

Brochure

# Synchronous motors

## High performance in all applications

We provide motors, generators and mechanical power transmission products, services and expertise to save energy and improve customers' processes over the total life cycle of our products, and beyond.



# Synchronous motors from the world's leading supplier

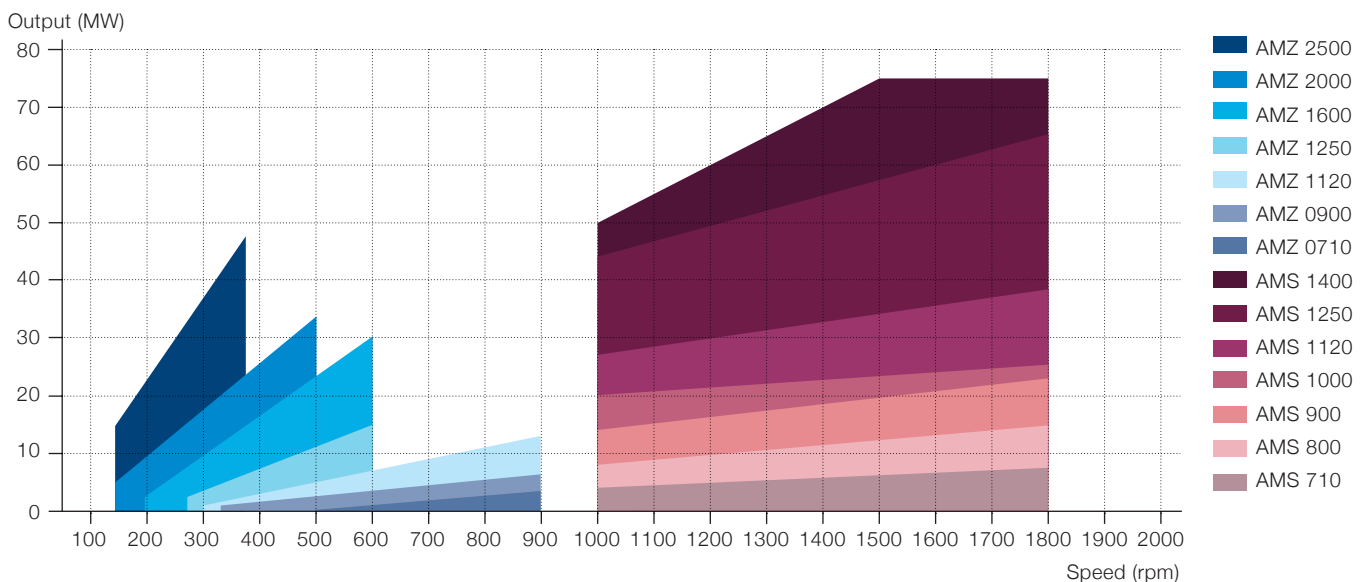
## Choose ABB efficiency and quality

ABB is the world's leading supplier of synchronous motors and generators. We have been designing and building AC motors for mission-critical applications for over a century, and our know-how and experience have made us the preferred supplier in many different industries.

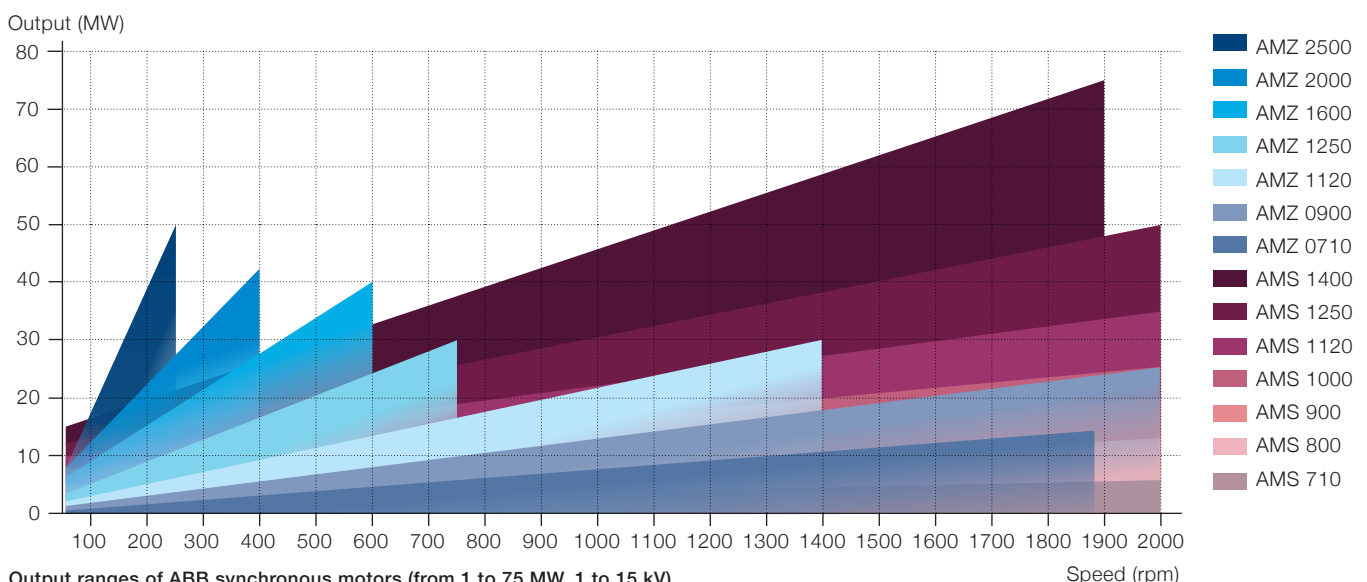
Our synchronous motors are delivering high performance in industrial processes, the marine and offshore sectors, utilities and specialized applications all over the world. In every case we work with our customers, using our expertise in different applications to tailor the optimum cost-effective solution based on our modular and standardized platforms.

High reliability and efficiency of our motors help our customers to cut operating, maintenance and energy costs as well as to reduce their environmental impact. Extensive service programs and our global organization support customers over their motors' entire life cycle.

### Fixed speed motors



### Variable speed motors



Output ranges of ABB synchronous motors (from 1 to 75 MW, 1 to 15 kV).

