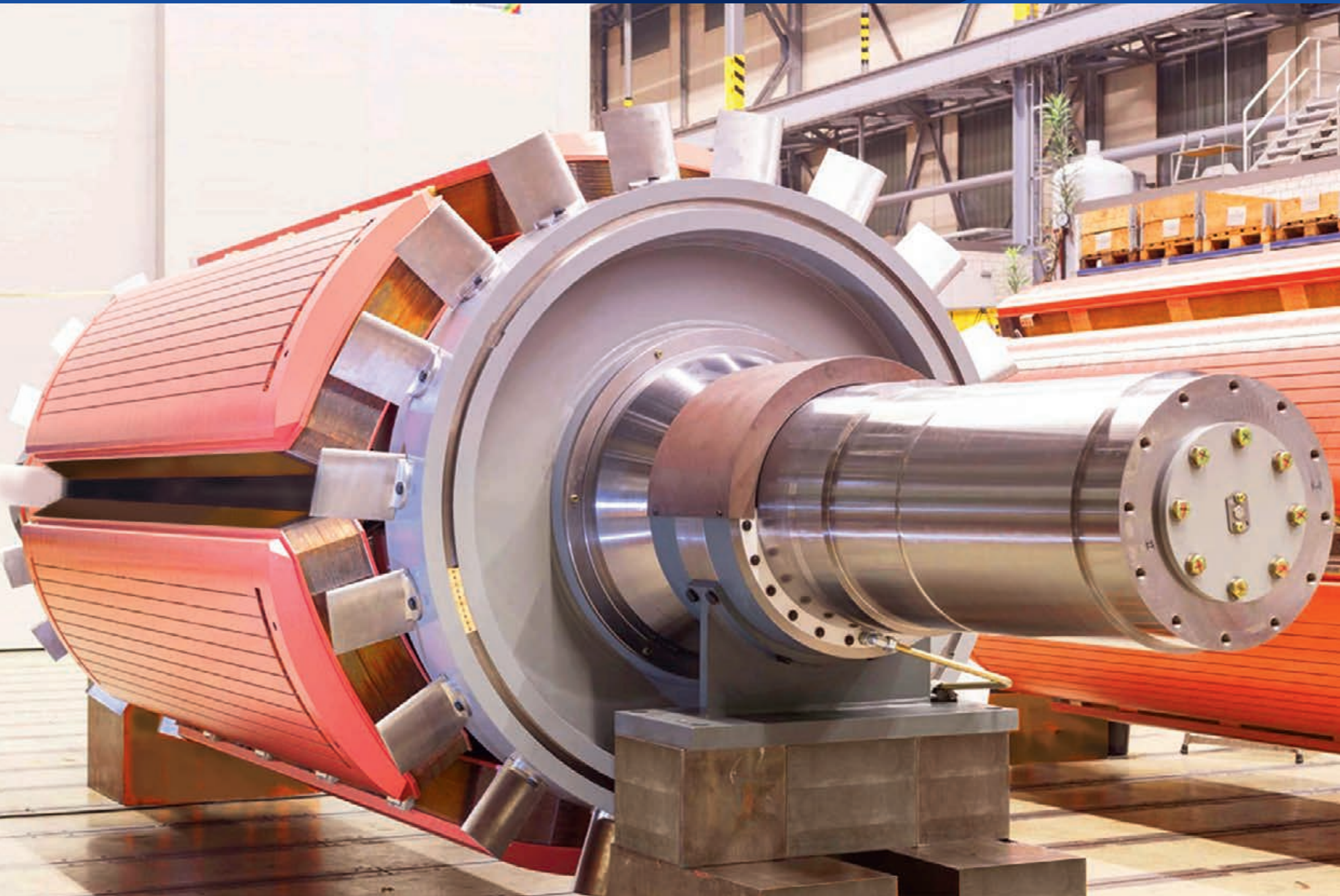
VOITH

Synchronous Condensers

The intelligent solution for the complexity of modern grids



Today's challenge: Ensuring grid stability

A synchronous condenser can seamlessly transition between supplying reactive power and absorbing reactive power.

Grid stability is a must, not an option.

Electrical energy is essential to modern life because it powers the technologies and systems that drive prosperity, enable social progress, and strengthen the wealth and well-being of communities, making the stability of the power grid a critical foundation for sustaining these benefits.

The increased participation of non-dispatchable sources, such as wind and solar, in the energy system, along with the construction of long transmission lines with High Voltage Direct Current (HVDC) technology, has created additional needs for reactive power, inertia, and short-circuit capacity to stabilize the grid.

