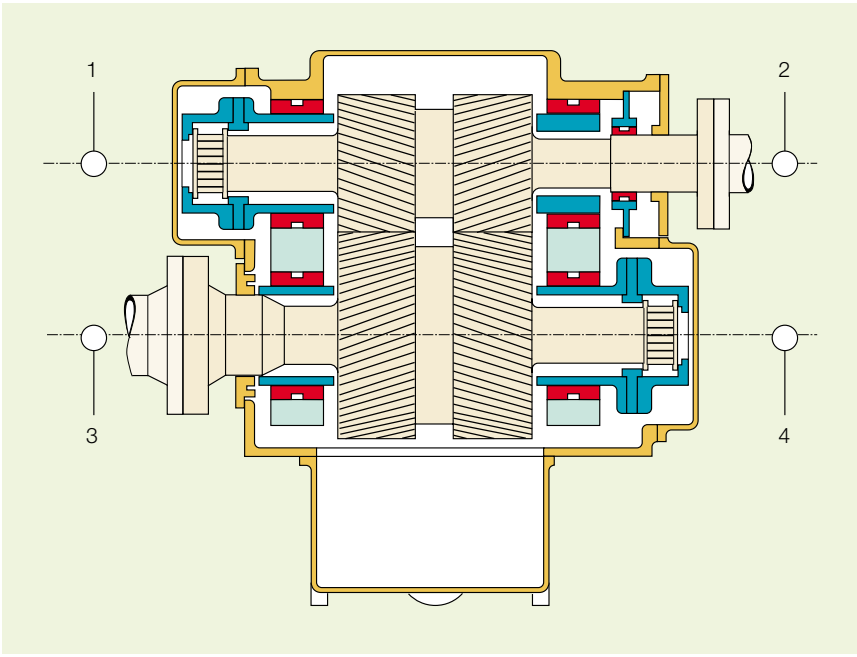


Possible combinations of the ATP1 and ATP2 packages 6

1 *Condensing turbine package*
2 *Steam turbine*
3 *Gear unit*
4 *Generator*
5 *Baseframe*
6 *Condenser*



ATP2 backpressure turbine with extraction of steam for heating purposes **7**



Double helical spur gearing **8**

1 *Turning gear*
2 *Turbine*
3 *Generator*
4 *Main oil pump*

together and cured under heat and pressure. They are insulated from the pole shoes and the magnet wheel by sleeves made of glass-fiber laminate. The switching and connection leads are insulated and braced. The connection leads to the brushless exciter are located inside the shaft, from which they are insulated by being embedded in silicon rubber.

Oil unit

The oil supply system has to secure a reliable supply of lubricating oil for the bearings under all circumstances and also provide the auxiliary energy for the control and safety system hydraulics. In the case of the packages and partial packages, the oil unit is integrated in the baseframe; when the components are installed separately it is set up on its own 10.