# Fixed and variable speed motors tailored for each specific application

## Fixed speed motors

Fixed speed synchronous motors are typically used in applications such as compressors, fans, pumps, wood grinders and refiners.

In each case we utilize advanced software tools to optimize the motor design for the specific application and ensure that the chosen starting method is appropriate. The results of this work are processed into an easy-to-understand format and incorporated into the technical specification we provide with each proposal.

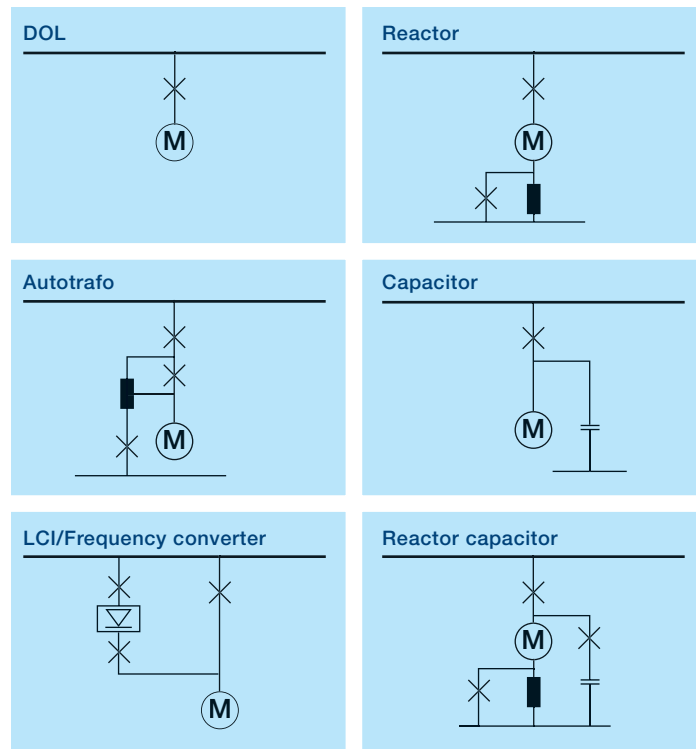
We can engineer the motor to develop sufficient torque for smooth starting and acceleration with the starting current limited typically to 350 – 500% of the rated value. If this will result in unacceptable line voltage drops then we can investigate alternative starting methods.

The main factors to be considered in selecting the starting method are the customer's requirements, network capability and the demands of the process. The starting methods most commonly used for fixed speed synchronous motors are direct-on-line (DOL), reactor, autotransformer, load commutated inverter (LCI or 'soft starter'), capacitor and reactor capacitor.

## Variable speed motors

Variable speed synchronous motors are typically used in demanding applications in process industries, and applications where variable speed delivers clear benefits. Rolling mills, mine hoists, pumps, and compressors are examples of variable speed applications. Synchronous motors with variable speed drives (VSDs) are also commonly used in the main propulsion system in vessels. In applications such as extruders, compressors and pumps, optimized electrical drive systems based on variable speed motors can provide considerable energy savings.

We supply motors and drives that meet torque requirements over the entire operating range, from zero to maximum process speed. This ensures smooth starting, acceleration and operation. For the optimum variable speed solution, we have optimized ABB motor-drive packages: ABB synchronous motor combined with ABB load commutated inverter or with ABB voltage source inverter, e.g. ACS5000 or ACS6000. Our engineering and application know-how ensures that all components in electrical drive packages, particularly the converter-motor interface, are optimally integrated to meet the needs of the process. Benefits include special converter-fed motor designs, increased efficiency and improved torque production capabilities.



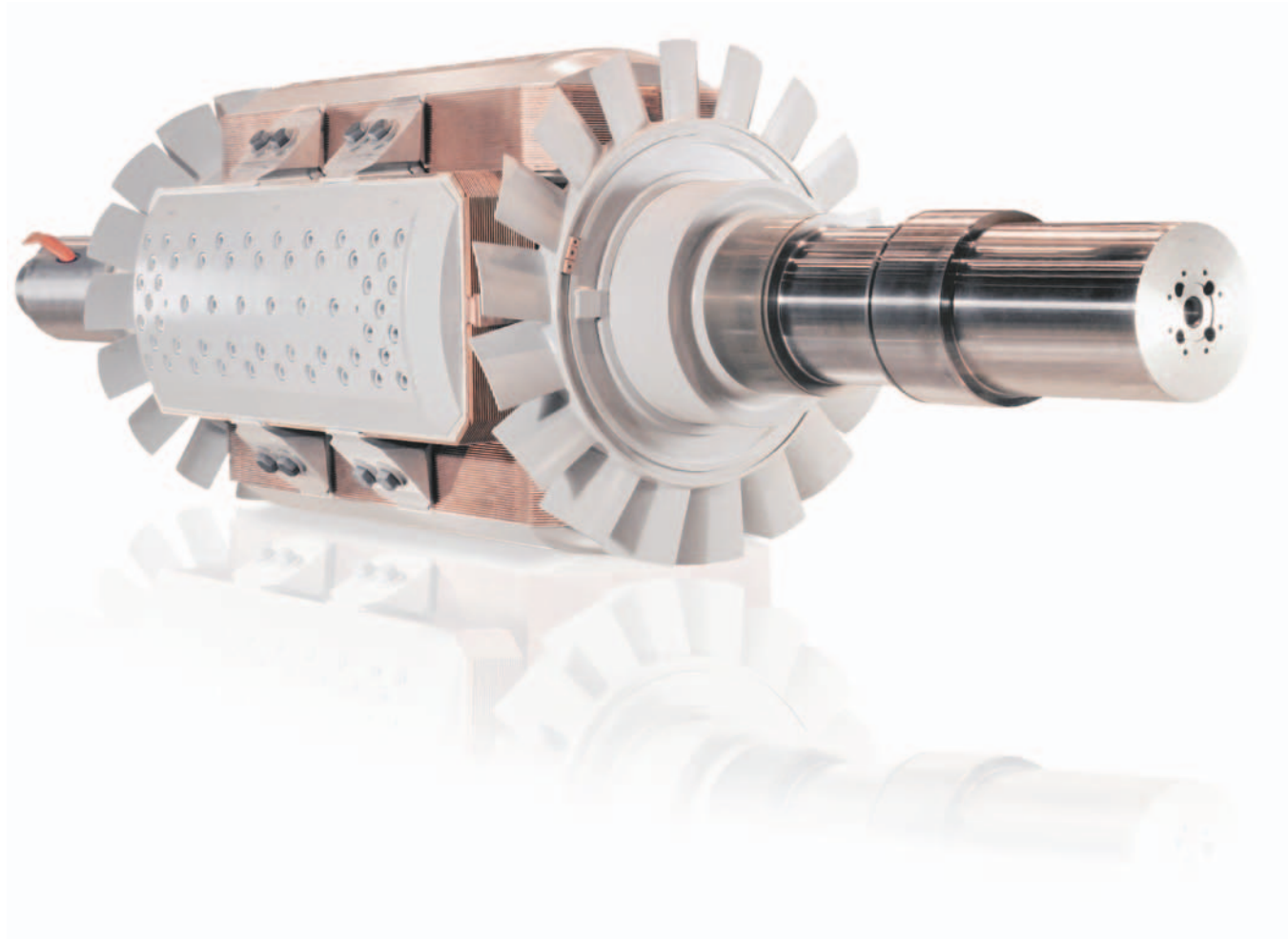
Typical starting methods for fixed speed synchronous motors.



