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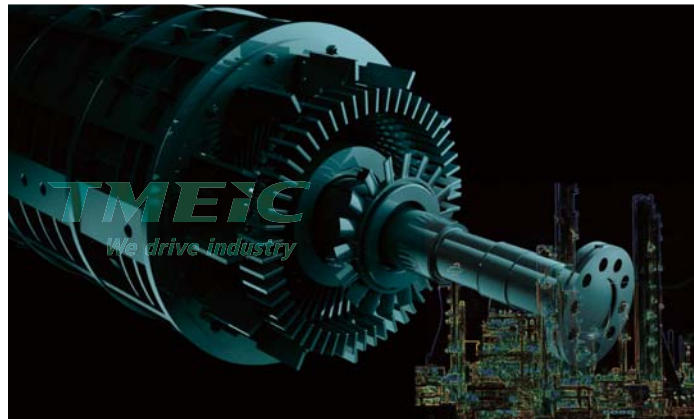
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**TMEiC**  
*We drive industry*

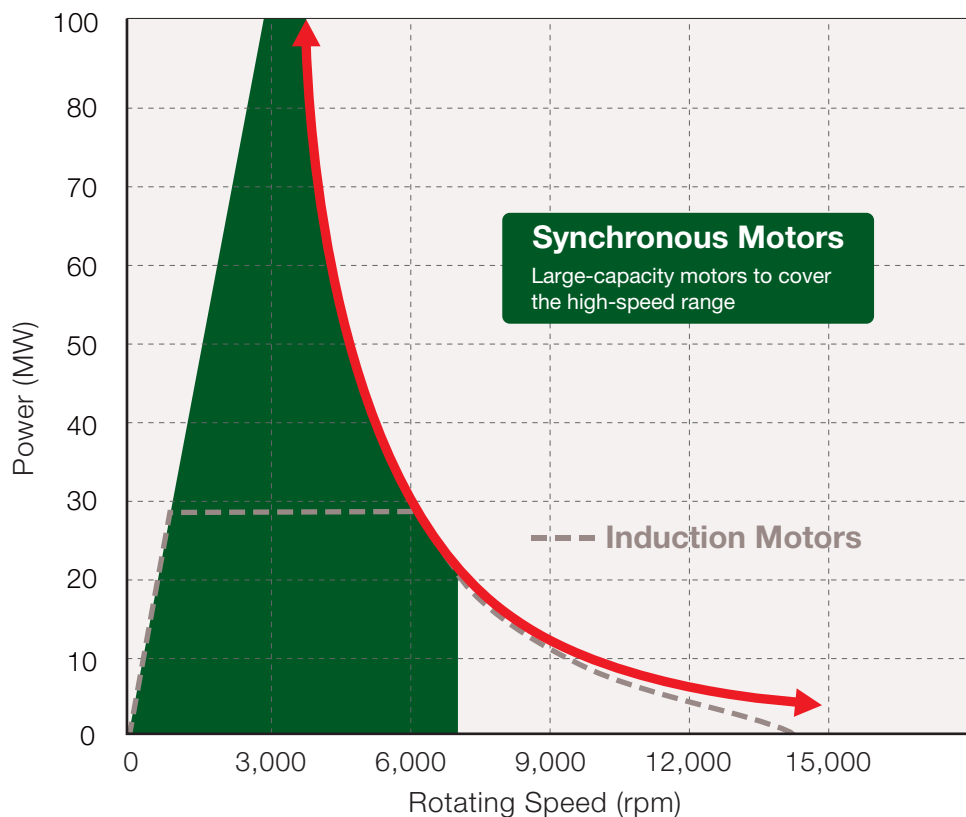
# ***Synchronous Motors***

## ***Empowering the Future***



# Ideal Solutions – Preferred Motors

The synchronous motors produced by Toshiba Mitsubishi-Electric Industrial Systems Corporation (TMEIC) are quickly becoming the preferred product of choice for industrial use. Why is that? One word: Reliability! Designed and built based on more than 200 years of manufacturing expertise, combining the industrial production experience of parent companies Toshiba and Mitsubishi Electric, our large-capacity, ultrahigh-speed synchronous motors are running machinery in production facilities around the world. Their low power loss, high-performance operation, minimal maintenance requirements and flexibility to be adapted to diverse machinery layouts are characteristics highly valued by current and past customers. Backed by a global service network, TMEIC synchronous motors provide a best-match solution for your industrial needs.



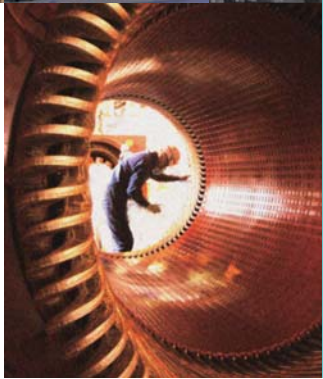
# for Industrial Use around the World



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# Meeting the Diversified Needs of