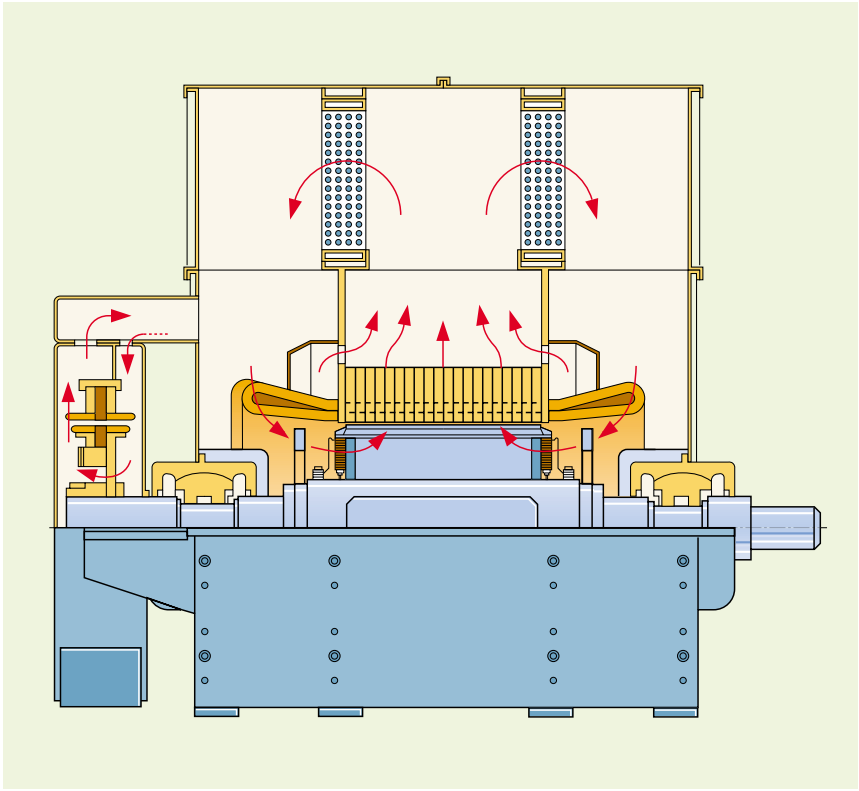
Three different oil tanks sizes (4,000 l, 7,000 l and 10,000 l) are available, corresponding to the oil unit standards of ABB Turbinen Nürnberg GmbH. The oil cooler is mounted either on the baseframe or on brackets fitted to the side of the baseframe. It can be dismantled for transport.

Condensing plant

The condensers used for ATP package units are of single-, two- or four-pass design. The condenser can be mounted at the height of the package (or partial package), being positioned either on the right-hand side or at the front. In cases where it is planned to use a table slab foundation, the condenser can be positioned underneath the package. It is mounted rigidly or on spring supports, depending on the arrangement of the package (partial package).

Complete ATP steam turbine package

An ATP steam turbine package is a factory-assembled unit, complete with piping and wired ready for operation 2.



4-pole ABB generator with air/water cooling 9

Such a package consists of:

- Turbine
- Gear unit
- Generator
- Oil unit

These components are mounted on a baseframe with integrated oil sump.

