Synchronous Hydro Generators

Horizontal & Vertical Applications
Power: 2,000 – 37,500 kVA
Speed: 150 – 900 RPM
Voltage: 3,000 – 13,800 Volts
Frequency: 50 & 60 Hz
We’ve manufactured generators for over 100 years.

GE has the capability to design and manufacture electrical machines for the most stringent application requirements. This century of achievement has built a rich tradition of technical excellence, quality and reliability.

Industry

Power Generation – Hydro Energy

Application

This line of synchronous generators has been specifically designed in response to the growing demand of small hydro plants. It incorporates a full range of features to address the applications and operational conditions demanded by this industry. This product line is customized for horizontal & vertical hydro turbine applications in a range of 2,000 – 37,500 kVA, 150 - 900 RPM.

GE Advantages

Rugged & compact design. Easy installation. Reliable operation.

• Shipped assembled or disassembled, based on customer request
• Compact construction with a small foundation
• The rigid mechanical configuration (shorter distance between bearings) allows for low vibration levels
• Follows critical industry trends for simple, modular and integrated designs
• Proven GE insulation system makes for a durable and reliable machine
• Modularized construction for fast and easy site installation
• Rotor designed to meet higher runaway speeds specific to hydro applications for Francis and Kaplan turbines
**Construction**

**Frame**
The stator frame is made of welded steel construction and manufactured with thick steel plates to prevent distortion during operation. Robust and rugged, these frames are designed to withstand the mass of a stator core, bending stresses and deflections. The frames are designed to minimize vibrations and noise levels. The frame bore is machined to ensure a uniform air gap between the rotor and stator, thereby minimizing the unbalanced magnetic pull. These frames are designed to withstand the extreme stresses due to short circuits.

Each machine is designed to be assembled on a robust concrete foundation or steel base. A minimum of four lifting points is provided in the generator to facilitate this process. Larger or heavier machines, which are shipped disassembled, are reassembled over the foundation at the site, as a part of the field installation process.

The frame is fabricated from structural steel plates to ensure an extremely robust and rigid support structure. The generator can be designed for open enclosure and totally enclosed water-to-air cooled. The exciter and rectifier hub are mounted at the non-drive end (NDE) enabling easy access for maintenance purposes.

**Stator Core**
The stator core assembly consists of segmented and insulated laminations of cold-rolled low-loss silicon steel, clamped between substantial side plates. Laminations are stacked up with a controlled burr in order to ensure minimal losses. Lamination steel is selected based on project requirements. The core is built inside a structural cage, which is then inserted into the frame and attached through weldments. Steel I-beam spacers spot welded to low carbon steel laminations form radial ventilation ducts along the core length. When core building is complete, the whole assembly is clamped under pressure with studs. The nuts and compression plates are welded in place while maintaining pressure.

**Laminated Poles**
The rotor has laminated poles fitted with strip or wire wound field coils and supplied with an amortisseur winding on the outer pole face.

**Laminated Spider**
The rotor spider is made of thin laminations, clamped with axial studs. According to design needs, there are axial holes to improve the air ventilation through the rotor. The laminated poles are attached to the spider with dovetails.

**Solid Spider**
The rotor spider and shaft are obtained from a one-piece machined carbon steel forging. According to design needs, there are axial holes to improve the air ventilation through the rotor. The laminated poles are fixed on the spider by using dovetails on the pole bottom.

**Rim Spider**
The rim is made of forged steel. The rim is shrunk on to a large web that is attached to the shaft by means of a hub and a key, then pole bodies are attached to the rim via a number of radial bolts.

Two axial or radial fans (according to design characteristics) are mounted on the shaft to provide airflow to maintain the machine temperature within the limits specified. The fans are used to provide double-ended ventilation, helping ensure an even temperature distribution across the field and stator windings.

**Rotor**
Three types of rotor construction can be utilized in this product line: a laminated spider with dovetailed poles, a rim spider with bolted poles, or a solid spider with dovetailed poles.

**Rotor with shaft-mounted out board exciter**
Mica composite, epoxy resin and vacuum-pressure impregnation (VPI) provide a robust and reliable insulation system.

The advanced insulation system on all large machines will typically reward you with years of reliable operation. GE’s insulation system is designed to minimize the effect of localized electrical stress and reduce the effects of partial discharge while increasing machine life and reliability. Components are selected to ensure reliability of the system as a whole.

The insulation system can meet applicable standards. All wound stators undergo global vacuum-pressure impregnation (VPI) treatment. Curing binds the stator components into a solid and rigid structure with excellent dielectric strength, dimensional stability and mechanical strength. It also increases the resistance of the winding to thermal shock, moisture and other contaminants.

Coil Insulation
Once assembled, the coils are inserted into the stator slots and the end connections are brazed and taped. GE’s coil lock bracing system supports the coils and makes the entire structure more rigid.