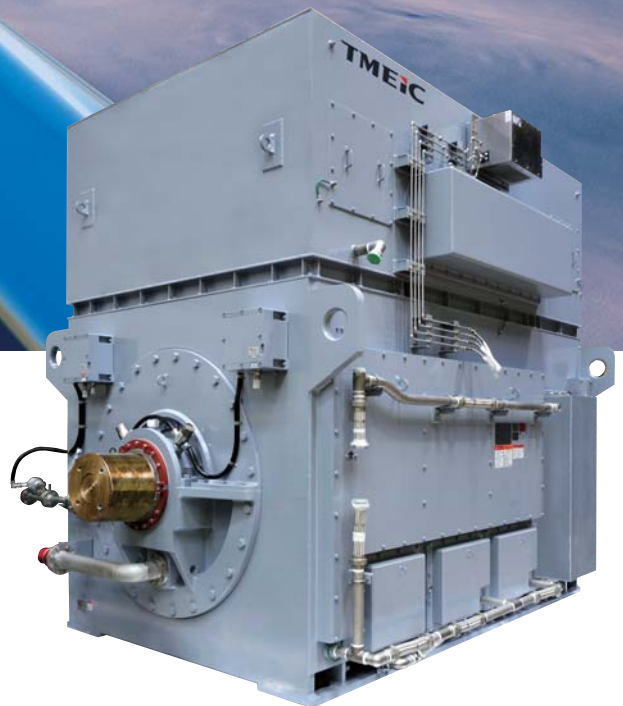
## Oil and Gas



**TMEIC**  
*We drive industry*

### Ultrahigh-speed, large capacities and flexibility

A long history of reliability and the flexibility to adapt to diverse machinery layouts continue to attract customer praise. As a leading manufacturer, TMEIC proposes optimal drive and motor products, including specially designed ultrahigh-speed motors, and generators.



for turbo-compressors



### High-efficiency and space savings

TMEIC has an impressive track record for the application of its hydrogen and natural-gas compressor drive systems utilized at oil and gas plants. Synchronous motors provide a remarkably high power-factor, even when operating at low speeds, and also contribute to enhancing the power-factor of the entire electrical system. As TMEIC motors have a high power factor and operate using a lower electrical current, smaller gauge cabling is used. Combined, these features enable smaller pit specifications, thereby helping customers to minimize installation space.

for reciprocating compressors

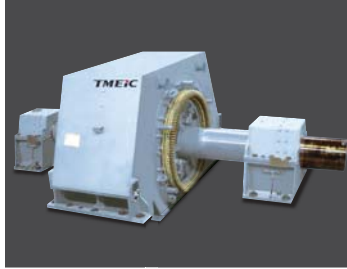


# Industry

## Mining



**for hoists (winders)**



### Excellent durability under harsh operating conditions

Motors for mining machinery like grinding mills and mine hoists, all with proven durability in harsh operating environments. Whether a large-capacity motor, overhung installation or a motor/variable-frequency drive combination, TMEIC has a best-match product for you.

## Metals

Hot-strip mills



**for mills**



### Robust operation in severe environments

Motors are designed to withstand heat, steam, dust and other particulates, as well as load impact force when operating in severe environments. When it comes to supplying reliable products and flexible solutions, TMEIC has an excellent record of customer satisfaction.

Blast furnaces



**for blowers**



### Large-capacity motors with outstanding reliability

TMEIC has earned an excellent reputation for the delivery of reliable high-power blast-furnace blower motors. Capitalizing on the system know-how gained from a wealth of experience, we provide highly reliable large-capacity motors, together with soft starters, that contribute to stable plant operations in applications with different power supply conditions.

Air separator



**for centrifugal compressors**



### Large-capacity compressor drives

Utilized to drive the large-capacity compressors at oxygen plants, TMEIC synchronous motors are assisting in the purification of highly concentrated oxygen, a necessary element in steel production. Specially designed for effective operation, these motors improve the power-factor of the electrical system. As a result, the system load is reduced and the start-up current can be restricted. This inhibits voltage fluctuation in the system, and provides customers the energy-saving benefits of highly efficient operation and appropriate power-factor levels.

## Pulp and Paper



**for chippers**



### Appropriate power-factor means lower operating costs

TMEIC synchronous motors are used in chippers and refiners in the pulp production process. The high power-factor eliminates power inefficiencies, thereby contributing to lower operating costs for customers.