We always use specialized software tools to optimize the motor design with the converter type best suited for the application. All common converter types are supported: load commutated inverter (LCI), cycloconverter (C) and voltage source inverter (VSI).



# The rotor is key to excellent overall performance



**The rotor plays a crucial part in achieving the best possible electrical and mechanical performance.**

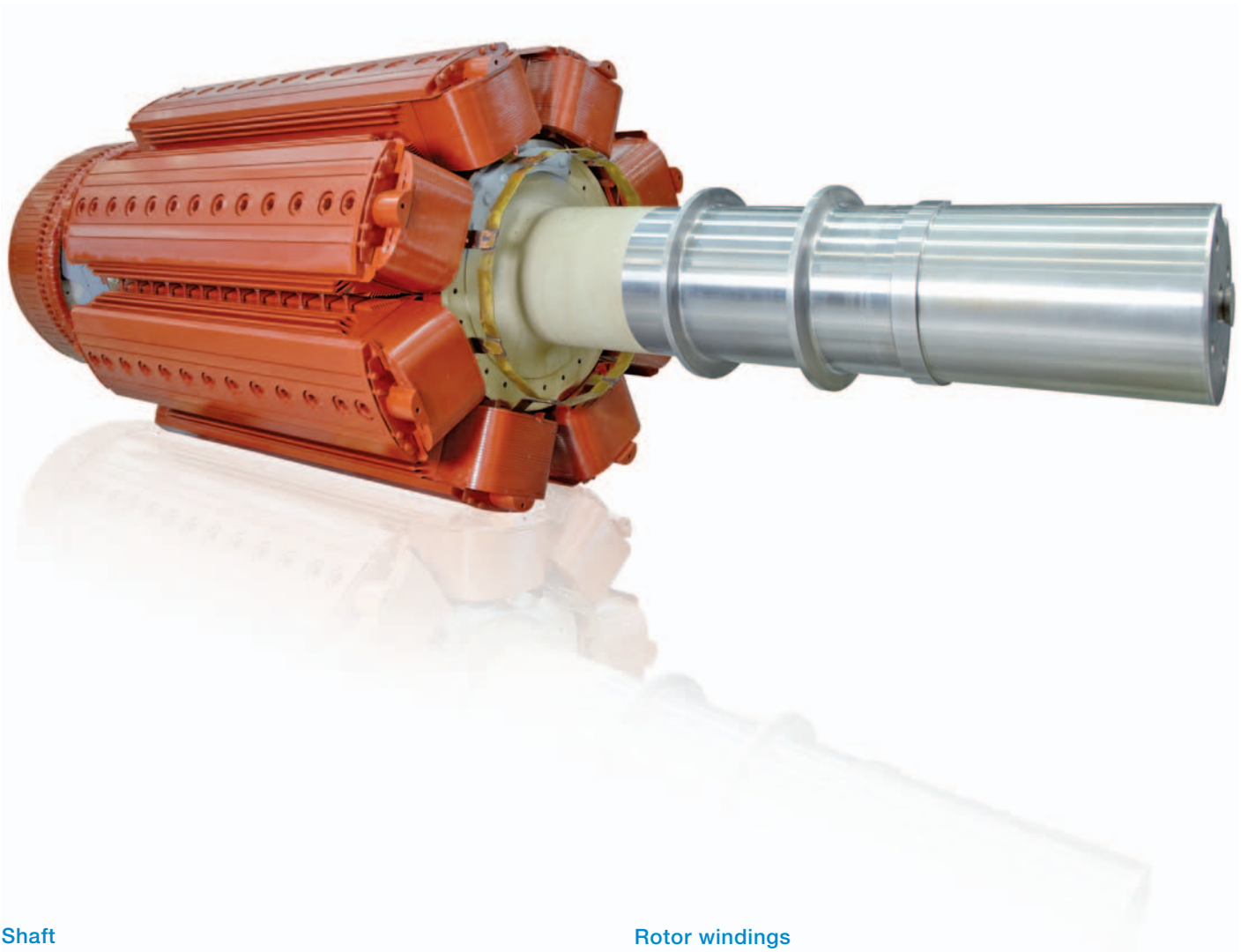
## **Higher speed motors**

(four and six poles) have solid rotors with integrated poles made from a one-piece steel forging. A solid pole plate is attached to the pole, and this design has good overload capability and low harmonics. At the same time this rotor configuration contributes to the motors' excellent starting characteristics, high starting torque and low starting current. The large cooling surfaces and effective flow of cooling air mean that the rotor temperature remains low and uniform, helping to ensure reliability and a long operating life. The coils are class H insulated for extra thermal margins. The rigid rotor construction and minimum distance between bearings ensure that the motor operates below the first critical speed, keeping vibration levels low.

