

4-Pole Turbine Generator

TMEiC
TMEIC Corporation



4-Pole Air-Cooled Turbine Generator

TMEIC have a proud and rich history of providing the latest generator technology for a broad range of industrial markets.

Vast application and design experience create solutions that have high reliability and lowest operational expense for customers. We utilize the latest mechanical and electro-magnetic design tools to assure our product meets customer requirements while optimizing performance & efficiency of operation.

Not only providing generation equipment, TMEIC also supports the customer's engineering works and site commissioning to complete the generator system.

Feature of 4-Pole Turbine Generator



Toshiba and Mitsubishi Electric lead the large generator business field and TMEIC have been assigned market responsibility for the supply of large capacity 4-pole turbine generators.

Flexibility

TMEIC provides the various kind of generator for customer's requirement. Each generator is customized and designed during the engineering stage.

*Compliance to global standards (IEC, IEEE)

*Project requirement (Cooling system, excitation type)

*Performance (Efficiency, Power factor, Short-circuit ratio, Impedance, etc.)

Reliability

TMEIC offers class leading reliability and performance.

*High quality insulation technique with VPI (Vacuum Pressure Impregnation) is TMEIC standard insulation procedure utilizing our class leading large VPI facility, which provides many benefits to the customer and achieves a longer life.

*Robust rotor construction.

The rotor is of salient solid pole construction. The rotor shaft is integrated with the pole bodies, which makes the shaft more rigid, increasing reliability up to over speed.

Maintenance

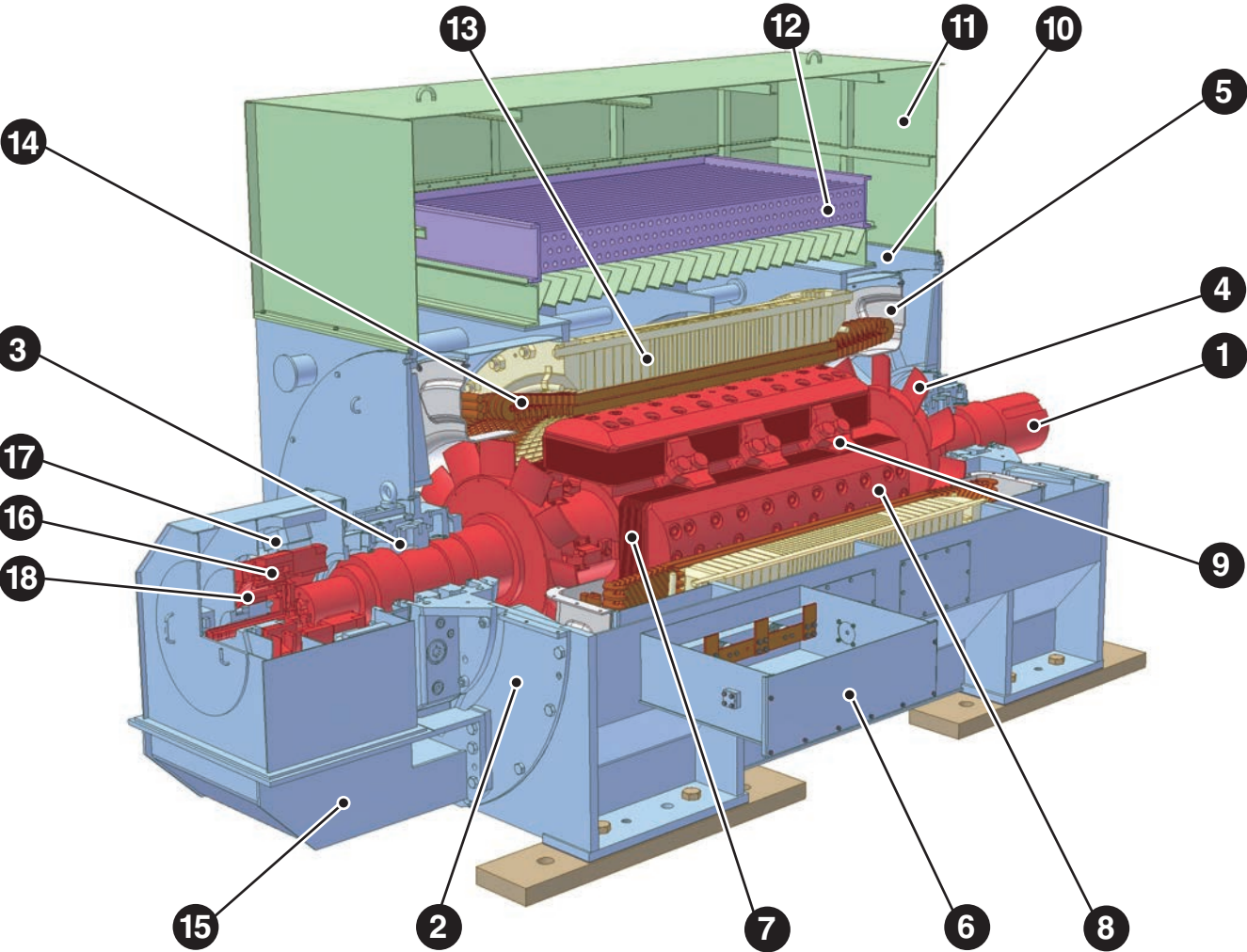
Easy and less maintenance is important for operational availability.