# Large-capacity, Variable-speed World-class Ultrahigh-performance



Rotating Speed

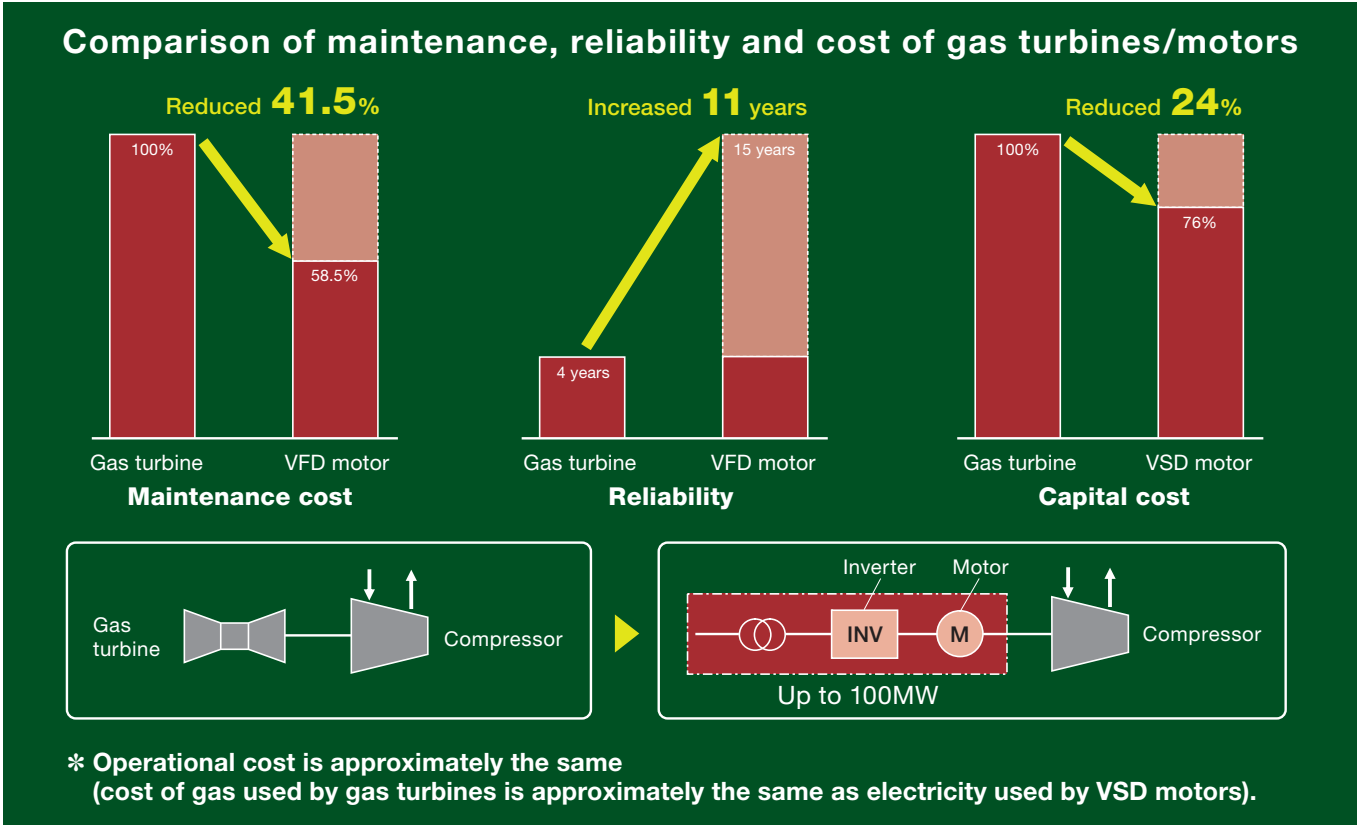
## 6500RPM & 100MW

In response to market demand, TMEiC now manufactures ultrahigh-speed synchronous motors with the largest capacities in the world. This requires special consideration of numerous factors such as the excitation system, cooling method, bearing structure, rotor structure, vibration and resonance speed. Applying state-of-the-art analytical methods, infusing the latest technologies utilizing extensive industry experience and pursuing the optimal design, highly efficient, stable operation is assured. Ultrahigh-speed operation also succeeds in eliminating the need for equipment such as compound gears, thereby contributing to more reliable, efficient equipment and less maintenance. TMEiC products also contribute to the environmental benefits of lower CO<sub>2</sub> emissions and improved energy-savings compared to existing equipment. Additionally, the company's explosion-protection technologies have made TMEiC motors a popular choice for many special applications, such as for pipelines and on ships.

# Motors

## Less Maintenance, Higher Reliability, Lower Cost

TMEIC is continuously working to enhance product efficiency. Improvement benefits are passed on to the customer in the form of enabling the simultaneous achievement of higher reliability and lower maintenance and capital costs. Efforts are applied to lowering costs over the entire lifecycle of a product, thereby realizing optimal cost performance and maximum return on investment.



### Low Vibration/ Low Noise

Preventing component deterioration is vital to maintaining the motor performance and longevity. Key to that is eliminating the source, wear caused by vibration. TMEIC variable-speed synchronous motors are specially designed and carefully insulated to suppress vibration. In addition to ensuring optimum performance and promoting a longer service life, operating noise is minimized. This contributes greatly to eliminating noise on factory floor, creating a more comfortable work environment.

