



TMEiC
We drive industry

Industrial Motors Overview

Introduction to TMEiC Motors



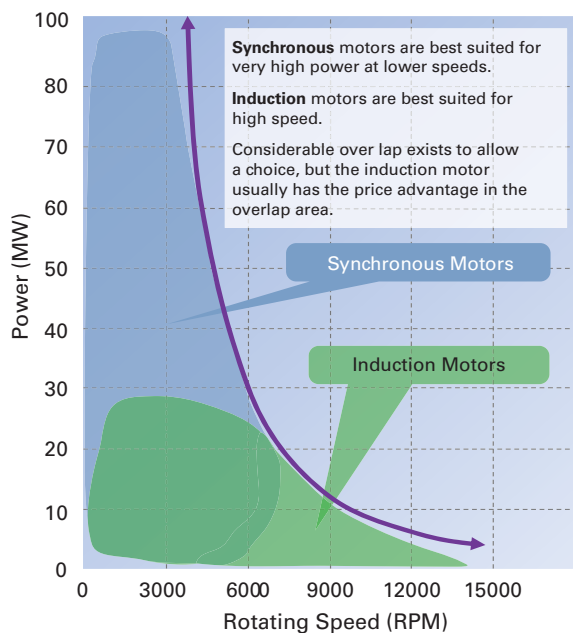
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Introduction to TMEIC Motors

TMEIC combines the best of Toshiba and Mitsubishi-Electric's experience in building motors that goes back over 100 years. TMEIC's motor offering includes induction motors from a few hundred horsepower, up to synchronous motors over 100,000 hp, driving a wide range of industrial applications such as pumps, fans, grinding, conveyors, and compressors.

In addition to applications directly connected to utility power, TMEIC motors can be matched with Variable Frequency Drives for ease of starting and for speed control. The VFD allows motor speeds as high as 12,000 rpm. This chart below and pages 4 & 5 illustrate the range of motors available.



Expansion of the oil and gas industry has created demand for large motors to drive gas compressors and oil pumps. These motors are located in the production areas and on interstate pipelines, and are usually designed with explosion protection. For special applications such as driving large compressors and blowers, motor ratings can reach or exceed 100,000 hp.

Meeting the demand for large motors for the metals industry, TMEIC has produced large synchronous and induction motors for the operation of steel rolling mills. The power levels for these motors go up to about 10 MW. They are covered in a separate brochure.

Features

High Reliability resulting from use of proven design technology, manufacturing expertise, wide use of robotics, tight quality control, and testing

High Efficiency resulting from detailed analysis of the electromagnetic field patterns and ventilating air flows

High Strength Insulation applied by robotic insulation winding and oversized epoxy resin vacuum impregnation tanks creates strong support and insulation

High Mechanical Strength through use of static and dynamic strength analysis of stator frame, rotor, shaft and bearings. Motor shafts are made of forged steel with high tensile strength

Benefits

Many years of excellent trouble-free service under difficult working conditions

Low electrical losses for high power conversion efficiency

Withstand surge and minimizes electrical shorts and winding fatigue failure

Minimizes mechanical deflection and vibration for longer equipment life

High-Quality Design, Manufacturing, and Testing

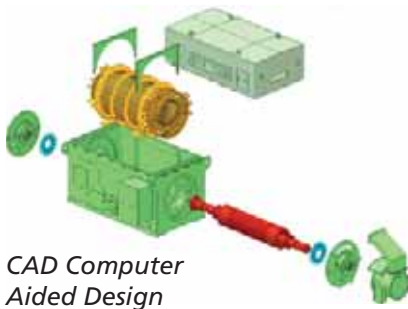
TMEIC produces high-quality motors by employing the best design, manufacturing, and test procedures. Advanced computer aided design and analysis allows motor performance to be predicted in advance. The world class manufacturing automation system produces high-quality parts, on time, with no exceptions. These automated systems produce components and assemblies meeting the highest quality requirements, delivery schedule, and long life.

Continuous Improvement
The manufacturing system has specified standards, and the actual performance is measured against these. Continuous quality improvement is built in, with product quality steadily improving as a natural outcome.