*Brushless type AC-exciter system, our standard excitation system, realizes the easy maintenance and long continuous operation.

*Bracket type generator are transported to site without the need for dismantling and installed at site without the need for re-assembly. First class sleeve bearings with floating labyrinth seal systems are used eliminating risks of oil leakage.

INTERNAL CONSTRUCTION

A typical construction of generator is shown below. The cooler is mounted on the top, AC-exciter with PMG (Permanent Magnetic Generator) is at the anti-coupling side and the frame has bearing bracket. The generator is assembled completely and tested at our factory and shipped without dismantling. This feature enables a compact size and small foot print. The minimum erection work is required.



Part NO.	NAME OF PARTS	Part NO.	NAME OF PARTS
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

Totally Enclosed Air-to-Water cooled type generator protects from environmental affects, such as, dust, debris, water splash, etc. The standard protection of degree is IP54, and IP55 is proposed for severe conditions. The line and neutral main terminal box is located at the side of generator for easy installation. The cooler is located at the top and cooling water inlet/outlet interface location is within the upper section so as, not to interrupt the turbine and generator mechanical system. The lubrication oil is supplied by common oil unit of turbine. Over-hang type AC-exciter with PMG is integrated with main shaft and the common cooling air is used.

STATOR₁

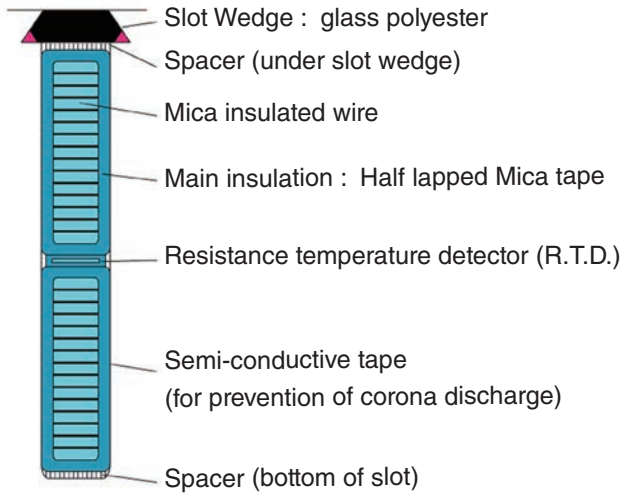
Stator Cores

Stator cores are high quality silicon steel plates and are laminated vertically by computerized robot automatically. After lamination, they are fixed with high tension by press machine.



Stator Coil

Each winding coil is wrapped with insulation tape by wrapping machine and they are set in the stator. Coil end is stiffened by experienced workers and proven techniques to eliminate vibrations which can lead to premature failure.