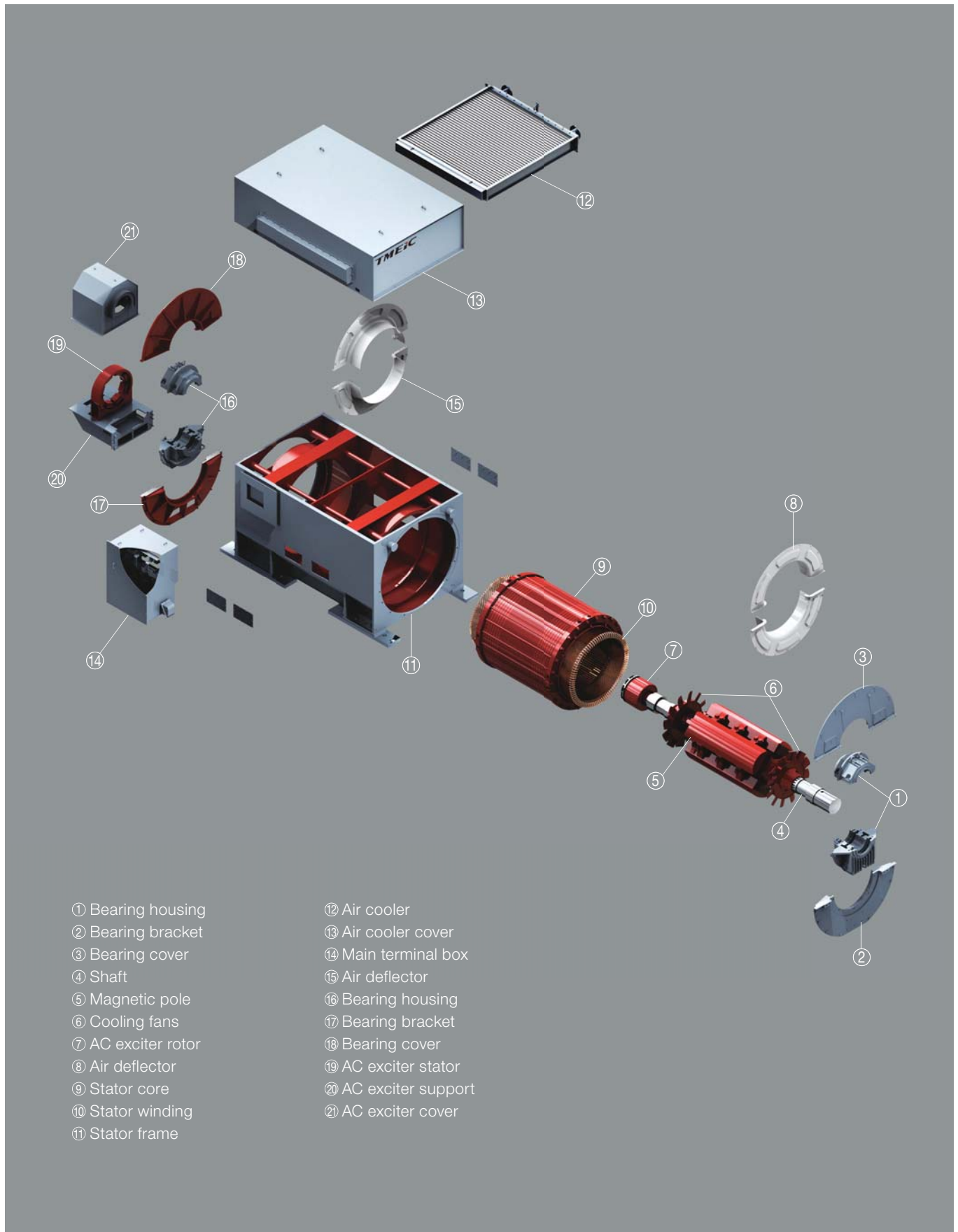
### Application Flexibility

The number of applications for synchronous motors used in industrial applications is extensive, and using them in series or combination with other equipment is a necessity. Providing advanced ancillary equipment like its variable-speed drives (VSD) and excitation systems, TMEIC is a favored supplier of high-speed and ultrahigh-speed motors. This is thanks to excellent application flexibility that enables them to be easily integrated into both new and existing production systems and processes.

### 24hr Nonstop Operation/ Long Service Life

TMEIC motors are highly regarded in industry for their reliability in 24-hour nonstop operation; one of the most important factors for maintaining high levels of productivity. Built for high performance and durability even in the harshest of operating environments, all motors are insulated using strict procedures and materials of the highest quality. These features contribute not only to stable, trouble-free nonstop operation, but also a long service life with minimal maintenance.

# Optimized Components and Stru



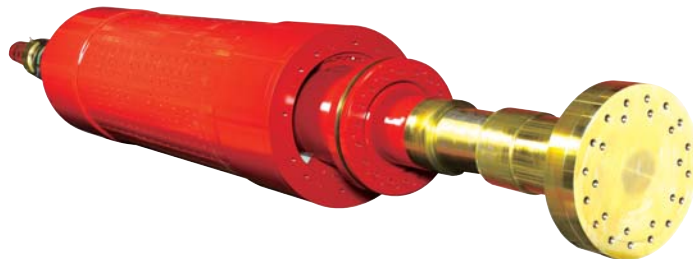


# Structural Design

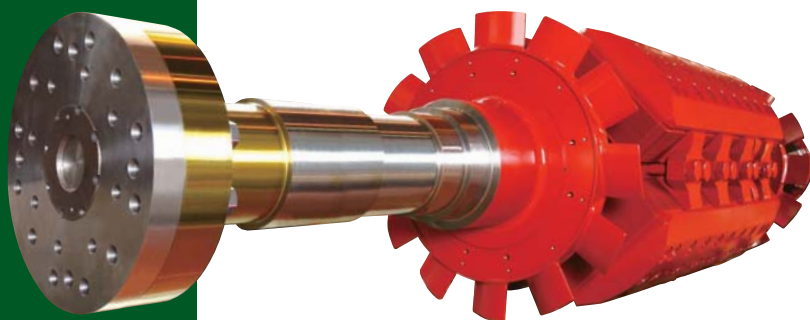
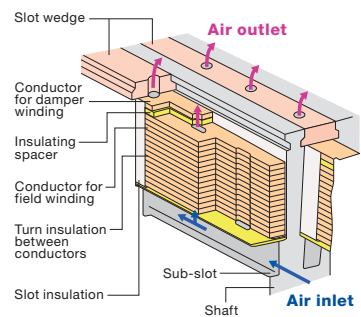
## Rotor

### High-speed, cylindrical solid rotors (two-pole)

The first step in manufacturing this rotor is selection of special steel-alloy materials for the two-pole rotor shaft that are able to withstand large centrifugal force. After machining, the materials are inspected using ultrasonic flaw detection and rotor balancing tests. This is a key factor in the manufacture of two-pole machines as it provides quality assurance of the materials and the manufacturing process. The rotor coil end is then secured using a shrink-fitted retaining ring, which is made of non-magnetic 18Mn-18Cr steel for large-capacity motors. Before final assembly, the rotor undergoes a high-speed balancing test. Cross-shaped slots engraved at the Y-axis equalize the stiffness at the X and Y axes to achieve highly balanced characteristics, and in turn, low vibration. To cool the rotor and rotor coils, cooling-air is passed through airflow ducts cut under the rotor slots and through holes cut in the rotor coils. The airflow path is optimized to create a constant, efficient cooling-air flow void of inconsistencies to ensure that a low rotor temperature is maintained.