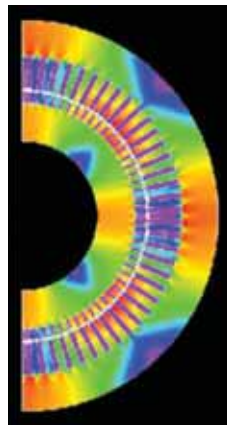


Large Stator Assembly

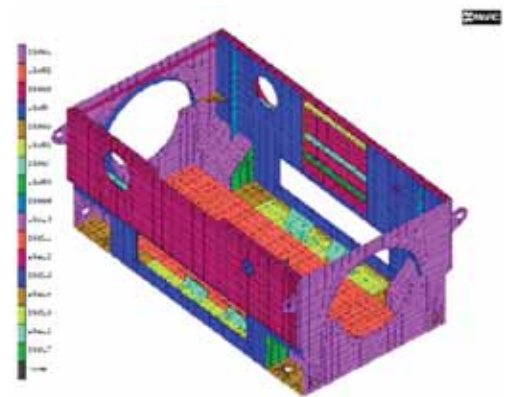
Excellent Motor Design Tools – Extensive CAD and Computerized Finite Element Analysis



CAD Computer Aided Design



FEM Electromagnetic Analysis



FEM Natural Frequency Analysis

TMEIC motor engineers make extensive use of computer aided design to produce their detail and assembly drawings, both two-dimensional and three-dimensional.

Enhanced computerized Finite Element Analysis is used to analyze and optimize electromagnetic field strength, rotor stress and dynamics, frame natural frequencies, cooling air flow patterns, and internal temperatures.

High-Quality Manufacturing – Computer Control and Robotics

Manufacturing procedures make use of computer control and robotics to increase the speed of the work, maintain accuracy, and ensure repeatability of the operations. Examples include:



Robotic Stator Core Lamination Stacking

- Air duct plate robotic assembly
- Segmented core lamination robotic assembly
- Round core lamination robotic assembly
- Rotor field core robotic assembly
- Computer controlled core stamping

World-Class Motor Test



TMEIC's fully instrumented computer automated test (CAT) facilities allow motors to be load and speed tested. The example facility shown here was built to test large motors and drives at high speed. This back-to-back test arrangement used:



- Variable frequency drive to provide power and desired speed to the test motor
- Generator to load the test motor
- Variable frequency drive to recycle power back to the supply

TMEIC Motor Product Overview

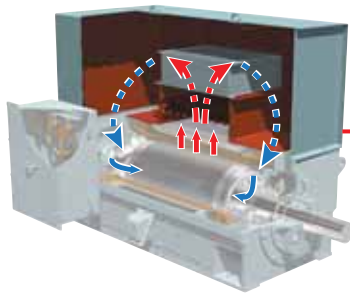
Product	Induction Motors				
	LV and MV TM21™-FII	Mill Motors TM-AC	MV Motors TM21-G	MV Motors TM21-H	MV Motors TM21-MII
Typical View					
Power	37-1,400 kW (50-1,870 hp)	44-370 kW (59-490 hp)	Up to 23,000 kW (30,800 hp)	Up to 8,000 kW (10,270 hp)	Up to 3,550 kW (4,750 hp)
Speed	Up to 3,600 rpm	Up to 1,300 rpm	Up to 3,600 rpm	Up to 3,600 rpm	Up to 3,600 rpm
Voltage	Up to 6.9 kV	420 Vac max.	2 – 11 kV	13.8 kV	2 – 11 kV
Enclosure	Totally Enclosed Fan Cooled –TEFC/ IP55	Totally Enclosed Forced Ventilated – TEFV Drip Proof Forced Ventilated – DPFV Totally Enclosed Non Ventilated – TENV	Weather Protected II-WPII/IP24W Totally Enclosed Air-to-Air-Cooled – TEAAC/IP54/IP55/IP56 Totally Enclosed Water-to-Air-Cooled– TEWAC/IP54/IP55/IP56	Weather Protected II-WPII/IP24W Totally Encl. Air to Air Cooled – TEAAC/IP55 Totally Encl. Water to Air Cooled – TEWAC/ IP55/56	Open Drip Proof – ODP/IP22 Weather Protected II- WPII/IP24W Totally Encl. Air to Air Cooled – TEAAC/IP55 Totally Encl. Water to Air Cooled – TEWAC/ IP55/56 Totally Encl. Separately (Pipe) Ventilated – TESV/IP55/56
Classified Area	Exn, Extc, Exd	N/A	Exn, Exe, Exp	Exn, Exe, Exp	Exn, Exe, Exp, ExtD
Rotor	Aluminum die cast rotor, or Copper rotor bars	Aluminum die cast rotor or Copper rotor bars	Copper rotor bars	Copper rotor bars	Alum. die cast rotor Opt. copper rotor bars
Bearing Options	Ball & roller bearings, grease lubrication	Ball & roller bearings, grease lubrication	Ball & roller bearings, grease lubrication Sleeve bearings	Ball & roller bearings, grease lubrication Sleeve bearings	Ball & roller bearings, grease lubrication Sleeve bearings
Available Standards	IEC, NEMA, BS, AS, CSA, API	Based on JEC-2137 and IEC 60034-1	IEC, NEMA, BS, AS, CSA, IS, JEC	IEC, NEMA, BS, CSA, JIS, JEC, JEM, API	IEC, NEMA, BS, AS, CSA, API
Major App.	Fans, Blowers, Compressors, Conveyors	Steel Mills, Aluminum Mills	Fans, Blowers, Compressors, Mills, Conveyors	Fans, Blowers, Compressors, Mills, Conveyors	Fans, Blowers, Compressors, Mills, Conveyors