## **Lower speed motors**

(eight or more poles) typically have rotors with the poles manufactured from 2 mm laminated steel sheet. The sheets are pressed together with inserted steel bars which are welded to the end plates. The poles are secured to the shaft or rotor center by bolts from above or below, or by means of dovetails. A copper or brass damper winding is often fitted. For lower speed motors the technically preferred option is to vacuum pressure impregnate (VPI) the rotor assembly after it is wound to achieve excellent insulation and mechanical strength. After impregnation, the complete rotor assembly is dynamically checked for balance.

Permanent magnet poles are used in certain variable speed applications. Permanent magnet rotors are straightforward constructions and do not need an excitation system. When necessary, high pole numbers can be used in low speed applications.



### Shaft

The shaft is manufactured of forged or rolled steel and machined to exact specifications. The shaft ends can be cylindrical, conical or flanged, or two shaft ends can be provided (double end drive).

### Rotor windings

The rotor windings are either made of preformed enameled rectangular copper wire or flat copper. Proper supports between adjacent windings are used to ensure stability up to the rated overspeed. The rotor windings are made to match the insulation class of the stator. This ensures outstanding reliability and a long service life, even with asymmetric loads or under exceptional conditions.

# Modular stator design enables performance to be optimized



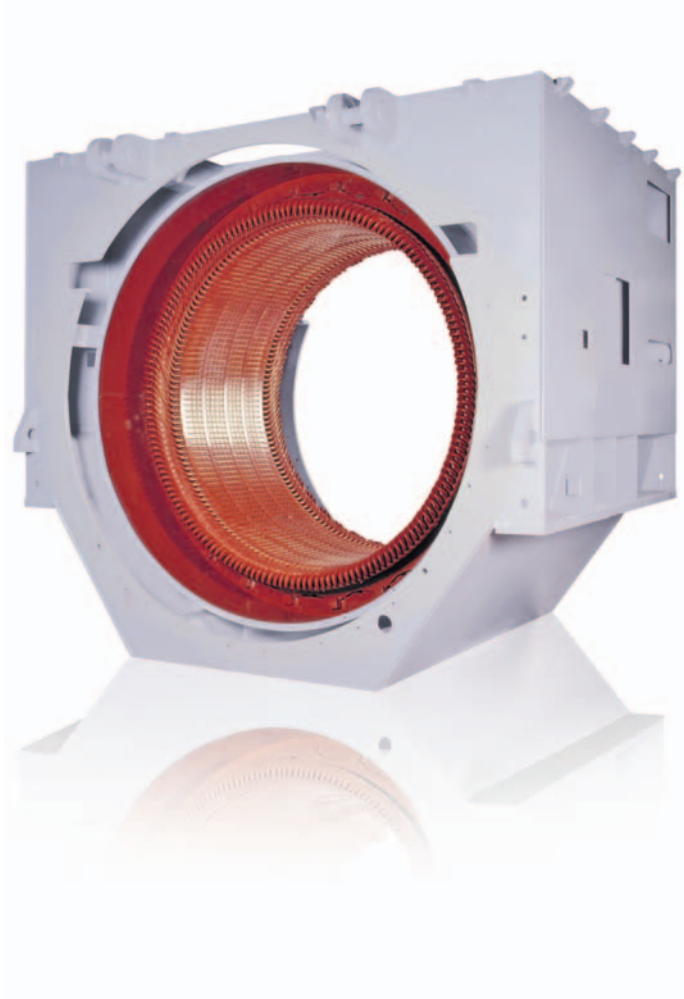
**Each application has its own specific requirements for motor performance. Our modular stator design allows us to precisely match the performance of every ABB synchronous motor to the needs of its application.**

The stator core itself is built of stacked, high grade, low-loss laminated electrical steel, insulated on both sides with high quality insulating coating (heat-resistant inorganic coating is also available). The use of high grade core material increases efficiency and therefore reduces operating costs. Radial cooling ducts ensure uniform and effective cooling.

The rigid stator construction transmits all forces via the frame to the foundation to minimize vibrations. The windings are insulated with Mica based tape. When the windings are in place, the complete stator undergoes vacuum pressure impregnation (VPI). The windings are class F insulated, which gives good thermal margins. This insulation system has been used very successfully over many years and in several thousand motors, and it provides reliability and a long operating life. Long-term reliability is also assured by the use of well proven methods for locking the coils into the slots and bracing the coil ends.



## Robust frame ensures great stability and optimum dynamic behavior



**For maximum flexibility, ABB synchronous motors are designed for horizontal, inclined or vertical mounting (vertical mounting available for motors with eight or more poles). The robust frame transfers dynamic and static stresses directly to the foundation, reducing vibration and contributing to the overall excellent performance of the motor.**

We can supply motors – even up to the largest sizes and outputs – as complete, ready-to-install units (in some cases the heat exchanger or terminal box has to be removed prior to shipment). This means that no further on-site assembly is needed, which substantially reduces installation times and cuts the risk that something could go wrong during installation.