High speed cylindrical solid rotor airflow



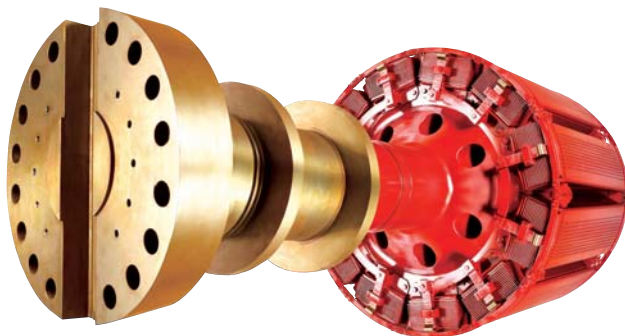
### High-speed salient solid pole rotors (four- and six-pole)

Solid rotors with integrated poles are formed through a one-piece steel forging process. The solid pole plate is then attached to the poles. This design provides superior overload capacity and reduces harmonic components. In addition, this rotor configuration contributes to the motor's outstanding starting characteristics, high starting torque and low starting current, sufficiently withstanding large moment of inertia on the load side. The optimized cooling structure (large cooling surface-area and efficient cooling-air flow) constantly maintains a uniform low rotor temperature. The rigid rotor structure and optimized distance between bearings realizes no first critical speed within 120% of the motor's rated speed and secures excellent low-vibration characteristics.

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### Low-speed salient pole rotors

Of the two types of poles used in rotors, solid poles are mainly used for fixed-speed applications while laminated poles are mainly used for variable-speed applications. Solid poles are formed through a one-piece steel forging process and a solid pole plate is attached. Laminated poles are made from laminated steel sheets which are compressed via welding or bolts connecting the inserted steel studs and end-plates. In addition, a damper winding made of copper-alloy is installed. The rotor spider shaft is formed by welding or shrink-fitting a yoke—made by rolling steel plates—to the shaft, and then solid or laminated poles are bolted to the outer surface of the rotor spider.





Stator



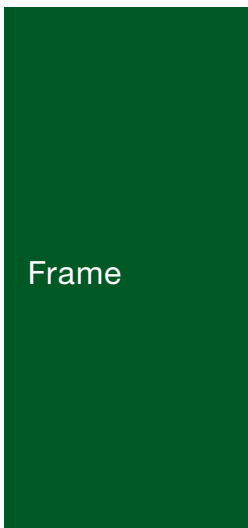
## Structure optimized for high efficiency

The stator core structure consists of electromagnetic steel sheets that are first laminated and then pressed using stud and end-plate bolt connections. The electromagnetic steel sheets are produced using high-quality, thin-plate silicon steel low in iron-loss and with insulation coating on both sides. The stator core, which contributes to high motor efficiency, has an air duct built into it. The air duct dimensions and its position contribute to realizing the best possible cooling efficiency, and ensure uniform heat distribution throughout the stator coil.



Using techniques such as the finite element method (FEM), model analysis is conducted to accurately understand the natural vibration mode, information that is then utilized to eliminate vibration inside the motor due to resonance. For ultrahigh-speed motors in particular, a spring support system is adopted to absorb the stator core vibration caused by electromagnetic force and achieve low vibration across a wide range of speeds.

Spring Support System



Frame

## High rigidity suppresses vibration

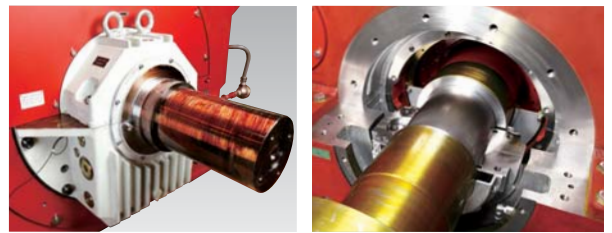
The stator frame is produced utilizing a combination of press processing and welding, realizing a compact, highly rigid structure. The rigid structure restricts vibration to a minimum by transferring all the excitation force applied to the stator through the frame to the base. Horizontal, inclined or vertical mounting is possible.



## Bearings

### Supporting smooth, reliable operation

The type of bearing system used is determined by operating conditions such as the application, radial and axial loads, impact load, revolutions per minute, ambient temperature, and other factors such as vibration level, coupling method and customer preferences. Brackets are adopted as standard for bearing support, and in the case of large machines, pedestal bearings are used. Standard sliding bearings have a two-part structure with the outer circumference cast in white metal. Maintenance and inspections are simplified as there is no need to remove the machine-side couplings. Tilting-pad sleeve bearings, which possess high vibrational stability, can be arranged by special request. Bearings are insulated to protect bearing metals from the axial current. In addition, a grounding brush can be used to ground the shaft. At low speed, bearings are self-lubricating based on an oiling process, and oil is self-contained so there is no need for an oiling device. At high speed, a forced-feed oil-supply system is used and an oiling device is required. When very low operating speeds are required, a jacking pump may be necessary.