			Synchronous Motors		
MV Motors TM21-L	Vertical Motors TM21-VL & VLL	High Speed (Custom design)	Main Drive Motor (Custom design)	Medium-High Power (Custom design)	High-Speed (Custom design)
					
Up to 18,500 kW (25,000 hp)	Up to 6,500 kW (8,700 hp)	Up to 8,000 kW (10,720 hp)	12,000 kW	Up to 80,000 kW (107,240 hp)	Up to 80,000 kW (107,240 hp)
Up to 3,600 rpm	Up to 1,800 rpm, option > than 30 poles	Up to 11,900 rpm on VFD power	Up to 1,540 rpm	Very low speed up to 3,600 rpm	Up to 6,500 rpm
2 –13.8 kV	2 –13.8 kV	2.3 -11 kV	Up to 6.6 kV	3.3 –13.8 kV	Up to 13.8 kV
Open Drip Proof – ODP/IP22 Weather Protected II-WPII/IP24W Totally Encl. Air to Air Cooled – TEAAC/ IP55 Totally Encl. Water to Air Cooled – TEWAC/ IP55 Totally Encl. Separately (Pipe) Ventilated – TESV/IP55	Open Drip Proof – ODP/IP22 Weather Protected II-WPII/IP24W Totally Enclosed Air to Air Cooled – TEAAC/IP55 Totally Enclosed Water to Air Cooled – TEWAC/IP55	Totally Enclosed Air to Air Cooled– TEAAC/IP55 Totally Enclosed Water to Air Cooled – TEWAC/ IP55 (Blower ventilated)	Totally Enclosed Water to Air Cooled – TEWAC	Totally Enclosed Air-Air Cooled– TEAAC/IP55 Totally Enclosed Water to Air Cooled – TEWAC/ IP55	Totally Enclosed Water to Air Cooled – TEWAC/ IP55
Exn, Exe, Exp, ExtD	Exn, Exe, Exp	Exn, Exe, Exp	N/A	Exp	Exp
Copper rotor bars	Copper rotor bars	Aluminum alloy rotor bars	Salient Poles	Cylindrical solid rotor for two- pole, salient pole all others	Cylindrical solid rotor, two-pole
Ball & roller bearings, grease lubrication Sleeve bearings	Antifriction bearings Tilting pad bearings	Magnetic bearings Tilting pad bearings	Sleeve Bearings	Sleeve bearings	Sleeve bearings Tilting pad bearings Magnetic bearings
IEC, NEMA, BS, AS, CSA, API	IEC, NEMA, BS, AS	IEC, NEMA, BS, AS	IEC, JEC	IEC	IEC
Fans, Blowers, Compressors, Mills, Conveyors	Pumps	Gearless Compressors	Metal Rolling Mills Turbo Compressors (Ind. Motors Also)	Mills, Blowers, Pumps, Compressors	Blowers, Gearless Compressors

TM21-M and TM21-L Series Induction Motors

TMEIC offers a range of medium voltage induction motors for larger Industrial applications such as fans, blowers, pumps, mills, compressors and conveyors. These motors offer higher efficiency and higher power factor than any previous design. The TM21-M and TM21-L have rugged

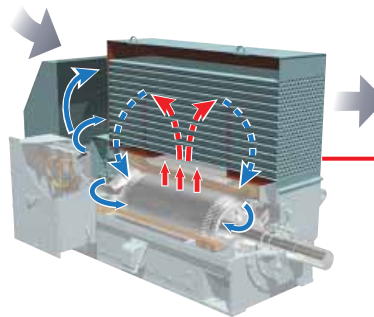
fabricated steel frames. Aluminum rotor bars are standard on the TM21-M, and copper rotor bars are standard on the TM21-L. Both series can be customized with different top enclosures for selected types of protection and cooling. The arrows in the illustrations below indicate airflow.