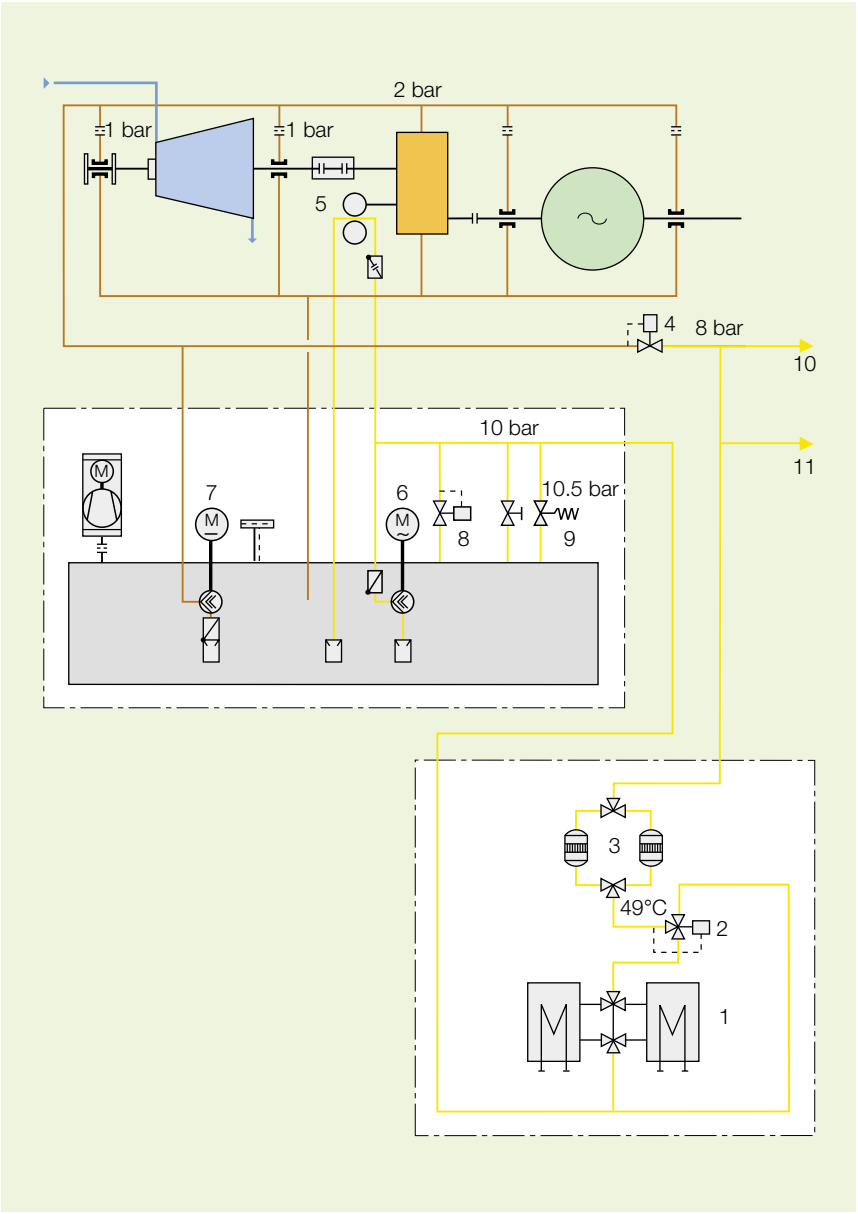
Several of the turbine components, for example the bladed rotor and the stationary blade carrier, cannot be standardized as they are project-specific. Instead, they have to be custom-built and optimized for the respective production process. CAD/CAM tools act as interfaces between the design and production offices and help to ensure that the components are manufactured exactly to the customer's specifications.

Data processing software for optimizing the blade channels provides the input data for the CAD programs. It generates drawings of the rotor and of the blading automtically and also produces the data needed by the CNC machines in the workshops. Components with critical time schedules, such as the cast metal casings and forged rotor, can therefore be ordered from the shops just days after the contract is signed, eliminating the cost of keeping such parts in stock.

Some applications for turbine generator packages

Compressor drives

One of the possible uses of an ATP steam turbine is as a compressor drive turbine in the chemical and petrochemical industries. ABB has been supplying this market for several years. Although turbines for driving compressors 11 are only slightly different to those used with generators, the range of requirements differs in some major ways. For example, high, widely varying speeds cause stress loads which are considerably higher than for generator drive applications, in which the speed is constant. Operators of tur-



Line diagram of the low-pressure oil system 10

1 *Oil cooler*
2 *Control valve for keeping the temperature constant at 49 °C*
3 *Oil filter*
4 *Pressure control valve*
5 *Main oil pump*
6 *Auxiliary oil pump*
7 *Emergency oil pump*
8 *Pressure control valve*
9 *Safety valve*
10 *To control system*
11 *To turning gear oil system*

bines used to drive compressors place a very high value on their dependability. This is not surprising, as often complete production lines depend on reliable operation of the compressor plant.

A key component in the reliability of the turbine is the blade design, which has to ensure that no dangerous resonance can occur. The blade characteristics are basically the same as those of the proven blading in the units that preceded the ATP. To prevent dangerous resonance, high-strength materials are used, while the blades in the upstream part of the turbine have vibration-damping shrouds fitted to them. Damping wires protect the blades in the low-pressure section from vibration.

ABB ensures excellent running quality by balancing the turbine blades at high speed under vacuum. The use of pivoted-pad bearings having good damping properties also improves the running quality. In addition, the entire shaft train's behaviour under torsional vibration conditions is tested for the purpose of determining, and eliminating, any signs of dangerous resonance phenomena.