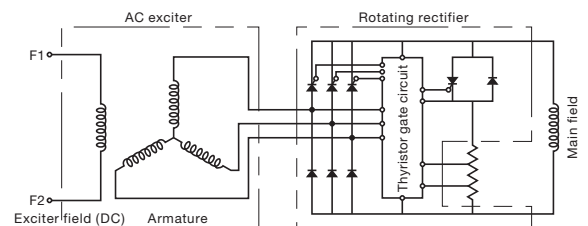


### Brushless excitation

TMEIC utilizes brushless excitation systems as standard equipment for its synchronous motors. These systems simplify maintenance, inspections and enable continuous operation over long periods. A variety of brushless excitation systems are available and differ according to requirement characteristics such as motor capacity, operating speed and start-up system, enabling the production of optimal systems that match customer requirements.

#### Brushless exciters for self-starting

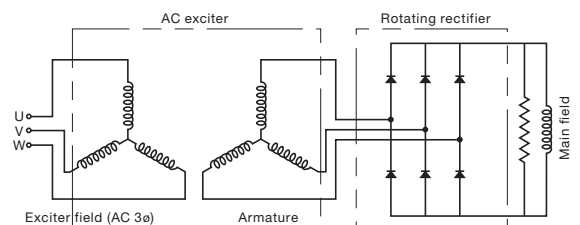
Self-starting brushless exciters incorporate optimum phase-angle field application equipment and a control module. Laminated rotor and stator cores and three-phase rotor (star connection) and stator coil windings are adopted. The three-phase AC current generated by the rotor coil flows to the rotating rectifier which is equipped with highly reliable diodes.



## AC Exciter

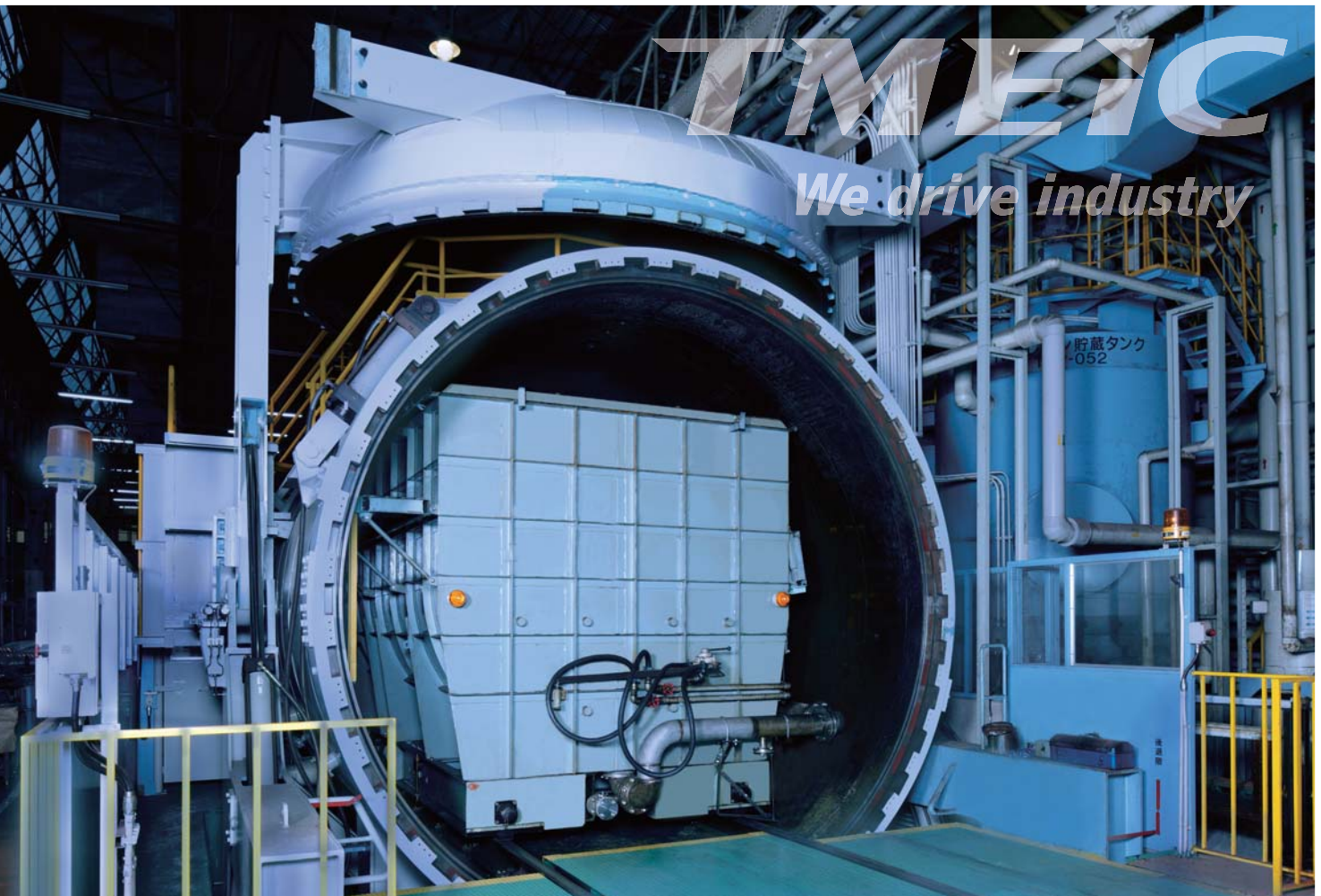
#### Brushless exciters for variable-speed-drive (negative phase sequence)

Variable-frequency-drive brushless exciters have a negative phase sequence. The rotor is laminated and a star-connection, three-phase rotor coil winding is utilized. The three-phase AC current generated by the rotor coil is delivered to a rotating rectifier equipped with highly reliable diodes. The stator core is also laminated and a three-phase stator coil winding is utilized. The stator housing and core are fixed to the motor frame or the motor base.