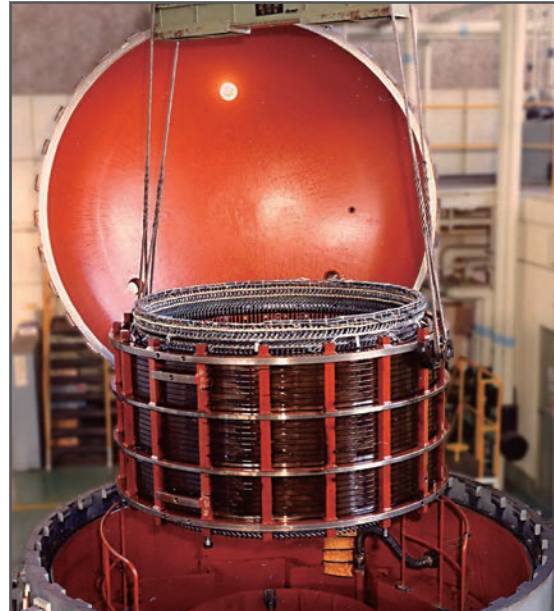


Constitution of Stator coil insulation

STATOR₂

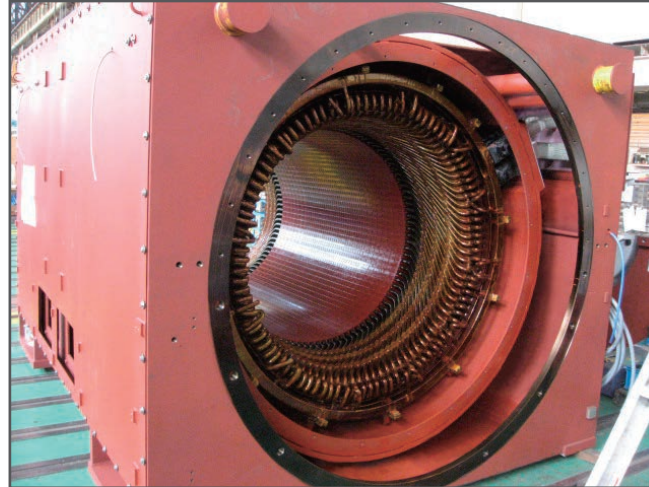
VPI treatment

Stator with coil is impregnated completely with insulation material through VPI (vacuum pressured impregnation). Whole stator with coil is impregnated completely by VPI facility, resulting in high reliability. Not only the mica taped coils but the complete iron core parts, including the bound parts of the coils, are impregnated with resin.



Frame

After VPI process, Stator is fixed in frame. Rectangular frame is robust and supports the stator core firmly and the bearing bracket is combined with the frame. This standardized design achieved vibration free operation. The temperature and vibration instrumentation for remote sensing and the junction boxes (auxiliary boxes) is provided at the side of generator frame and the arrangement of boxes are flexible for external cable connection.



ROTOR

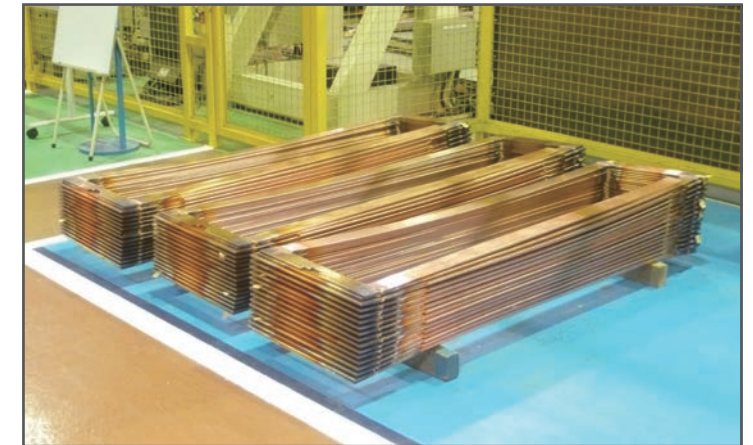
Machining Rotor Shaft

The rotor is constructed of the pole body, pole heads and field coils. The pole body is machined from a single steel forging and is of salient pole construction. To cope with vibration and overspeed, the rotor shaft, which is forged integrally with the pole body, is designed to withstand the primary critical speed being increased by 20% or more over the rated speed. This means that starting and stopping can be performed without passing the primary critical speed, resulting in greater resistance to vibration.



Rotor Coil

The rotor coil is fabricated from rectangular copper strips, with fin effects for optimum cooling. Insulation is provided between layers, and field coils are formed under pressure and heat.



Completed Rotor

After the pole body has been fitted with field coils, the pole head are tightly bolted. All bolts, subjected to nondestructive inspection, are tightened under strict fastening control to ensure high reliability.



COOLER AND LUBRICATION

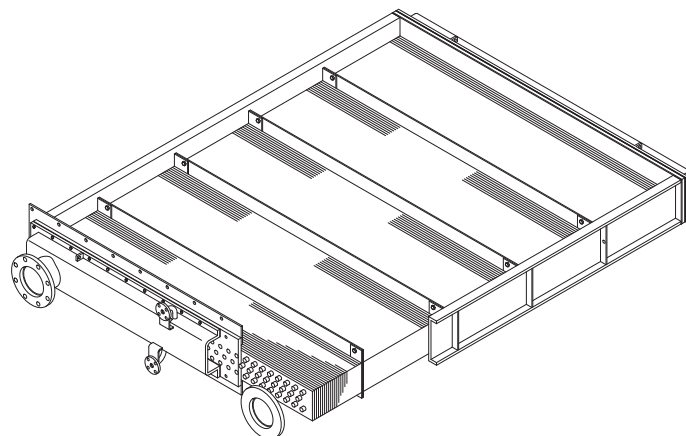
Cooler unit & Ventilation system

Cooler is mounted on the top of generator to transport and install with generator without additional site works.

Even if water leakage occurs in the cooler, the water collects on the protection sheet between cooler and generator frame and it is detected by the water leakage detector.

The standard cooler tube material is deoxidized copper, and 2x67% capacity coolers are provided for IEC standard. Various options are also available for project requirement and water quality, etc.