Combined cycle plants

ATP turbines are very well-suited for use in combined cycle facilities. The single-shaft configuration, in which the generator is driven by the gas and steam turbine together, is a very successful design concept that ABB has used for projects in Germany and in the Netherlands. The gas turbine installed in each case is the ABB GT10 [2]. With its dry-low NO_x combustion chamber, this turbine exhibits the lowest pollutant emissions in its class. When steam is also extracted for heating purposes, fuel utilization can be as high as 88 percent.

The exceptional success of this concept is the result of the combination of high efficiency and low emissions. What is more, service costs are lower, mainly because the GT10 industrial gas turbine replaces what is often nothing more than an aeroderivative unit not designed originally for such applications.

Potsdam South combined heating power plant handed over after only 24 months

The requirements of the German utility *Energieversorgung Potsdam GmbH* (EVP) when awarding the contract for the Potsdam South combined heating power plant [3] were as follows:

- High reliability and availability
- Optimum total efficiency
- Good performance under part-load conditions
- Low emissions

- Fast completion of site construction work

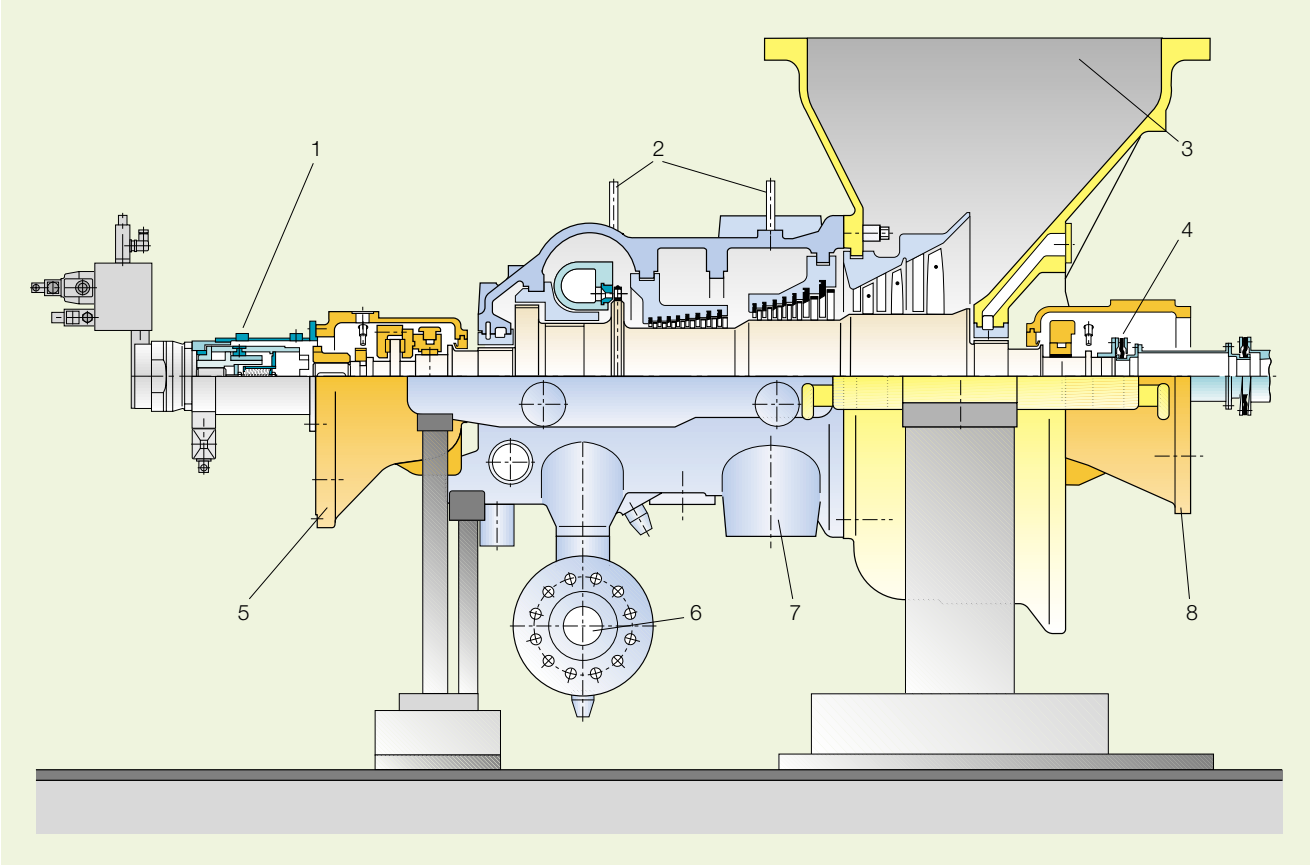
These requirements could be met by a cogeneration power plant producing heat and electrical power. Only 24 months (including the time needed to gain approval) lay between the contract being awarded and turnkey hand-over of the plant in December 1995. Potsdam South, which replaces an older plant on the same site, generates 84 MW of electrical power and has a thermal power rating of approximately 275 MW – values which are tailored exactly to the requirements of the Potsdam area. The power plant is able to meet the total electricity demand and about 85 percent of the city's district heat requirements. Reasons for ABB winning this contract included the plant's very good economy, the guaranteed fast completion of the project, the low emissions made possible by the innovative dry-low NO_x burner technology, high plant availability, and the good experience with similar plants built by ABB. The new CHP plant, which can burn natural gas as well as light fuel oil, is capable of a fuel utilization of 87 percent with cogeneration.