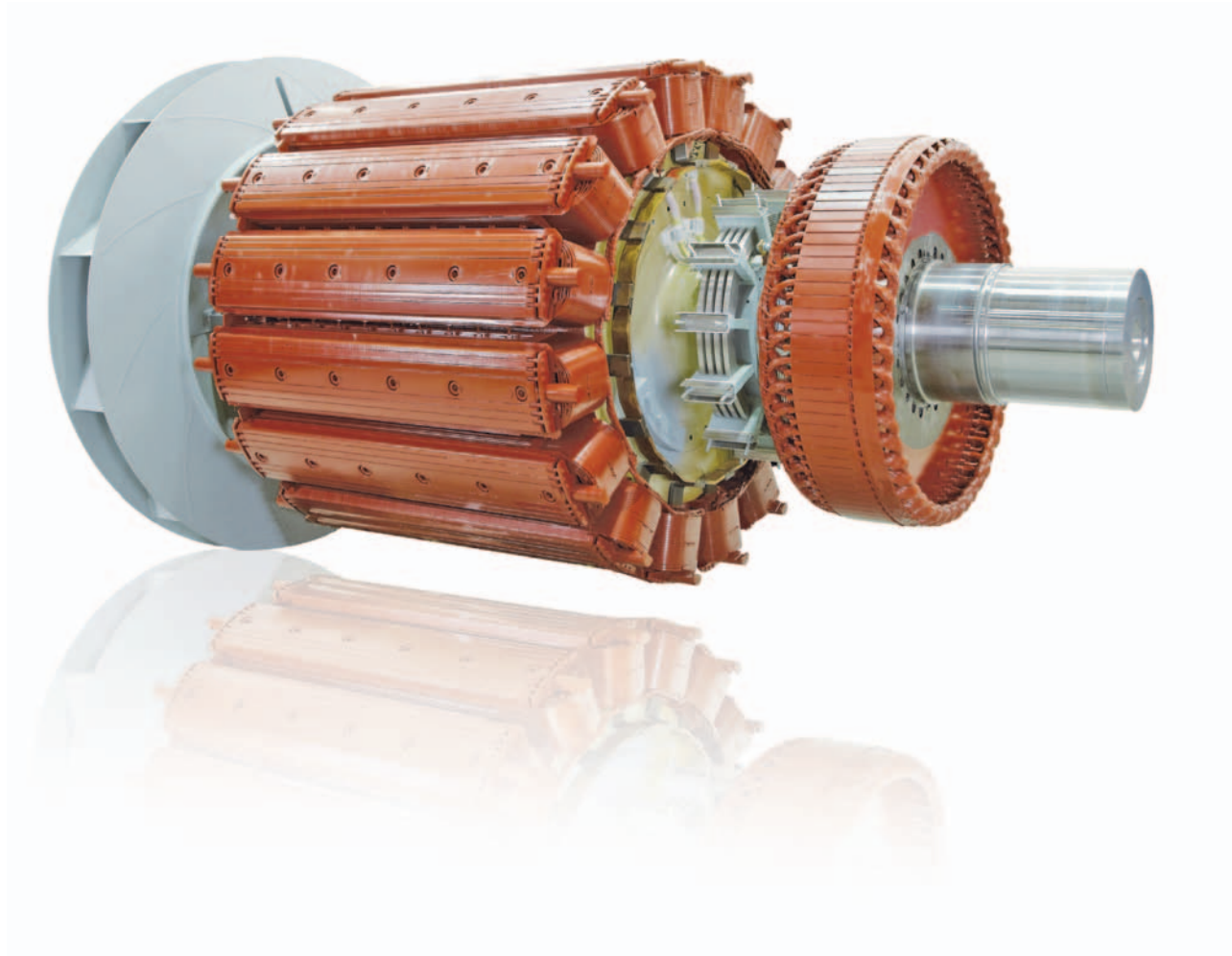


Our R&D team works closely with manufacturers of driven equipment, using FEM and dynamic animation techniques, to analyze vibration models, test critical parts and verify that hazardous mechanical resonances will not occur in the motor.

### **Corrosion protection**

Our motors are designed and built to withstand the relevant environmental conditions. All surfaces made of steel, aluminum alloy or cast iron are treated in accordance with the chosen paint system. Selection of a suitable paint system gives reliable anti-corrosion protection even under the most severe environmental conditions. For moderate indoor conditions the standard finish is moisture-proof in accordance with the relevant standards. Solvent free paints are used wherever possible in order to minimize environmental impacts.

# The right excitation method for every application



**At ABB we take care to ensure that the excitation system meets the very high overall standards of reliability that we have set for our synchronous motors.**

For fixed speed applications and variable speed applications with less demanding dynamic control requirements, a brushless exciter and automatic voltage regulator are generally provided. The brushless system has no wearing parts, and the external excitation power requirement is low.

The brushless exciter is a separate AC generator mounted on the motor shaft at the non-drive end. In most fixed speed motors the field winding is DC fed; in variable speed motors (and fixed speed motors with LCI starting) the field winding is AC fed. The exciter is vacuum pressure impregnated using the MCI method, ensuring that the windings are sealed and secured. The advanced and yet straightforward design has

a low component count and effective protection functions, and it offers high reliability and easy access for maintenance.

For variable speed applications where very fast and accurate speed or torque control are required, the motor is generally equipped with brushes and a slip ring unit to allow excitation and control of the motor from the frequency converter.

The slip rings are mounted on the motor shaft with access via removable inspection covers. In general the slip rings and mounting flange or hub are made of steel, and they are normally mounted as a single unit. Slip ring units with brass rings, as well as split flange mounted units, are available on request. The slip ring unit is fitted with brass connection pins to facilitate installation.

No excitation system is needed for variable speed motors with permanent magnet rotors.



**Higher speed motors** (four and six poles) use a compact, brushless exciter unit mounted on the rotor shaft outboard of the bearings. No independent support or alignment is required. The high level of field forcing delivers improved system performance, which increases the production of reactive power and is beneficial when faults arise in the supply network.

**Lower speed motors** (eight or more poles) typically have a brushless exciter unit mounted inside the motor enclosure.



#### Excitation control

The motor excitation control panel can be supplied in a variety of basic formats. It houses the excitation equipment, protection system and logic functions for starting. Various options are available on request.

We offer a wide range of instrumentation and control equipment to protect synchronous motors and ensure excellent reliability and availability, and extended product lifetimes.

#### Integration with plant automation systems

The motor excitation control panel can, as an option, be adapted for immediate integration into a superior management and supervisory system. Communication via modem can also be supplied to facilitate remote support.

# Effective and uniform cooling of the complete motor

With a wide range of cooling methods available, the optimum system can be selected for the motor's operating and environmental conditions. Whichever method is chosen, it will provide effective cooling of the complete motor. The three most commonly used cooling arrangements are air-to-water, air-to-air and open air.

## Air-to-water closed circuit cooling

The cooling air circulates in a closed circuit through the active parts of the motor and then through an air-to-water heat exchanger. This cooling method is especially recommended if the cooling water is located nearby. This configuration is an ideal solution for situations where closed circuit cooling is required due to installation outdoors, installation in a hazardous area, or whenever the quality of the surrounding air is not otherwise suitable for direct cooling. It is also ideal for installations in machine rooms with limited ventilation, such as on board ships or in pumping stations which are fully enclosed.