Totally-Enclosed Air-Water-Cooled Type TEWAC/IP55

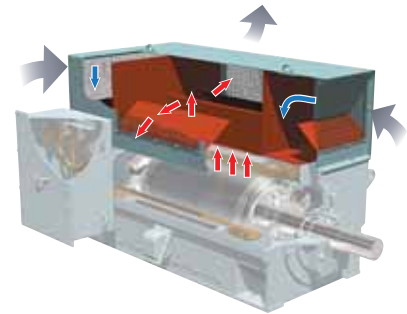
Includes an air-to-water heat exchanger in the air housing above the motor.

A drain in the air housing protects the motor from damage caused by water leakage.



Totally-Enclosed Air-Air Cooled Type TEAAC/IP55

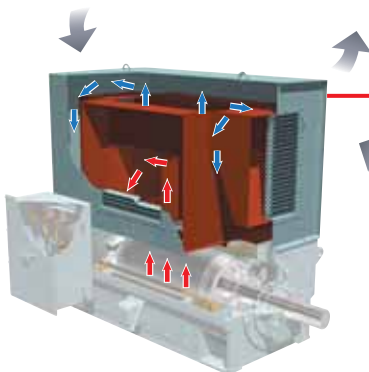
In a corrosive or harmful environment, a totally-enclosed fan-cooled motor can be applied. An external fan directs fresh air through the pipes in the air housing above the motor. The pipes serve as a heat exchanger in which outside fresh air passing through cools the hot air inside.



Open Drip Proof Type ODP/IP22

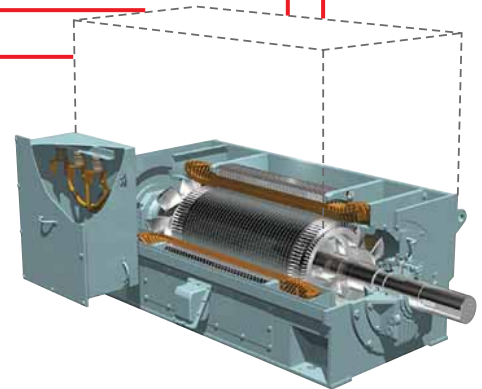
A drip-proof type motor has a cooling air intake and hot air exhaust window located at the top of the hood.

Openings are covered by screens and enclosure is constructed to prevent intrusion of water drips and other foreign materials into the motor and meets NEMA WP-I requirements.



NEMA Weather-Protected WP2/IP24

This motor is designed for outdoor operation. The air housing is in accordance with NEMA WP2, and features three right-angled turns for air intake, dropping velocity below 3 m/sec (600 ft/min.), trapping water, dust, and foreign materials.



	TM21-M	TM21-L
Power	50 HZ	160 - 2,800 kW (210 - 3,750 hp)
	60 HZ	200 - 3,550 kW (270 - 4,750 hp)
Voltage	2 kV - 11 kV	2 kV - 13.8 kV
Speed	Up to 3,600 rpm	Up to 3,600 rpm
Poles	From 2 up to 10	From 2 up to 24
Rotor	Aluminum Casting	Copper Bar

Fundamental Building Block 21-M and 21-L

- IC01, IC61 and IC81W cooling per IEC Standard construction are available by changing the top-mounted air housing.
- The main terminal box can be rotated every 90°, and is large enough for easy cable connection.
- International standards such as IEC, NEMA, BS, AS, etc.
- Optional classified areas: Exn, Exe, Exp, ExtD
- Insulation Class F, B Rise design is standard

High-Speed Induction Motors



11,900 rpm, 1.8 MW, Induction Motor

For very high speeds, induction motors are used. These are custom designed for special applications such as driving gearless compressors.

Rotor – Squirrel cage with aluminum rotor bars specially designed with stiff-shaft low vibration

Stator – Two pole windings, spring mounted for vibration isolation

Bearings – Oil-fed sleeve bearings or Magnetic bearings

Data for typical high speed induction motors are shown below.