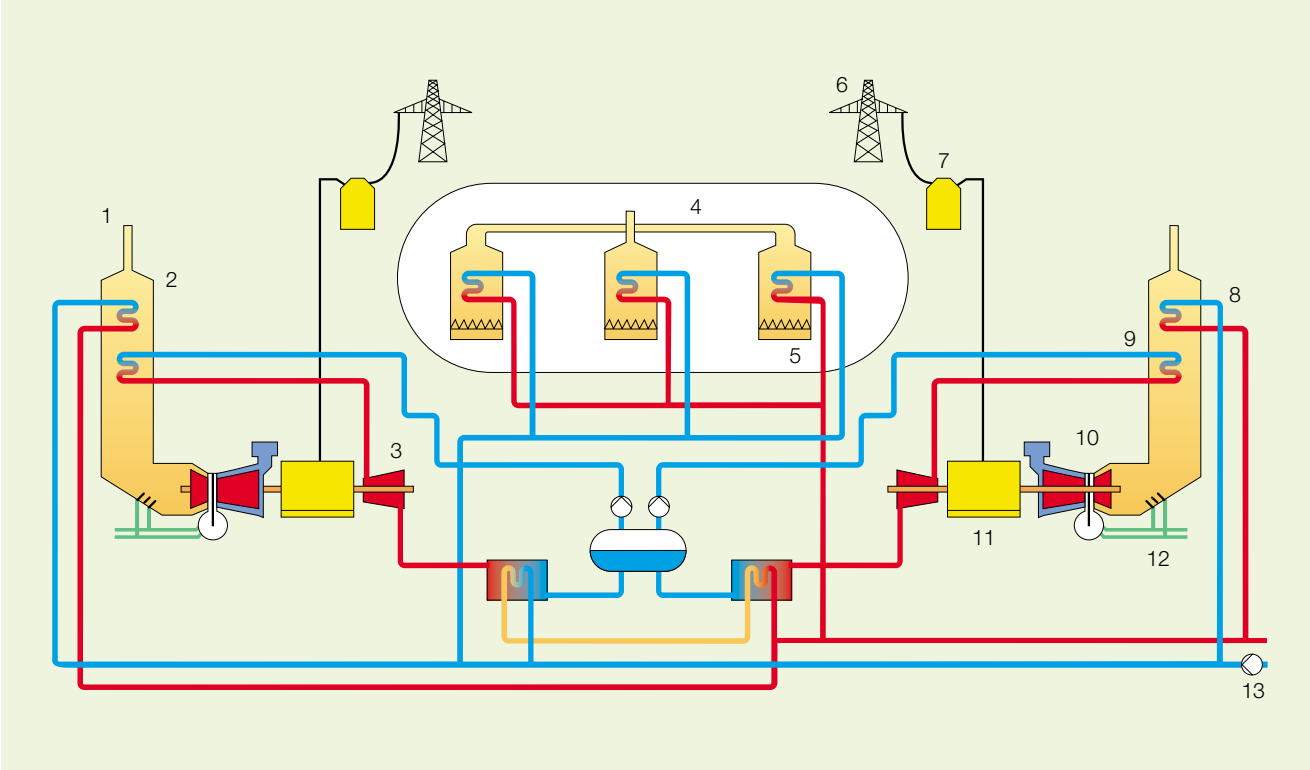
The base-load facility of the new plant consists of two combined cycle units. Each unit comprises a GT10 gas turbine and a 15-MW condensing turbine of type V32A from the ATP family, which is used as a district heating turbine **12**. Heat for the district heating system is provided by two heating condensers rated at 80 MW_{th}, two heat-exchangers in the heat-recovery boilers rated at 15 MW_{th}, and three hot-water boilers rated at 180 MW_{th}. In addition, there is a peak-load district heating plant with three hot-water boilers. Besides the energy conversion plant, ABB also supplied the electrical and control equipment (Procontrol P) for the entire plant. A special feature of the combined cycle facility is that the gas and steam turbine drive the generator via a single shaft train. This allows a high energy density within a very small space; a length of 32 m is all that is needed for both of the turbines and the generator.