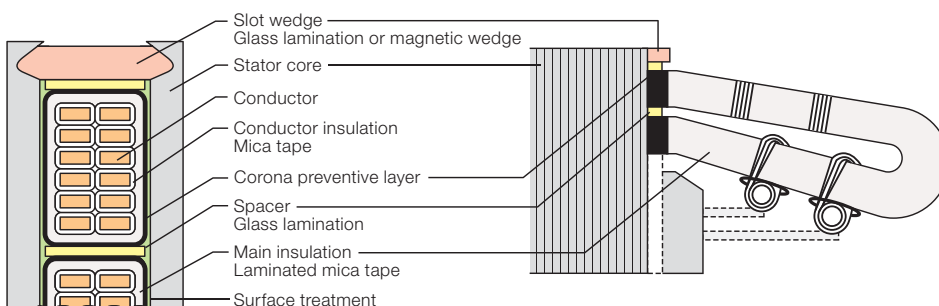
# Superior Reliability through Precise Insulation



## Vacuum-pressure Impregnation for systems up to 250MW – Built on refined technologies and a record of success

As standard, the entire core and windings of TMEIC motors undergo vacuum-pressure impregnation (VPI) using epoxy resin. The TMEIC VPI treatment subjects the whole winding to impregnation simultaneously so as to provide a continuous, strong and highly reliable insulation structure free of even minute weak points. In addition to outstanding insulation performance, the excellent heat conductivity of the winding provides a powerful cooling effect. These features are the foundation of additional benefits for the customer, such as class-F heat resistance, excellent surge withstand capacity, high resistance to severe environmental conditions, strong, durable mechanical characteristics, and consistent insulation characteristics.

### Example of insulation construction

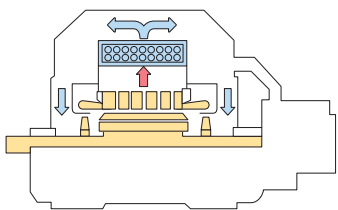
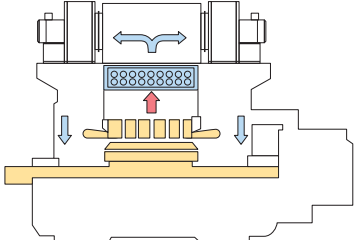
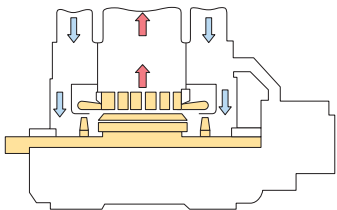
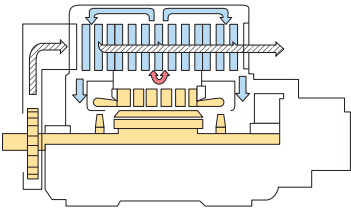
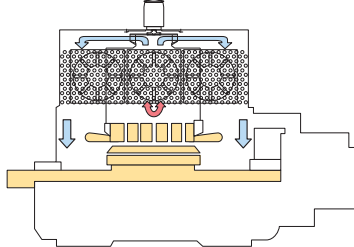
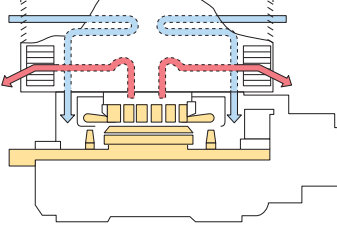


The insulation class and specifications utilized depend on the inverter surge values, and are designed to ensure highly reliable insulation. Mica tape is used to prevent corona discharge effects, and there is a special area for conductive corona protection.



# Efficient, Effective Cooling

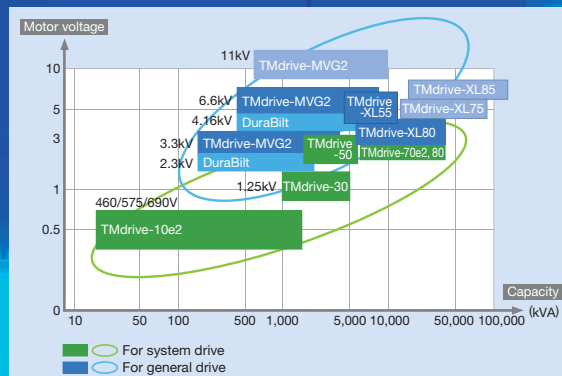
TMEIC motors are specially designed for high performance, which requires that they be efficiently and effectively cooled during operation. Depending on the type of motor, there are three cooling methods to choose from: weather-protected, air-to-air or water-to-air. We will help you to choose the one that best matches your needs.