Synchronous condensers stand out for their reliability, proven performance, and attractive cost-benefit. Unlike static solutions, they are rotating machinery, which enables them to deliver much more than just reactive power. They play a key role for grid stability in case of large disturbances, helping to avoid blackouts or brownouts.

Typically installed at substations at the end of large transmission lines or at critical connection nodes, AC/DC converter stations, or at large electro-intensive consumers, synchronous condensers add physical inertia, stabilizing the grid against frequency fluctuations and keeping the Rate of Change of Frequency (RoCoF) low, even in case of sudden shifts in power generation or consumption. If required, the inertia can be further expanded by integrating external flywheel systems.

They also provide high short-circuit power to trigger protective breakers, which static systems cannot deliver. Synchronous condensers can deliver fault current levels as high as five times their nominal rating.

Their reactive power output increases when voltage decreases, making them superior to static devices for voltage regulation during faults. Unlike static capacitor banks, which only supply reactive power and cannot absorb it, a synchronous condenser can seamlessly transition between supplying reactive power (acting as a capacitor) and absorbing reactive power (acting as an inductor) by adjusting its field excitation. Synchronous condensers are specially designed to provide an extended, time-limited overload capability, sustaining an additional 50% output or more for up to 30 seconds or even longer.

Expertise in large-scale power generation

With more than 150 years of experience in the power generation business, Voith has manufactured thousands of electrical machines, including some of the largest and most powerful generators and motor-generators in the world. Machines with high inertia and grid-stabilizing characteristics have always been part of our core business, and this technology is fully incorporated into our synchronous condensers.

Their development has benefited from our many engineering centers and laboratories for electrical machine technology, as well as the most advanced methods available, such as Finite Element Analysis (FEA) for both two- and three-dimensional electromagnetic and frequency simulations. Additionally, Computational Fluid Dynamics (CFD) methods were used to optimize air circulation and thermal management.

Voith synchronous condensers

The Voith salient pole machine design offers major advantages compared to other concepts based on cylindrical rotors. The larger inertia provides high grid stability, requires less maintenance, and is easier to service. They have an outstanding smooth operation with very low vibrations in the shaft line system

Salient pole machines have lower losses and provide a wider under-excited (leading operation) capability. They also offer improved voltage support during the most severe faults (such as 3-phase or 2-phase short circuits). Since they do not require a hydrogen environment for operation, they are inherently safer and much easier to maintain.

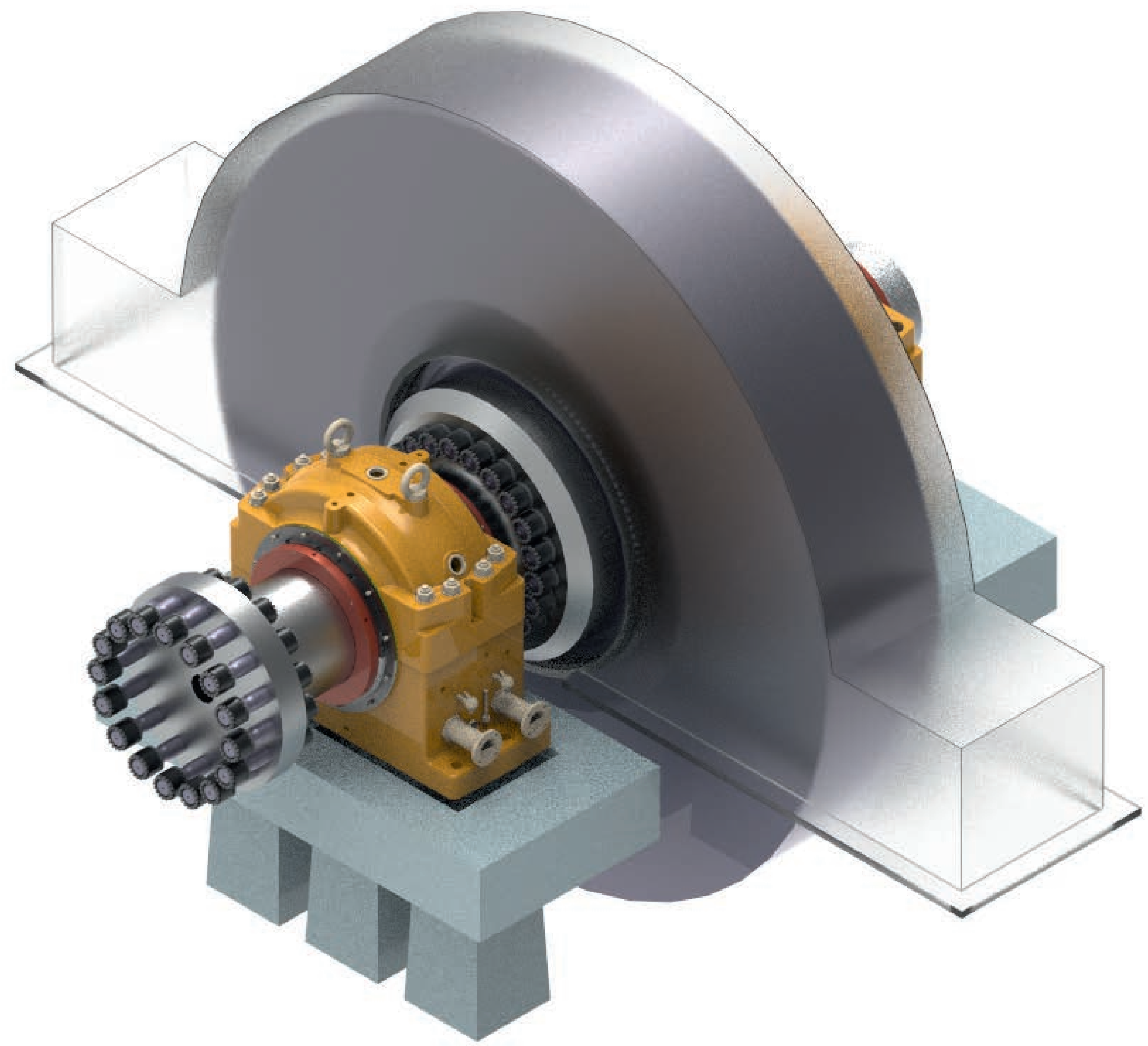
The Voith solution offers concrete benefits to its customers:

- Standardized equipment and systems
- Wide application range (more than 300 Mvar)
- Projects designed with high reliability factors
- Engineering and R&D expertise.
- All parts are modeled in accordance with BIM standards.
- On demand, a dedicated current injection method ensures suitable loads on the brushes regardless of the machine's output, reducing brush wear and carbon dust.

Selecting a Voith synchronous condenser

All Voith standard synchronous condensers share the following characteristics:

- The active parts have the same dimensions and masses, the same number of slots, bars, poles, for both applications at 50 or 60 Hz.
- Machines are horizontal, three-phase, AC-type, air-cooled, and designed with either an open-circuit or closed-circuit cooling system and static excitation. The starting method is via an SFC. One SFC can start several machines in sequence avoiding the need of one pony-motor for every machine, thus reducing losses and maintenance efforts.



Typical flywheel on its shaft and bearings

If the inertia provided by the rotor of the machine is not sufficient to cope with the grid needs, a flywheel of adequate size can be supplied. It is mounted on its own shaft and supported by two additional bearings. Inertia constant H up to 10 s or more are doable. In the standard execution the flywheel spins in atmospheric pressure air avoiding vacuum chamber, sealing system and pumps, thus reducing maintenance efforts

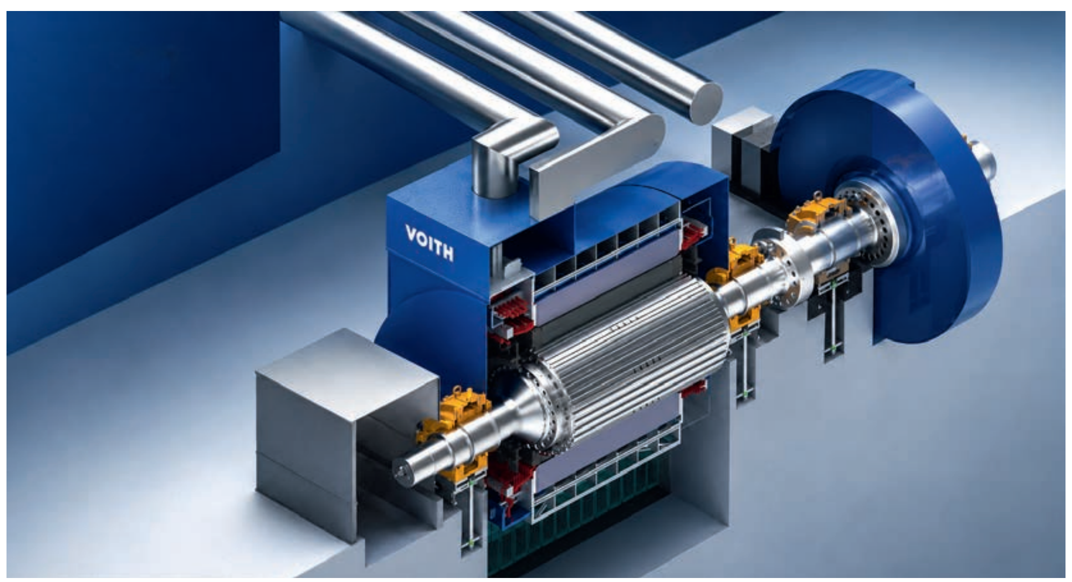
Voith synchronous condensers are designed for both indoor and outdoor installation. For outdoor installations, the machine must always be completely enclosed (TEWAC: Totally Enclosed Water-to-Air-Coolers), with water-to-air coolers installed in the machine and external coolers to cool down the water used for the cooling of the internal air in the machine.