Cooling air is isolated from the surrounding environment and circulates within the generator body. The warm air passes through the cooler and becomes cold before being re-circulated.



Bearing and Lubrication system

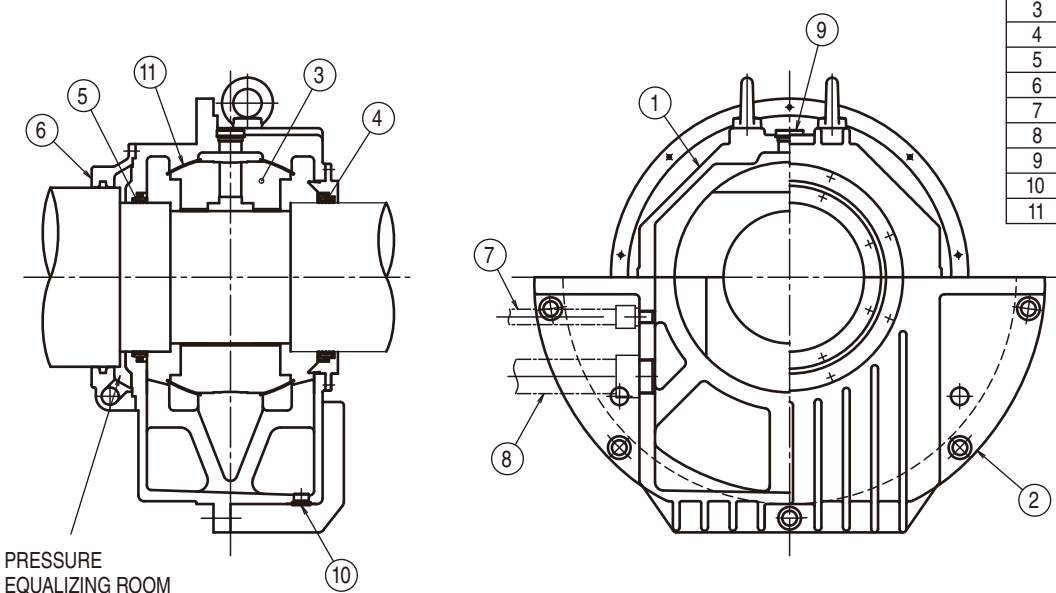
Sleeve bearings with force fed oil lubrication makes for simple and reduced maintenance. Air seal structure prevents oil leakage, since it keeps the internal air at positive pressure against ambient preventing oil from entering into the generator.

The bearing is electrically isolated between rotor shaft to eliminate the circulation of shaft currents at anti-coupling side.

Forced lubrication oil is supplied from turbine oil unit for sleeve bearing.

Appropriately sized inlet and outlet pipes make the smooth oil flow and prevent the vapor phenomena.

Floating labyrinth seal of bearing also prevents oil leakage.



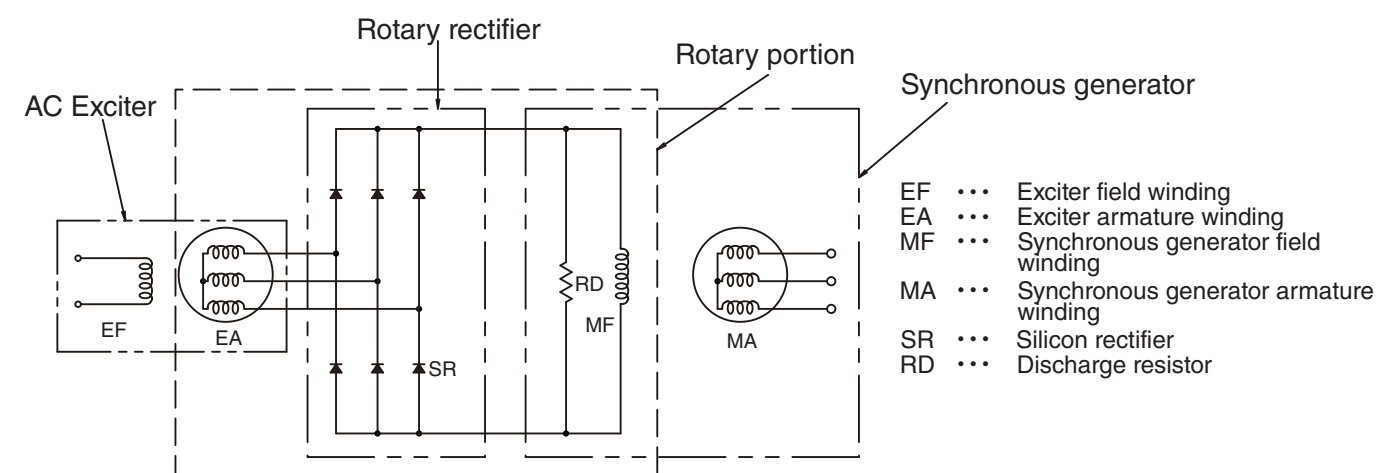
P.NO.	NAME OF PARTS
1	BEARING HOUSING
2	BEARING BRACKET
3	BEARING METAL
4	OUTER FLOATING LABYRINTH SEAL
5	INNER FLOATING LABYRINTH SEAL
6	MACHINE SEAL
7	OIL INLET PIPING
8	OIL OUTLET PIPING
9	TOP SIGHT GLASS
10	OIL DRAIN PLUG
11	INSULATION