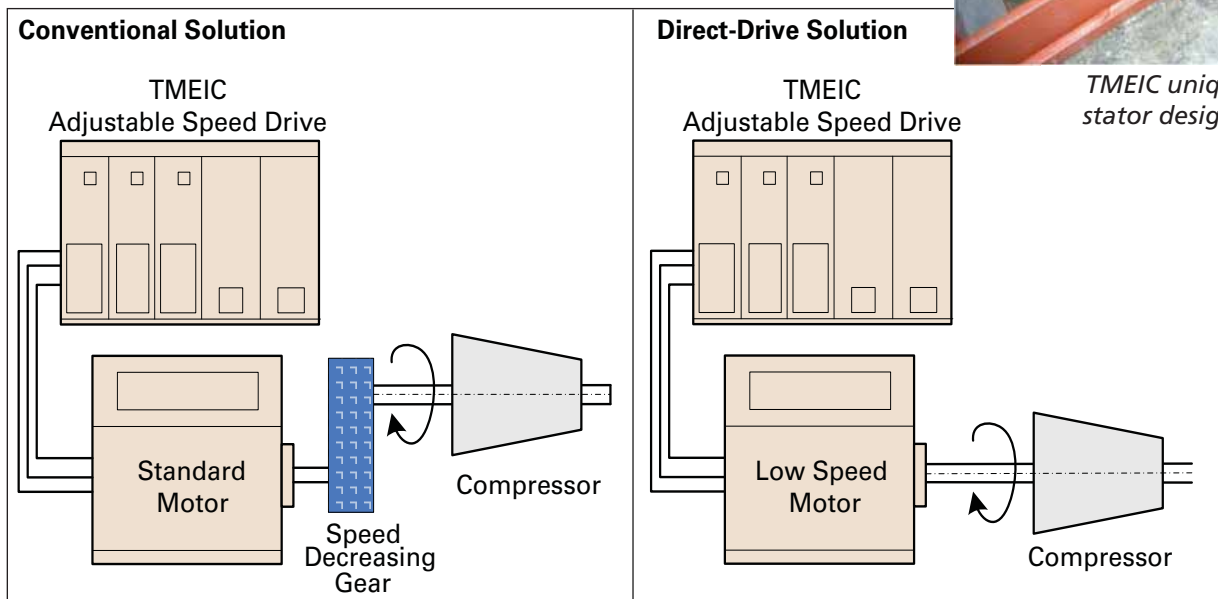
Power	Up to 8000 kW
Supply Voltage	2.3-11 kV
Poles/Speed	2 Poles/to 12,000 rpm
Enclosure	Totally Enclosed Water to Air Cooling TEWAC/IP55 or Air to Air TEAAC/IP55
Classified Areas	Exn, Exe, or Exp Protection
Available Standards	IEC, NEMA, BS, AS

High Speed Motor and Drive Systems

TMEIC's unique capabilities in designing high speed motors for direct-drive solutions eliminate speed increasing gearboxes or mechanical clutches. The net result of this solution is lower cost, smaller footprint, higher system efficiency, smaller parts and spares inventory to maintain, and worry-free service.



TMEIC unique spring-mounted stator design reduces vibration



Medium-High Power Synchronous Motors

TMEIC custom designs and builds medium and high power synchronous motors for special applications such as driving mills, blowers, pumps and compressors. The example shown here is a 53 MW synchronous motor for a steel mill blower. It runs at 3,000 rpm with a 10 kV supply. Data for typical synchronous motors are shown below.



Up to 3,600 rpm, 53 MW, Synchronous Motor

Power	2000 kW up to 80 MW, either Utility Fed or VFD Powered
Supply Voltage	3.3-13.8 kV
Poles/Speed	Up to 34 Poles/Up to 3,600 rpm
Enclosure	Totally Enclosed Water to Air Cooling TEWAC/IP55 or TEAAC/IP55 – Other Enclosures Available
Classified Areas	Exn/Exp Protection Available
Available Sync Field Designs	Brush Type, DC Brushless, AC Brushless

Rotor – Cylindrical solid rotor for 2 pole, salient pole for 4 to 34 poles

Bearings – Oil-fed sleeve bearings

Low Speed Induction Machines

TMEIC’s unique capabilities in designing low speed motors for direct-drive solutions eliminate speed decreasing gearboxes or mechanical clutches. The net result of this solution is lower cost, smaller footprint, higher system efficiency, lower parts and spares inventory to maintain, and worry-free service.