## Air-to-air closed circuit cooling

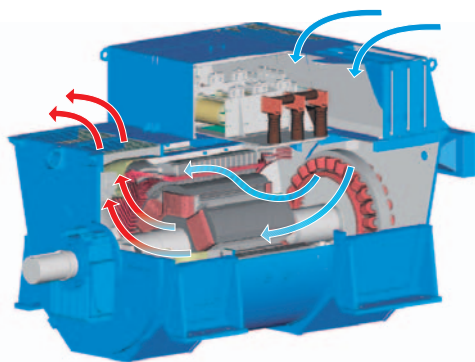
The cooling air circulates in a closed circuit through the active parts of the motor and through an air-to-air heat exchanger. This solution is generally used in situations where a closed circuit cooling system – such as air-to-water cooling – is required but water is not readily available. This cooling arrangement requires an additional shaft-mounted or separate electric fan to ensure sufficient air flow through the cooler.

## Open air cooling

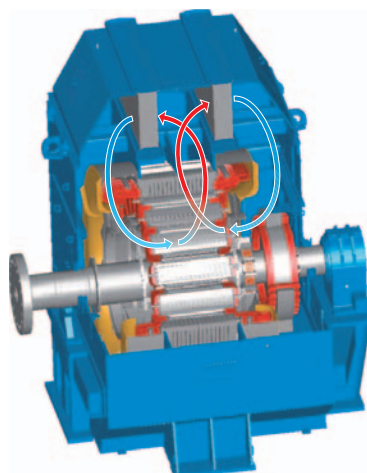
Open air cooling can be used where the air in the immediate environment is relatively clean and there is adequate air circulation. The cooling air is typically drawn in through filters, passed through the active parts of the motor, and then exhausted back to the environment. If the machine room ventilation system cannot compensate for the temperature gradient, the motor air outlet can be ducted to exhaust the air outdoors.

## Enclosure protection classes

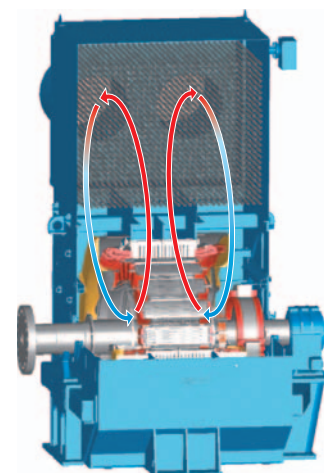
The motor enclosures feature protection in classes IP23, IP44, IP54 and IP55 (totally enclosed), or equivalent NEMA protection classes. Motors are also available for hazardous areas in accordance with IEC/ATEX or NEC regulations (non-sparking or pressurized construction).



An open air cooled motor (IC0A1) with drip proof protection (IP23)



A totally enclosed motor (IP54) using an air-to-water heat exchanger (IC8A1W7)



A totally enclosed motor (IP54) using an air-to-air heat exchanger (IC6A1A6)

# Proven insulation system delivers ultimate reliability

**ABB synchronous motors use the MICADUR® Compact Industry (MCI) insulation system, which is based on the vacuum pressure impregnation (VPI) method. The VPI and curing of the completely wound and connected stator winding with a specially formulated epoxy resin ensures a sealed and homogenous insulation system. This results in high dielectric strength, excellent heat transfer, and the elimination of hazardous internal partial discharges.**

We have been using the MCI system for more than 30 years. It has been used on tens of thousands of our larger motors and generators, which are operating successfully all over the world. No primary insulation failures due to thermal aging have been experienced. Thermal lifetime tests performed on the MCI system show that its endurance substantially exceeds IEC and IEEE requirements.

MCI insulated windings require very little maintenance. In most cases it is only necessary to take steps to prevent the ingress of moisture or dirt during periods when the motor is not operating, as this could reduce the cooling ability of the winding.

The systematic VPI process is highly effective:

- Oven curing – after the VPI process has been completed, stators and rotors are cured in an oven at high temperature. This produces very strong and stable insulation with high mechanical and electrical strength. This is especially important in order to resist inadvertent high stresses from out-of-phase synchronization, transients and short circuits. Even the largest wound stators are impregnated as complete units. This ensures that both the insulation and the mechanical properties of the windings are excellent – which means that they can withstand vibrations induced by the driven equipment and the mechanical stresses caused by transients such as short circuits.

## **Stator winding and insulation classes**

Medium and high voltage windings up to 15 000 V are made of form wound rectangular copper wire insulated with multiple layers of glass-fiber reinforced mica-tape.

All materials used, including the VPI resin, exceed the requirements of thermal class F. After insertion into the slots, the coils are firmly held in place by means of slot wedges and surge ropes at the coil heads prior to the VPI treatment. The completed process assures a long and trouble-free operating life.



# High quality sleeve bearings for trouble-free operation

ABB synchronous motors use quality sleeve bearings that withstand high levels of vibration and offer excellent performance. The bearings provide the same high levels of reliability under static as well as dynamic (radial and axial) loads. Their excellent heat transfer capability makes them equally suitable for low and high speed applications.

The choice of bearing arrangement and type is based on the application, radial and axial loads, rotation speed, coupling type, and customer preferences. Operating conditions such as ambient temperature, air cleanliness, vibration levels and shocks affecting the bearings are also taken into account.

End-shield mounted bearings are always used in higher speed (four and six pole) motors. Pedestal mounted bearings are generally used for the largest frame sizes. Motors with pedestal bearings are as easy to mount and align as those with end-shield mounted bearings. The motors are normally delivered ready assembled and require no further assembly on site. Separate pedestal bearing motors are often mounted on a common base frame.

Sleeve bearings last as long as the expected life of the motor, provided that the operating conditions and maintenance intervals are as specified.

The bearing housing is designed to permit easy access for inspection and maintenance. The bearings are insulated from the motor frame to eliminate circulating currents in

the shaft, and the shaft can be earthed. The bearings are sealed against oil leakage with labyrinth seals. Sleeve bearings are designed to be insensitive to misalignment and to permit large axial play.