Riel substation

In the TEWAC design, the cooling system is a closed-loop type, i.e., cooling air circulates in a closed circuit inside the machine. Cold air from the water-to-air coolers enters axially on both sides, due to the negative pressure created by axial fans. After thermal exchange, the hot air returns to the water-to-air coolers, and the cycle continues. The cooling water also circulates in a closed circuit, either to a dry-cooler system – where radiators with electric fans blow ambient air to cool the water to the designed temperature – or to a wet cooling tower. The dry-cooler system or wet cooling tower is always installed outside, even for indoor installations.

For indoor installation, the machine is installed inside a shed, and either an open or closed cooling system can be used.

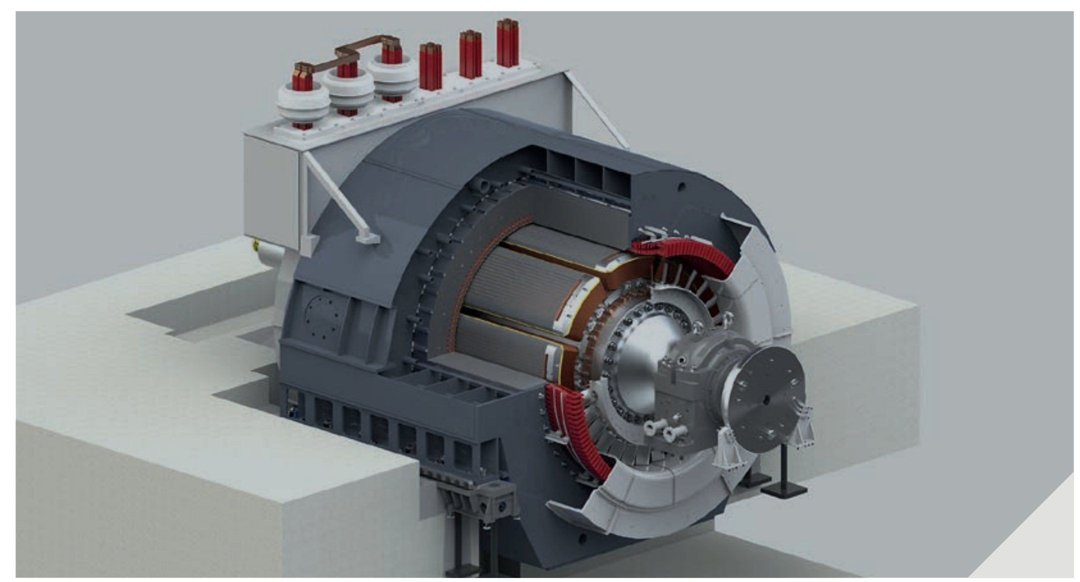
In the open-loop cooling system, no water-to-air coolers or external coolers are necessary. Cold air is drawn from outside the shed by the negative pressure created by axial fans. At the entrance to the shed, the air passes through shutters and filters installed on the wall. After thermal exchange, the hot air is expelled on the opposite side through a duct. Noise dampers are installed at the end of this duct.



Closed loop cooling system

In open-loop cooling systems, the cold air temperature is always equal to the ambient temperature. For example, if the ambient temperature is 40°C, the cold air inside the machine will also be at 40°C.

In closed-loop systems, if the ambient temperature is 40°C, this will be the cooling air temperature at the dry-cooler system. Consequently, the water temperature in the water-to-air-coolers will be higher than 40°C, and the cooling air inside the synchronous condenser can be up to 15°C higher than the ambient temperature — i.e. up to 55°C. In locations where the ambient temperature is always low, and it is possible to maintain the water temperature at or below 30°C, the synchronous condenser overexcited outputs (Mvar) can match those of the open-loop cooling system, as shown in the table.