EXCITATION SYSTEM

Excitation system: Brushless type excitation with PMG(Permanent Magnetic Generator) is our standard and recommended for easy and maintenance free continuous operation. The system consists of an AC-exciter, a rotary rectifier and a PMG. AC-exciter is a 3-phase AC generator of the revolving armature type and the rotating rectifier has a rectifier circuit firmly mounted on the shaft at anti-coupling side. No initial excitation power is required, as the excitation power is supplied from PMG as the generator rotates. Short circuit current also keeps its value by field current supplied from PMG when short circuit occurs. Rectifier diode has enough margined to satisfy the severe operation.

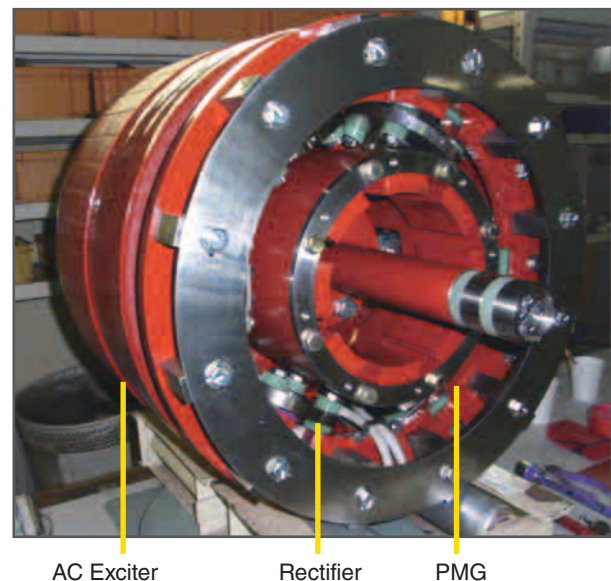
Rectifier

Rotating rectifier is mounted on the shaft, and consists of high reliability diodes for 6 arms (1S-1P-6A). Discharge resistor protect the diodes from abnormal induced voltage.



Exciter and PMG

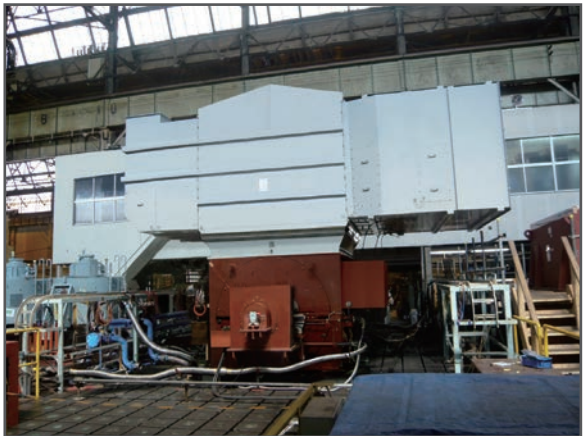
Brushless exciter with PMG is over hung on the generator shaft. So, additional bearing is not necessary. Collector ring is not required and there is no carbon brush and therefore no carbon dust, no daily inspection is therefore required.



OTHERS

TEAAC Enclosure

When cooling water is not available, we can apply totally enclosed air to air (TEAAC) type enclosure.



Accessories

Various types of instrumentation is equipped on the generator for remote sensing and local indication, such as, RTD(Resistance Temperature Detector) for stator winding and inner air temperature detection, leakage water detector, etc.

The orifice at oil inlet flange is also provided after calibration during actual oil flow test at our factory. The detail application is fixed during the engineering stage to comply with customer's requirement.