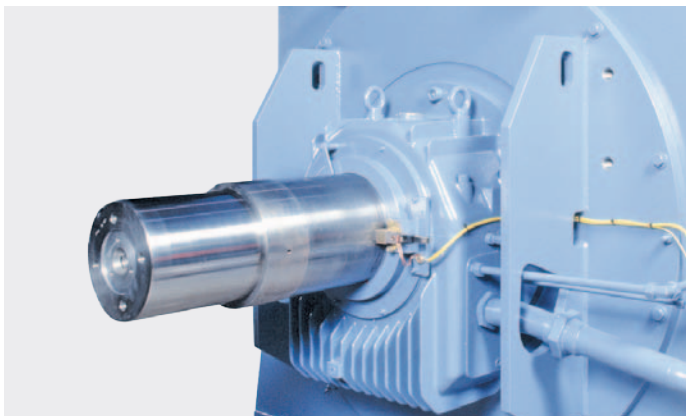
## Lubrication

In some cases the bearings are self-lubricated by means of an oil ring, which picks up the lubricating oil and transfers it directly to the shaft, forming an independent and highly reliable lubrication system.

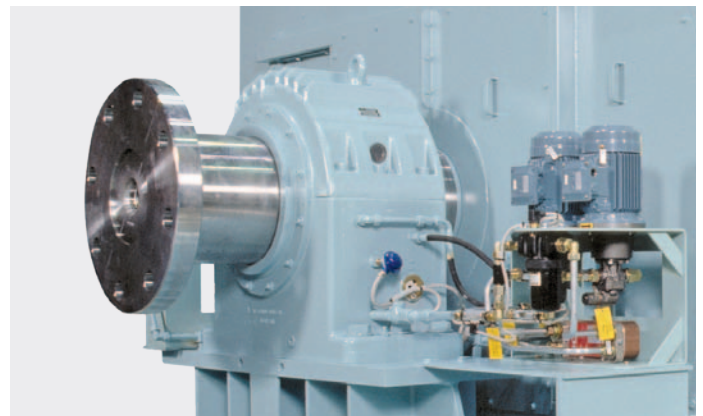
In applications involving large loads, high speeds, high ambient temperature or where the motor is mounted in an inclined position, an external oil cooling and circulation system may be necessary, unless the oil is supplied direct from the lubrication system of the driven equipment. In certain applications which run at slow speeds, a jack-up system may be necessary for starting.

Hydrostatic jacking oil systems are available for low-speed applications and, in specific situations, for use during motor start-up/shut down.

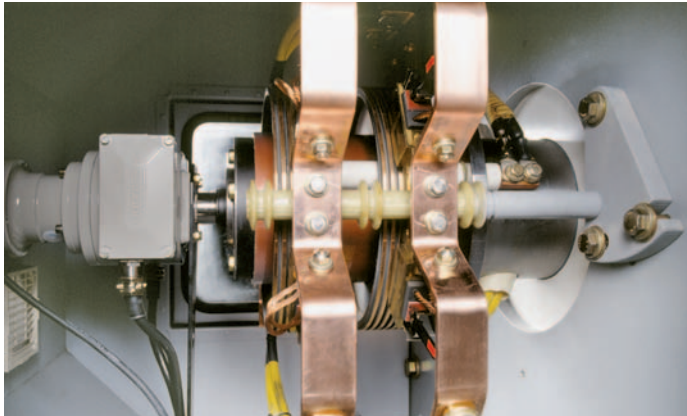
Flange mounted sleeve bearing



Pedestal mounted sleeve bearing



# Comprehensive range of accessories



## Accessories

We offer a large selection of accessories, e.g. for measuring, protection, termination, lubrication and mounting of the motor. Accessories include PT-100 sensors, earth fault protection relays, surge arrestors, CTs, rotor telemetrics, sole plates and anchor bolts. Certain accessories are included as standard, depending on the size and type of motor.



## Terminal boxes

A separate main terminal box is mounted on the side of the motor, featuring bus bars outside the motor frame and allowing connections from any specified direction. The neutral terminal box is typically mounted on the opposite side of the motor from the main terminal box. For auxiliary and instrument cables, separate auxiliary terminal boxes are supplied as required.

# Testing is fully integrated into manufacturing processes

Testing forms an integral part of our manufacturing process. Tests – including quality monitoring, inspections and insulation reliability evaluations – are performed on components as they progress from one manufacturing stage to the next. In addition, every motor undergoes a comprehensive set of final tests before dispatch in order to verify that it meets the customer's requirements in all respects. The results of this final test are compiled into a report which is supplied to the customer once testing is completed.

All tests are performed according to IEC 60034 unless otherwise specified. Testing according to NEMA MG 1, IEEE-115 or classification society requirements is available on request.

## Routine tests

The routine test program is performed on every motor and is included in the price of the motor.

## Type tests

Type tests are performed in addition to the routine tests. They are normally performed on one machine in a series of motors not previously manufactured, or at the customer's request.



## Special tests

Special tests may be conducted to verify performance in special conditions. They may, for example, be based on customer specifications, hazardous area or marine classification society requirements.

## Pro-active services for optimum performance and extended lifetime



Synchronous motors always play a critical role in the plants where they operate, making availability and reliability the top priorities. We offer a complete portfolio of services to maximize the availability, reliability and performance of ABB synchronous motors. Our worldwide organization and network of selected partners ensure that we can respond quickly and support customers wherever they are located.

Our service offering covers the whole product life cycle, from consulting, installation and commissioning, through diagnosis, maintenance, spare parts and repairs, to migration and upgrades. Training for customer personnel is also available.

ABB's Life Cycle Management Plan for motors and generators prevents equipment failure due to component aging. The recommended maintenance program for ABB synchronous motors consists of four levels (L1 – L4) spaced at intervals over the product's lifetime. The age of the motor and ambient conditions in which it operates determine when each maintenance process should be undertaken. The service program can be adapted as necessary to meet specific requirements.

We also offer specialized tools such as ABB LEAP (ABB Life Expectancy Analysis Program), which is a diagnostic tool for assessing the condition of the stator winding insulation. Testing can be performed during the normal L1 – L4 maintenance procedures, and the results provide a basis on which specific preventive service actions can be planned. Preventive service measures reduce unplanned – and therefore expensive – shutdowns caused by failures that could have been foreseen.