Open loop cooling system

Complete solution

As a leading energy solutions provider, we cover everything from synchronous condenser units onwards. With a proven track record in handling large-scale projects globally, we provide a reliable partnership for complex endeavors, optimizing plants to meet grid requirements. As a full-line supplier, we ensure plant optimization, leveraging advanced simulation tools for cost-effective solutions and superior project management. Voith's expertise in grid stability studies and plant integration makes us the trusted partner for all requirements.

Voith ensures plant reliability and safety through long-term operation and maintenance contracts, supported by our OnCare monitoring system. Smart asset management and predictive maintenance minimize unplanned outages, while our automation and control systems guarantee safe and optimized plant operation. We cover all operational and control modes of synchronous condensers, empowering our customers to maximize their assets' availability with total confidence.

Voith supplies the complete scope:

- Control systems, monitoring and protection
- Starting and braking systems
- Cooling systems
- Electrical and mechanical auxiliary systems
- Layout studies, as requested
- Assembly and commissioning
- After market services and spare parts
- Flywheel (if required)

Product portfolio

VHSC 150

Inner coolant	Air			
Max. ambient temperature	40 °C			
Temperatures	Class 130			
Overload capacity	1.5 x rated current for 30 s			
Frequency	50 Hz		60 Hz	
Rated speed	750 rpm		900 rpm	
Rated voltage	11.5 kV		13.8 kV	
Cooling type	Open loop or TEWAC (water ≤ 30 °C)	TEWAC with dry coolers	Open loop or TEWAC (water ≤ 30 °C)	TEWAC with dry coolers
Overexcited output at rated voltage (at step-up transformer leads)	135 Mvar	125 Mvar	165 Mvar	150 Mvar
Underexcited output at SC rated voltage at GSUT HV leads and If_{min} ~ 0.1 If0	100		120	
Short-circuit power at GSUT HV leads	525 MVA		625 MVA	
Inertia constant H at max. overexcited output (at SC leads) without flywheel	1.9 s	2.1 s	2.3 s	2.5 s
Inertia constant H at max. overexcited output (at SC leads) with flywheel	up to 10 s			
Excitation type	Thyricon 500			
Noise level (ISO 3746)	85 dBA at 5 m from shed	85 dBA at 1 m	85 dBA at 5 m from shed	85 dBA at 1 m

VHSC 300

Inner coolant	Air			
Max. ambient temperature	40 °C			
Temperatures	Class 130			
Overload capacity	1.5 x rated current for 30 s			
Frequency	50 Hz		60 Hz	
Rated speed	750 rpm		900 rpm	
Rated voltage	12.5 kV		15.0 kV	
Cooling type	Open loop or TEWAC (water ≤ 30 °C)	TEWAC with dry coolers	Open loop or TEWAC (water ≤ 30 °C)	TEWAC with dry coolers
Overexcited output at rated voltage (at step-up transformer leads)	250 Mvar	225 Mvar	300 Mvar	270 Mvar
Underexcited output at SC rated voltage at GSUT HV leads and If_{min} ~ 0.1 If_0	190		240	
Short-circuit power at GSUT HV leads	1,050 MVA		1,250 MVA	
Inertia constant H at max. overexcited output (at SC leads) without flywheel	2.6 s	2.9 s	3.2 s	3.5 s
Inertia constant H at max. overexcited output (at SC leads) with flywheel	up to 10 s			
Excitation type	Thyricon 500			
Noise level (ISO 3746)	85 dBA at 5 m from shed	85 dBA at 1 m	85 dBA at 5 m from shed	85 dBA at 1 m

Design and tolerances according to IEC 60034-1 / IEC 60034-3 / IEC 60034-33. GSUT (Generator Set-Up Transformer) taps with OLTC (On-Load Tap Changer) at the High-Voltage side with tap range sufficient to keep the voltage in the rage of +/-5 % of the rated value.

References in recent years

1974
Dutra I/II, Brazil
100 Mvar, 02 Units

1978
Recife II, Brazil
150 Mvar, 01 Unit

1982
Teresina II, Brazil
150 Mvar, 01 Unit

2017
Terminal Rio, Brazil
-75 / +150 Mvar, 02 Units

2017
Rurópolis, Brazil
-55 / +110 Mvar, 01 Unit

2017
Tapajós, Brazil
-75 / +150 Mvar, 01 Unit

2015
Riel, Canada
-125 / +250 Mvar, 04 Units

2016
Janaúba, Brazil
-90 / +150 Mvar, 02 Units

2017
Ariquemes, Brazil
-90 / +150 Mvar, 01 Unit

2017
Ji-Paraná, Brazil
-90 / +150 Mvar, 01 Unit

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