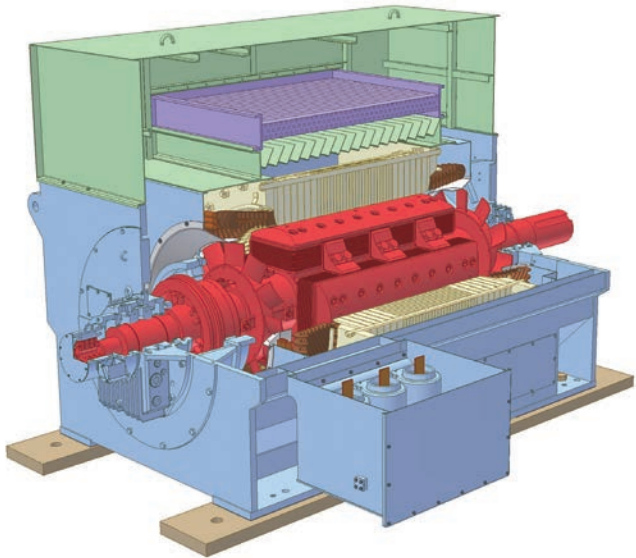
The separate space heaters for generator body are provided as standard for anti-condensation. The suitable rating is designed for site ambient condition and the heater operation is coordinated with operation status.

Sole plate, fixing bolt, shim, etc. are standard scope. They can be delivered separately prior to the generator shipping schedule for installation within the foundations at an appropriate time scale.

Standard Instrumentation		
Designation	Quantity	Type
Winding temperature	6	RTD
Inner air temperature(cold/hot)	3	RTD
Bearing temperature	2	RTD
Water leakage detector	1	---
Orifice	2	---
Space heater	1set	---
Sole plate	1set	---
Anchor bolts	1set	---

Internal construction of medium size

The construction of medium size generator is shown below. General construction is same as large size generator, except for exciter is located inside of generator.



TEST & INSPECTION

TESTS OF GENERATOR

The tests of generator are performed in accordance with IEC60034 standard unless otherwise specified. The generator will be driven by a suitable driving motor during running test.

Test item	Standard	First Unit		Duplicate Unit	
		Factory	Witness	Factory	Witness
A. Electrical measurement and test for generator					
1) Measurement of coil resistance	IEC-60034	○	△	○	△
2) Measurement of insulation resistance	IEC-60034	○	○	○	△
3) Dielectric test	JEC-2130	○	○	○	△
4) Open-circuit characteristic test	IEC-60034	●	●	×	×
Voltage balance check	IEC-60034	●	●	×	×
Phase sequence check	IEC-60034	●	●	×	×
5) Three phase short circuit characteristic	IEC-60034	●	●	×	×
Current balance check	IEC-60034	●	●	×	×
6) Measurement of segregated losses	IEC-60034	●	●	×	×
7) Efficiency calculation	IEC-60034	●	●	×	×
8) Equivalent heat run test	IEC-60034	●	●	×	×
B. Mechanical inspection and test for generator					
1) Outline and layout check	TMEIC standard	○	○	○	△
2) Measurement of vibration	IEC-60034	○	○	○	△
3) Overspeed test	IEC-60034	○	△	○	△

- : Marked item will be done. Test report will be submitted.
● : Marked item will be done if the generator is new design.
But if the generator is repeat design, marked item will not be done.
Type test result will be submitted.
△ : Marked item will not be done. Test report will be submitted.
× : Marked item will not be done.

Rotor Shaft Balance Test

To minimize the vibration at operate condition, the rotor balancing is adjusted by adding the weight on each correction plane.

For up to 30,000kVA, two plane dynamic balancing test is carried out after completion of the rotor assembly. Over 30,000kVA, running balance test is carried out after final assembly.



RESEARCH AND DEVELOPMENT

Introduction of TMEIC's Research and Development

We are produced and designed based on the Research and Development to continue supplying all customer with a better 4-Pole-Generator.

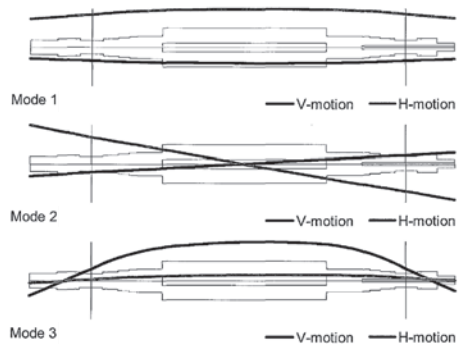
Wide and special knowledge such as the technology of electromagnetic, mechanical, material and insulation are necessary to achive this our an aim.

This chapter introduces an example of our Reserch and Development.

Reserch1 (Rotor characteristic)

4-pole generator rotor is long and thin, additionally, rotated high speed, so we should get the characteristic. Critical speed, Q-factor, vibration mode and stability of bearing are analyzed for each generator, measuring balance weight effect and vector at routine test process.

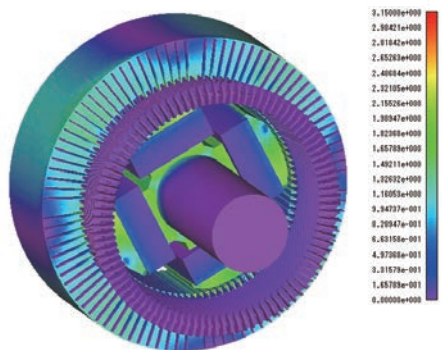
Critical Speed



Reserch2 (Magnetic flux)

Magnetic flux analysis is effective for design of high efficiency machine. It leads to high promotion of efficiency to reduce leakage magnetic flux.