Advantages

- **Cost savings** – individual approval tests & expensive full load tests eliminated
- **Reduced testing** requirements lowers delivery time
- **Simpler Exn designs** reduce machine costs (when compared to alternative inner pressurized or flammable enclosures)
- **Lower cost of ownership** – eradication of the air supply system required for inner pressurized machines minimizes maintenance and operating cost

Special Features

- High efficiency saves energy
- Low vibration and noise
- High reliability
- Meet international standards such as IEC, EN, BS, NEMA
- Easy installation
- Quick delivery



SAG Mill and Motor

Large High-Speed 2-Pole Synchronous Motors



High Speed 25 MW 3,780 rpm Synchronous Motor

TMEIC builds a range of custom designed, high-speed, high-power synchronous motors for driving large compressors.

The example on the left shows a 25 MW synchronous motor designed for variable speed operation from 2,500 to 3,780 rpm with a 7 kV variable frequency drive.

Other TMEIC designs are available for synchronous motor top speeds up to 6200 rpm. This can allow large compressors to be driven without a gearbox.

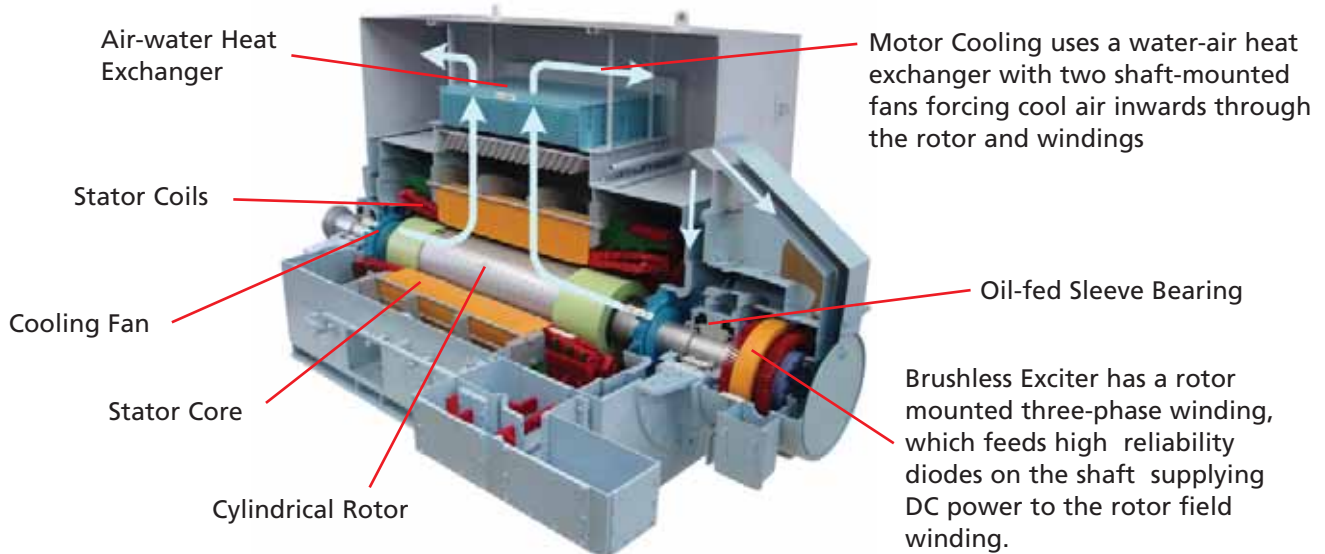
Power – Motor output levels up to 80 MW (107,200 hp) are available, and speeds up to 6,200 rpm when used with a matched variable frequency drive such as the TMEIC TMdrive®-XL85.

Rotor – The rotor is a two pole, cylindrical design with a shaft mounted brushless exciter.

Bearings and Maintenance – Oil lubricated sleeve bearings are used. No slip rings are required with the brushless exciter.

Quality Manufacturing and Standards – TMEIC’s motor manufacturing is certified to ISO 9001 and ISO 14001. Motors can be certified by third party agencies such as CSA, Lloyd’s and Baseefa. Motors can be designed to international standards such as IEC, NEMA, BS, and AS.

Power 60 HZ	15 MW (20,100 hp) up to 80 MW (107,200 hp)
Supply Voltage	3.3 kV to 13.8 k V
Enclosure	Totally Enclosed Water to Air Cooled – TEWAC/IP55
Classified Areas	Exp certification for use in hazardous areas Zone 1 & 2, using an internal pressurization system
Motor Speed	Up to 6,500 rpm
Insulation Class	Class F



High-Speed Synchronous Motor – Internal Details

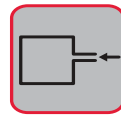
Hazardous Area Protection and Low & Medium Voltage Motors

Types of Explosion Protected Machines

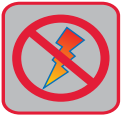
TMEIC provides motors with different levels of explosion protection for a range of operating environments found in the process industries, in particular the Oil & Gas industry. Protection in dust environments, Zone 22, is available as ExtD according to IEC61241-1.