Name	<b>Totally enclosed water-to-air-cooled (TEWAC)</b>	<b>Totally enclosed water-to-air-cooled with fan (TEWAC with fan)</b>	<b>Totally enclosed pipe-ventilated (TEPV)</b>
Figure			
Degree of protection	IP55	IP55	IP55
Cooling method	IC81W	IC86W	IC97
Utilities required	Cooling water	Cooling water, power-supply for fan	Cooling air
Cooling path	Cooling air circulates in a path closed off to the outside through the heat source inside the motor and the water-cooled heat exchanger	Cooling path is the same as above but the fan creates a forced airflow	Cooling air supplied from the outside circulates in a path closed off to the outside through the heat source inside the motor and the heat exchanger, located at a distance, through a duct
Features	Good cooling performance; environmental resistance; most compact and cost-effective solution for large-capacity motors for sites with supply of cooling water; noise can be restricted to low levels	Fan further enhances cooling performance; accommodates wide range of operating speeds in variable-speed systems	Most compact, cost-effective solution for sites with a supply of cooling air but without a supply of cooling water
Name	<b>Totally enclosed air-to-air-cooled (TEAAC)</b>	<b>Totally enclosed air-to-air-cooled with fan (TEAAC with fan)</b>	<b>Weather-protected type II (WPII)</b>
Figure			
Degree of protection	IP55	IP55	IP24W
Cooling method	IC611	IC666	IC01
Utilities required		Power-supply for fan	
Cooling path	Cooling air circulates in a path closed off to the outside through the heat source inside the motor and the air-to-air heat exchanger	Cooling path is the same as above but the fan creates a forced airflow	Air from outside the motor passes through air filters and the heat source inside the motor and is emitted to outside the motor
Features	Bigger than TEWAC in terms of external dimensions but can be used even on sites where there is no supply of cooling water	Fan further enhances cooling performance; larger capacity possible; accommodates wide range of operating speeds in variable-speed systems	Most compact, cost-effective solution for sites where the air outside the motor is relatively clean and there is a stable supply of cooled air

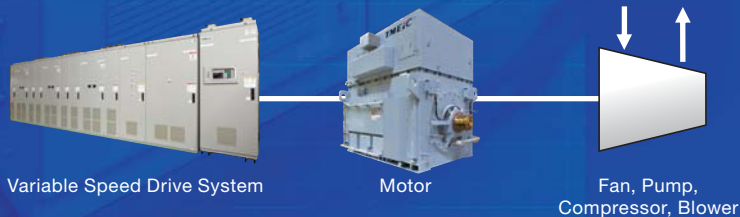
# Drive Systems You Can Trust



Fusing the power-electronics technologies of Toshiba and Mitsubishi Electric, TMEIC provides high-performance, highly reliable drive products that solve a wide range of user needs. With a product line-up including individual units and total systems covering capacities from several kVA to over 100MVA, there's a best-fit solution for any industrial need.



Drive systems enable highly precise motor control that can maximize plant productivity and contribute to reducing both energy costs and CO<sub>2</sub> emissions. TMEIC uses its vast experience and cutting-edge technologies to provide motor and drive systems capable of variable-speed control, from ultralow to ultrahigh speeds.



# Wide Selection of Operating Ranges and Capacities

## Fixed-speed motors

Boasting outputs at the highest levels in the world, TMEIC fixed-speed motors are capable of low to high operating speeds, and are matched to the load demands of each specific application. Whether it is the low-speed, high-torque load of rolling mills and reciprocating compressors, the high-speed load of compressors for oil and gas pipelines or the standard load of multipurpose pumps, fans and blowers, there's a motor designed to match your requirements. TMEIC motors are compatible with global standards such as those of NEMA in North America and the International Electrotechnical Commission (IEC). In addition, motors are built to match to the usage environment and comply with explosion-protection standards (Exn, Exp) and the standards of individual countries (IECEX, CSA, Gost, CQST, CCOE). Furthermore, backed by solid achievements in a broad range of fields, it's possible to accommodate special requests for API and ABS specifications.



<b>Power</b>	Up to 100MW (134,000hp)
<b>Speed</b>	Up to 3,600rpm
<b>Voltage</b>	Up to 13.8kV
<b>Applicable types of protection</b>	Exn, Exp
<b>Rotor construction</b>	Cylindrical rotor or Salient pole rotor
<b>Typical applications</b>	Compressors, Blowers, Mixers

## Variable-speed motors

TMEIC, developing its drive systems while taking the same approach as that for its fixed-speed motors, has achieved optimal operation with highly reliable variable-speed control. This variable-speed control, together with the application of brushless synchronous motors, enables eco-conscious, energy-saving operation with no need for the maintenance of brushes required if using DC or wound rotor induction (WRI) motors. Additionally, the ability to operate at ultrahigh-speed (i.e., speeds higher than that of synchronous speeds) eliminates the need for gears, previously required under normal circumstances, and enables significant reductions in equipment and maintenance costs. In tune with market needs, TMEIC is driving forward the evolution of synchronous motors to ultrahigh-speeds and larger capacities.

<b>Power</b>	Up to 100MW (134,000hp)
<b>Speed</b>	Up to 6,500rpm
<b>Voltage</b>	Up to 11kV
<b>Applicable types of protection</b>	Exn, Exp
<b>Rotor construction</b>	Cylindrical rotor or Salient pole rotor
<b>Typical applications</b>	Metal rolling mills, Compressors





# Global Sales/Service Network



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## Corporate Profile

**TOSHIBA**  
 Toshiba Corporation

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**1896** Tokyo Electric Co., Ltd. established

**MITSUBISHI**  
 Mitsubishi Electric Corporation

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**1921** Mitsubishi Electric Corporation established



**TMEiC**  
 Toshiba Mitsubishi-Electric Industrial Systems Corporation

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**2003** The industrial systems departments of Toshiba Corporation and Mitsubishi Electric Corporation, were merged to create Toshiba Mitsubishi-Electric Industrial Systems Corporation (TMEiC)



Applying a wealth of experience and cutting-edge technological prowess in the design of industrial systems that contribute to social development and the global environment. TMEiC

**We drive industry**

TOSHIBA MITSUBISHI-ELECTRIC INDUSTRIAL SYSTEMS CORPORATION

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