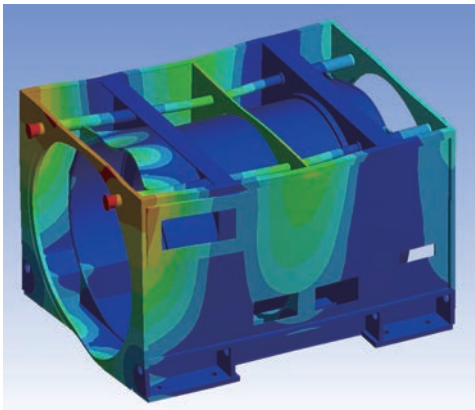
In addition, we can avoid a local heating by excessive magnetic flux density.



Reserch3 (Frame eigen frequency)

Frame is joined to stator core, so it is subjected to excitation force by stator core. If frame eigen value harmonize excitation frequency, frame vibration grows, and it occur various problems.

We get a frame eigen frequency with analysis and confirm vibration with measurement for real machine.



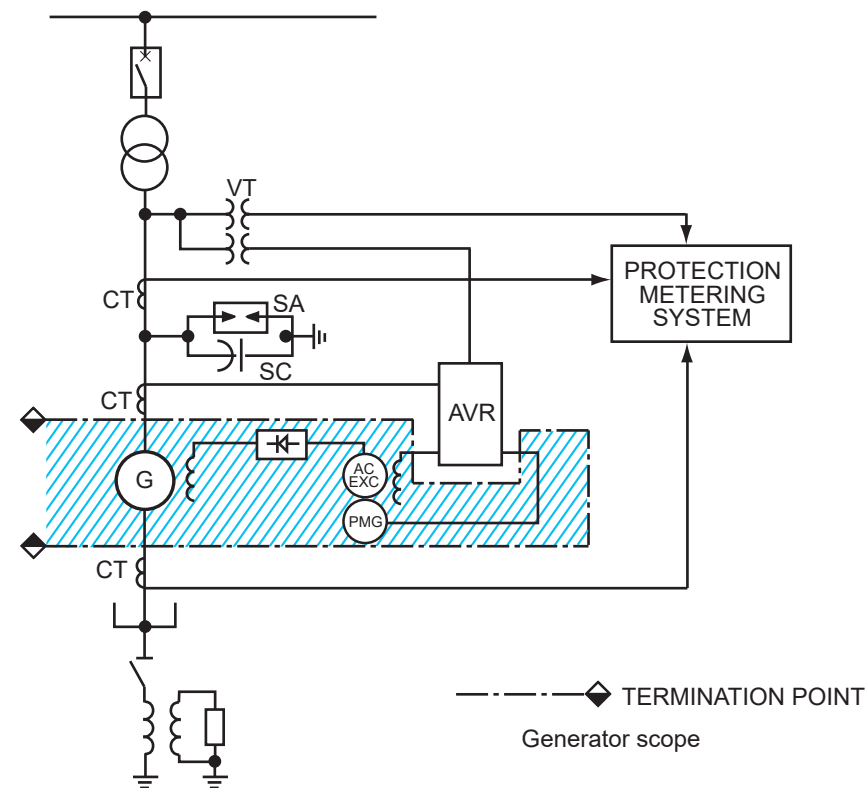
SPECIFICATION

Item	Standard Specifications	Options
Ratings		
Rated output	10000 ~ 70000kVA (approximately)	
Rated voltages	6.6kV, 11kV or 13.8kV	According to customer's specifications
Frequency	50Hz or 60Hz	
Poles	4	
Rated speed	1500min ⁻¹ or 1800min ⁻¹	
Rated power factor	80% ~ 90% lagging	According to customer's specifications
Enclosed type	Totally enclosed, water to air cooled type (TEWAC)	
Protection	IP54	According to customer's specifications
Cooling method	IC8A1W7	According to customer's specifications
Applicable standard	IEC60034	According to customer's specifications
Site conditions		
Location	Indoor	Outdoor
Ambient temperature	MAX.+40℃ MIN.-5℃	According to customer's specifications
Altitude	Less than 1000m	According to customer's specifications
Humidity	Less than 95%	According to customer's specifications
Voltage variation	Less than±5%	According to customer's specifications
Frequency variation	Less than±2%	According to customer's specifications
Rotor configuration	Salient pole solid rotor	
Insulation rating	F-Class insulation	
Temperature rise	B-Class temperature rise	F-Class temperature rise
Excitation system	Brushless excitation (with PMG)	According to customer's specifications
Direction of rotation	According to customer's specifications	
Shaft construction		
Shaft extension	Single shaft	According to customer's specifications
Shaft end geometry	Solid	According to customer's specifications
Air-Cooler		
Location	Top mount	According to customer's specifications
Water inlet temp.	32℃	According to customer's specifications