Exn – Non-Sparking - Machines which, in normal operation, are not capable of igniting a surrounding explosive atmosphere.



Exp – Inner Pressurized - Explosive gas that may cause ignition is excluded from the inside of the machine. The motor housing is pressurized with air to ensure no gases enter.



Exe – Increased Safety - Machines that do not produce dangerous sparks or temperatures in normal service or starting. Special increased safety measures are taken.



Exd – Flame Proof Enclosure - Machines are constructed to contain an internal explosion and prevent the transmission of flame to the external atmosphere. The temperature of operation is such that it cannot ignite the surrounding gas.

Global Protection and Certification

Explosion protection certification for TMEIC's motors has been obtained around the world, as illustrated in this table.

	USA	UK	Europe	China	Korea	Russia	Australia	Canada	Others
Standard	NEC	EN	EN + ATEX	GB	IEC or KS	IEC or AS	IEC or GOST	CSA	IEC or EN
Certification Body	FM, UL, etc.	Baseefa	Baseefa, PTB, etc.	CQST	KOSHA	CCVE	TestSafe Baseefa	CSA	Baseefa
Records	Exd, Exp, Exe, Exn	Exd, Exp, Exe, Exn	Exd, Exp, Exe, Exn	Exd, Exp, Exe, Exn	Exd, Exp, Exe, Exn	Exp, Exn	Exd	Exn	Exd, Exp, Exe, Exn

TM21-FII Series Totally Enclosed Fan Cooled Low and Medium Voltage Motors

TM21-FII Series motors are widely applied in industrial applications such as small and medium size fans, blowers, compressors, pumps, and conveyors. They are tough and suitable for harsh conditions.

Power – The TM21-FII series power output ranges from 37 kW (50 hp) to 1400 kW (1,850 hp). With a choice of poles, the series provides a selection of speeds from 720 rpm up to 3,600 rpm.

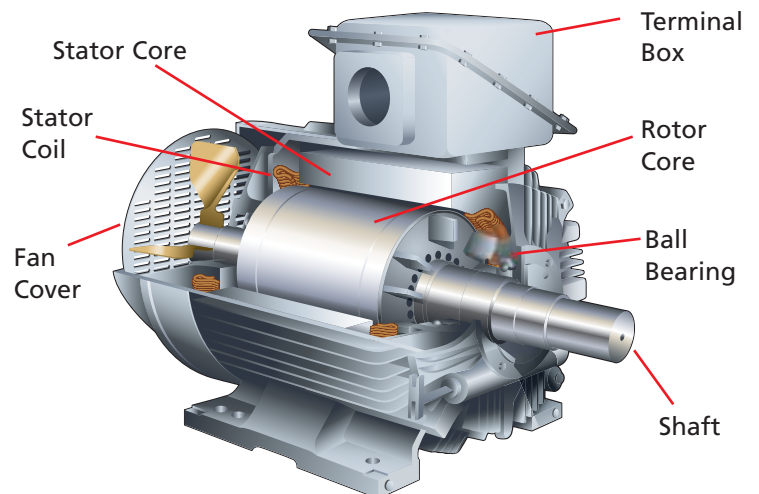
Frame – The TM21-FII series have a cast iron fin frame with improved ventilation flow.

Rotor – The squirrel cage rotor is a highly-reliable aluminum die-casting.

Bearings and Maintenance – Ball and roller bearings or oil lubricated sleeve bearings are applied based on rating and application requirements. Optimized design makes re-greasing simple.