The combined cycle power plant generates heat and electrical power simultaneously. The exhaust exiting the gas turbine at about 500°C is used to produce

ATP1 condensing turbine for mechanical drive applications **11**

1 *Non-drive end with electrohydraulic turning gear*
2 *Openings for inspections*
3 *Exhaust flange*
4 *Drive end with diaphragm coupling*
5 *Front bearing housing*
6 *Steam inlet valves*
7 *Opening for steam extraction or steam admission*
8 *Rear bearing housing*





Heat flow diagram of the Potsdam South combined cycle cogeneration plant 12

1 *Stack*
2 *Heat-recovery boiler*
3 *Steam turbine*
4 *Hot-water boiler*
5 *Fuel gas*
6 *HV grid*
7 *Transformer*
8 *District-heat exchanger*
9 *Steam generator*
10 *Gas turbine*
11 *Generator*
12 *Supplementary firing*
13 *Potsdam district heating network*

steam in the heat-recovery boiler. Auxiliary firing is possible, allowing the exhaust-gas temperature in the heat-recovery boiler to be raised to about 750˚C in order to meet any increases in demand for heat and electricity.

The new plant in Potsdam exhibits a constant efficiency in part-load operation. This is achieved by regulating the air flow into the combustion chamber by means of adjustable compressor stages in the gas turbine. The new dry-low NO_x burners reduce the formation of nitrogen oxides considerably. The combined cycle facility offers not only high fuel utilization and low emissions but also high flexibility for fast adaptation to variations in the power and heat demand that can occur with changes in the weather.

ATP – design concept with a future

With its ATP family, ABB offers power utilities future-oriented turbines with proven components that guarantee very high reliability. Its success speaks for itself: since being introduced in mid-1993, orders for more than 25 ATP1 and ATP2 units have been received worldwide. This success has led to ABB extending the power range of the ATP family to approximately 100 MW. The new ATP steam turbine series, dubbed ATP3 to ATP8, was introduced to the market in February of this year (1996) in Prague, Czech Republic.

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[1] ABB Drives: GBA Synchronous generators. (Brochure)
[2] ABB STAL: The economic production of heat and power, gas turbine GT10. (Brochure)
[3] ABB Turbinen Nürnberg: Heizkraftwerk Potsdam. (Brochure)

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