Our synchronous motors are designed to provide easy access for service and maintenance, and the services we offer will ensure the motors deliver trouble-free operation over an extended lifetime.



# Reliable operation in a wide range of applications



Typical industries served: 1 Air separation | 2 Cement | 3 Oil, gas and petrochemical | 4 Marine | 5 Metals and minerals | 6 OEMs and system integrators | 7 Power generation | 8 Pulp and paper | 9 Water and wastewater

**ABB synchronous motors deliver efficient and reliable operation in many different applications. We have extensive experience in designing and building motors that precisely match the customer's needs across a range of different industries.**

We have supplied motors for:

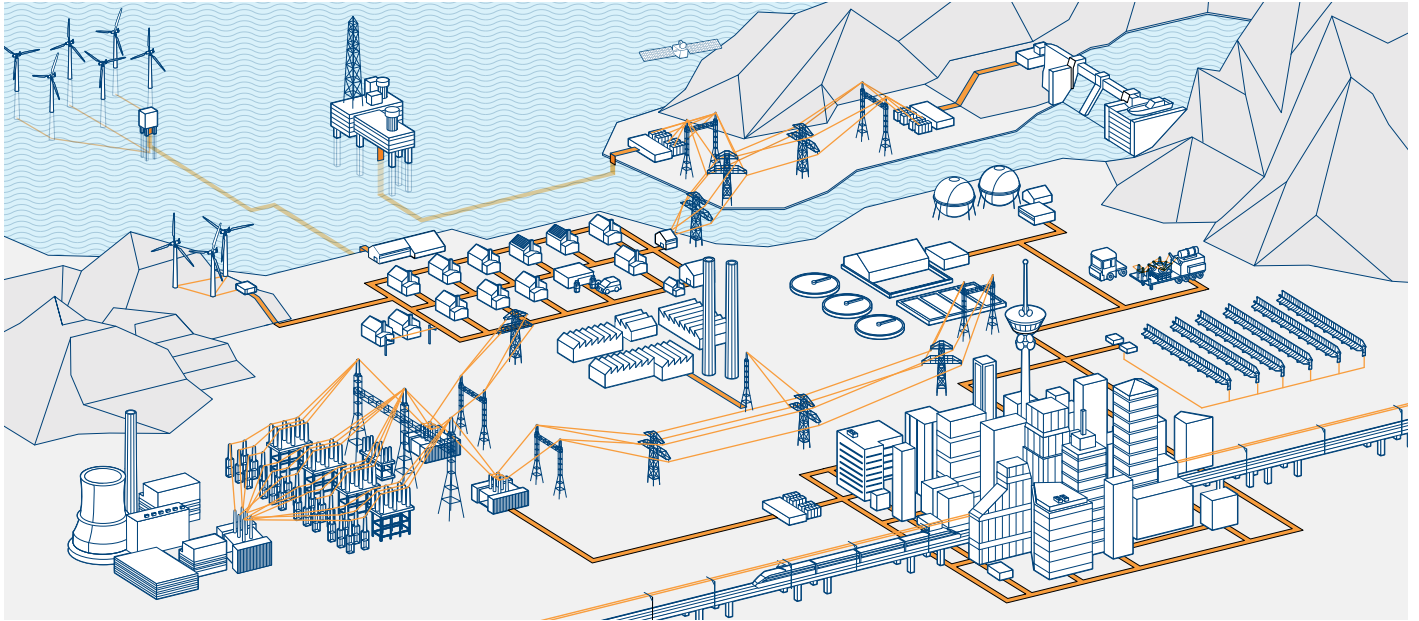
- Oil, gas and petrochemical: compressors, pumps and extruders
- Marine and offshore: variable speed motors in azimuthing propulsors and shaft line applications
- Metals and minerals: rolling mills, hoists, processing lines, SAG and ball mills, and blowers
- Power utilities: pumps and condensers
- Pulp and paper: chippers, refiners and grinders
- Water and waste water: pumps
- Air separation: compressors
- Special applications: wind tunnel motors and MG sets

# Proven performance around the world



1 Azipod® propulsion unit | 2 Mine hoist motors | 3 Refiner motor | 4 Rolling mill motor (twin drive) | 5 Hydrogen gas compressor motors | 6 Medium section motors

# Total offer of motors, generators and mechanical power transmission products with a complete portfolio of services



**ABB is the leading manufacturer of low, medium and high voltage motors and generators, and mechanical power transmission products. ABB products are backed by a complete portfolio of services. Our in-depth knowledge of virtually every type of industrial process ensures we always specify the best solution for your needs.**

## > Low and high voltage IEC induction motors

- Process performance motors
- General performance motors
- High voltage rib cooled motors
- Modular induction motors
- Slip-ring modular motors
- Synchronous reluctance motors

## > Low and medium voltage NEMA motors

- Steel frame open drip proof (ODP) motors
- Weather protected, water cooled, fan ventilated
- Cast iron frame (TEFC)
- Air to air cooled (TEAAC) motors

## > Motors and generators for explosive atmospheres

- IEC and NEMA motors and generators, for all protection types

## > Synchronous motors

### > Synchronous generators

- Synchronous generators for diesel and gas engines
- Synchronous generators for steam and gas turbines

## > Wind power generators

## > Generators for small hydro

## > Synchronous condensers for reactive power compensation

## > Other motors and generators

- Brake motors
- DC motors and generators
- Gear motors
- Marine motors and generators
- Single phase motors
- Motors for high ambient temperatures
- Permanent magnet motors and generators

- High speed motors
- Smoke extraction motors
- Wash down motors
- Water cooled motors
- Generator sets
- Roller table motors
- Low inertia motors
- Traction motors and generators

## > Life cycle services

- Installation and commissioning
- Spares and consumables
- Preventive maintenance
- Predictive maintenance
- Condition monitoring
- On-site and workshop
- Remote troubleshooting
- Technical support
- Engineering and consulting
- Extensions, upgrades and retrofits
- Replacements
- Training
- Service agreements

## > Mechanical power transmission components, bearings, gearings

# Contact us

[www.abb.com/motors&generators](http://www.abb.com/motors&generators)

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