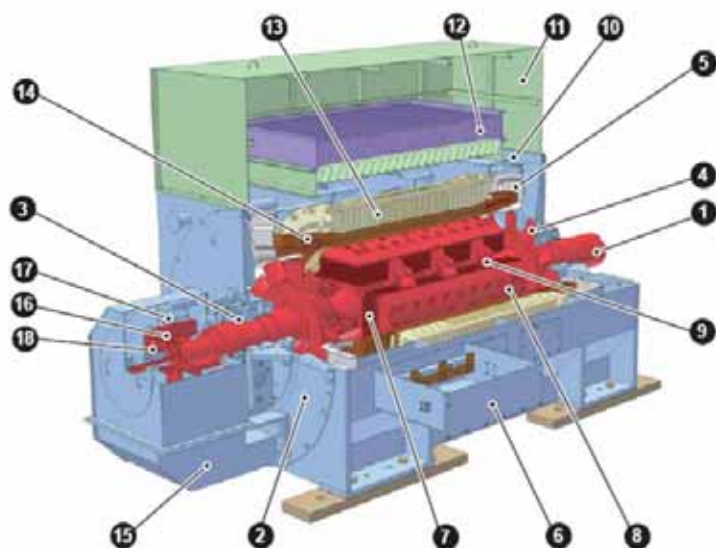
Quality Manufacturing and Standards – TMEIC manufacturing is certified to ISO 9001 and ISO 14001. Motors can be certified by third party agencies such as Lloyd's, CSA, Baseefa, and etc. Motors can be designed to international standards such as IEC, NEMA, BS, AS, etc.

Power Output	37 kW (50 hp) up to 1400 kW (1,850 hp)
Number of Poles	2 P up to 10 P
Supply Voltage	Up to 6,600 V
Enclosure	Totally Enclosed Fan Cooled: TEFC/IP55
Classified Areas	Exn, Extc, Exd
Frame Size	250 ~ 500 (IEC basis)
Temperature Ratings	Class F insulation, Class B design Optional Class F and Class F Rise



TM21-FII – Totally Enclosed Fan Cooled Internal Details

Generators – Diesel and Turbine Driven



1	Rotor Shaft	10	Frame
2	Bracket	11	Air Cooler Cover
3	Bearing With Insulation	12	Air Cooler
4	Fan	13	Stator Core
5	Fan Guide	14	Stator Coil
6	Main Terminal Box	15	Exciter Support
7	Rotor Coil	16	Rotary Rectifier
8	Pole Head	17	AC Exciter
9	Rotor Coil Bracket	18	PMG

TMEIC produces a range of high-quality, custom designed generators for power by turbines or diesels. The four-pole designs provide power levels up to 50,000 kVA at 50 or 60 Hz, 1500 rpm or 1800 rpm. Higher speed two-pole generators provide power levels up to 100,000 kVA.

Reliability - All generators are built in the same plant as, and to the same high standards as the large motors. Manufacturing procedures to obtain the highest reliability include Vacuum Pressure Impregnation of the insulation, employing a forged rotor with integral pole bodies for the maximum shaft rigidity and higher critical speed, and accurate rotor shaft balancing.

Maintenance - Easy maintenance is realized using a brushless AC exciter with a permanent magnet generator. The oil-fed sleeve bearings employ a floating labyrinth seal to prevent leakage, and positive internal pressure to prevent oil entering the generator.

The cutaway drawing in the upper left shows a typical four-pole generator with top mounted air cooler and water heat exchanger.



Type	Two-pole, 5,000 to 100,000 kVA power
Rotor	Solid cylindrical rotor
Voltage	Rated 11 kV, 13.8 kV
Speed	3,000 rpm or 3,600 rpm
Frequency	50 or 60 Hz
Power Factor	85% lagging
Enclosure	Totally enclosed, water to air cooled (TEWAC)
Insulation	Rating F-Class insulation
Excitation	Brushless exciter with PMG
Bearings	Sleeve bearings, oil lubricated
Oil	0.1 Mpa bearing pressure



Type	Four-pole, 10,000 to 50,000 kVA power
Rotor	Salient pole solid rotor
Voltage	Rated 6.6 kV, 11 kV, 13.8 kV
Speed	1,500 rpm or 1,800 rpm
Frequency	50 or 60 Hz
Power Factor	80~90% lagging
Enclosure	Totally enclosed, water to air cooled (TEWAC)
Insulation	Rating F-Class insulation
Excitation	Brushless exciter with PMG
Bearings	Sleeve bearings, oil lubricated
Oil	0.1 Mpa bearing pressure

Global Support



Wherever You Are, We Are Right Next Door

TMEIC has the capability to provide world-wide service support with trained field service engineers. Spare parts depots are strategically located close to main industrial centers.

In Asia & Pacific: Customers are supported by TMEIC service personnel and the TMEIC factory in Japan.

In North America: Customers are supported by TMEIC factory service personnel from Roanoke, Virginia.

In Europe: Customers are supported by TMEIC European service personnel.

Motor and Generator Service: EASA and IPS Service Centers support TMEIC motors and generators across North America.



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