Supply pressure	0.5MPa (Allowable design value)	According to customer's specifications
Kind of water	Fresh Water	According to customer's specifications
Type of cooling tube	Single tube	According to customer's specifications
Tube material	Deoxidized copper	According to customer's specifications
Direction of piping flange	Left side (viewed from exciter side)	Right side (viewed from exciter side)
Bearings		
Type of bearings	Sleeve bearings (forced lubrication)	
Oil temperature	45℃	According to customer's specifications
Oil pressure	approx. 0.1MPa	
Lubricating oil	ISO VG32	According to customer's specifications
Direction of piping flange	Left side (viewed from exciter side)	Right side (viewed from exciter side)
Main terminal		
Number of terminal	6 terminals (Star connection)	According to customer's specifications
Terminal box position	Right side (viewed from exciter side)	According to customer's specifications
Painting		
Painting color	Munsell 2.5PB6/2	According to customer's specifications
Thickness	50μm or Above	According to customer's specifications
Accessories	1 set - Sole plate	
	1 set - fixing bolts	
	6 pcs - Stator winding temperature detector RTD	
	2 pcs - Bearing temperature detector RTD	2 pcs - Dial type bearing temperature indicators
	2 pcs - Inlet air temperature detector RTD	
	1 pc - Outlet air temperature detector RTD	
	1 set - Space heater	
	1 set Auxiliary terminal box for instrumentation	
	1 pc - Air-cooler water leakage detector	
	1 set - Orifice for lubrication oil inlet	
	1 set - Earth terminal	
	1 set - Special tool	
		1 set - Vibration probe fixing work at factory (Probes to be supplied by turbine manufacturer)
		1 set - Oil flow sight
		1 set - Copper belt/carbon brush for shaft earthing

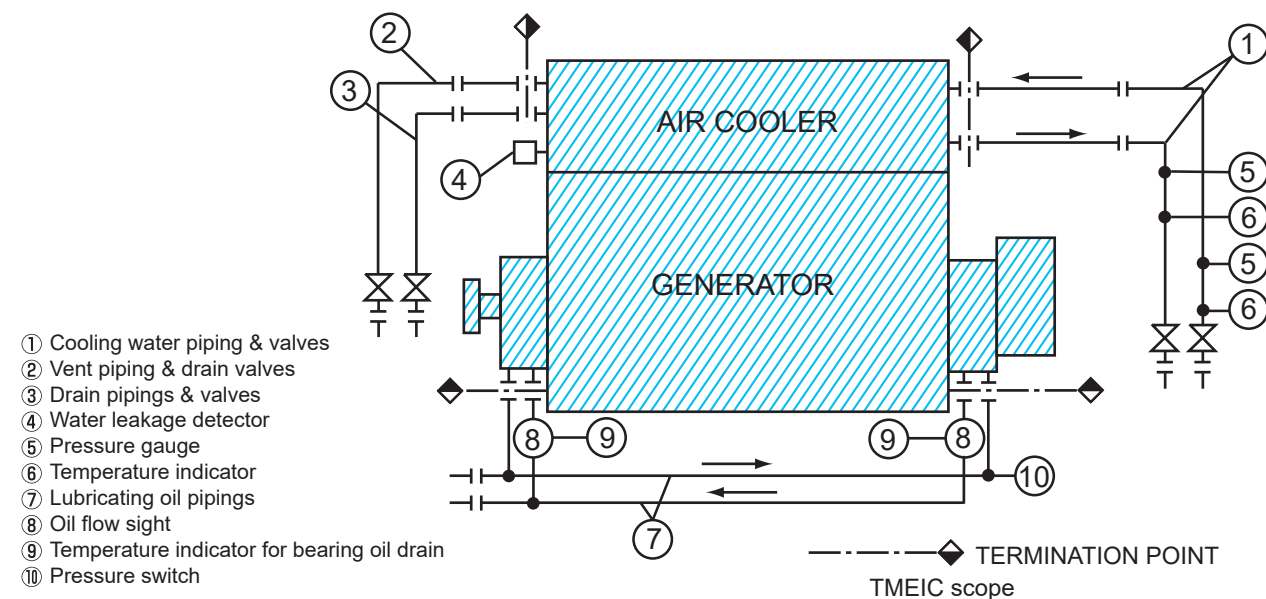
TERMINATION POINT

The single line diagram and piping & instrument diagram show the typical termination point of our generator system with excitation and purchaser's scoped.

Electrical system



Lubrication and Cooling water system



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