The binding agent used is GE’s third generation epoxy resin, selected and tested to IEEE-1776 for chemical compatibility, thermal/dimensional stability, and electrical properties.

The mica composite insulation is designed for uniform ground insulation dielectric strength.

Above 6000 volts, a semi-conducting paint is applied to the slot portion and graded beyond the core to provide corona protection.

A protective armor of heavy glass tape is used for protection against mechanical shock and abrasion.

The coil turns in the slot section are bonded using heat and pressure to achieve dimensional accuracy of the finished coil.

Even stator coil spacing maintains the electrical and mechanical integrity of the machine.
Excitation

**Brushless Excitation System**
The exciter is a three-phase AC generator with a rotating three-phase bridge rectifier.

The exciter stator core is made of laminated, hot rolled or cold rolled steel, held together by steel endplates.

The DC field coils are wound in a concentric pattern using formers and mounted on the frame poles.

The whole assembly undergoes a varnish treatment. The exciter rotor armature consists of a three-phase winding system. The core consists of steel laminations that are stacked and held with end plates and wound with enamel covered round copper wire. The whole assembly then undergoes a varnish treatment.

The rectifier hub includes liberally rated diodes. The leads from the armature are connected directly to the hub, and the two DC output leads from the hub are connected to the main field and clamped to prevent movement.

The exciter armature and rectifier hub are assembled by interference onto the shaft. The complete exciter and rectifier hub assembly is enclosed in a steel sheet cover. For ease of maintenance, a removable plate gives access to the rectifier hub.

As a protection for the diode bridge under normal conditions, a varistor is supplied in parallel with the rectifier hub.

**Collector Ring with Brushes**
The brushes are electrographite type, open terminal. The quantity of brushes is determined taking into account the current density required for an efficient working of the excitation system. The brush holders are selected in order to provide the required contact pressure between the brushes and the collector rings.

The collector rings are low carbon steel material, providing thermal conductivity required to keep the system at the temperature level according to applicable standards. There are two kinds of collector rings: smooth (standard) and grooved rings (for special cases).
Bearing configuration: thrust and guide bearing at NDE side and only guide bearing at DE side.

NDE thrust bearing is assembled into a housing, which is bolted at the upper endshield, and the upper endshield is bolted against the stator frame.

NDE guide bearing works in contact with a thrust block, which is the piece that connects the rotor shaft to the thrust bearing surface, by means of a key connection in the shaft.

High-pressure oil lift systems are frequently supplied at NDE thrust bearing to allow easy start-up (due to the high pressure at the thrust bearing surface) and also better installation and maintenance handlings.

DE guide bearing is assembled at the lower endshield, together with its support, and it works in contact with a track built in the rotor shaft.

Lower endshield is bolted against the stator frame, and it is positioned at the inner side of the stator frame.

All the components assembled at the lower endshield (DE guide bearing, supports and covers) are split, in order to permit the assembling process (due to rotor shaft flange diameter, usually larger than DE guide bearing inner diameter). The access to those pieces is done by means of openings in the lower endshield, which is closed after the assembly process is finished.

Horizontal

There are normally two sleeve bearings, each mounted on a pedestal that is bolted to the base. Each bearing liner is made from steel, lined with white metal and is split on the horizontal centerline. The standard two-bearing arrangement (which can be varied, by agreement, to suit the type of coupling used) assumes a limited end-float coupling, and non-locating bearings are provided. (Typical end-float is ± ½ inches).

Thrust bearing can be provided on the DE or NDE side, according to requirements.

Oil throwers on the shaft and oil seals on the pedestal are provided to prevent oil leakage and contamination. High-pressure oil lift systems are frequently supplied at each bearing to allow for easy installation and maintenance.

NDE bearing liner is insulated from the bearing housing. A removable link is provided to ground the drive end bearing and to facilitate testing of the bearing insulation.
Cooling System

Enclosure and Ventilation
The generator is designed for open enclosure (WPI, IP23/24) or totally enclosed air-to-water (TEWAC/CACW) cooling system (top or bottom cooling).

Air is circulated inside the machine by two internal fans and the rotor. The radial ducts in the stator core, the design of the end windings and a careful review of the air path, ensure temperature uniformity in all parts of the machine.

Top Mounted Cooling

Bottom Mounted Cooling

Cold air

Hot air

Cooling circuit for vertical generators
### Automatic Voltage Regulation (AVR)

The AVR utilizes a fast response microprocessor to control its AC to DC converter power stage output that provides excitation to the generator to regulate the difference between the generator stator voltage reference set point and feedback signal to zero. Reactive power sharing during parallel operation of generator with other generators or a power system is achieved by the use of droop compensation where the voltage feedback signal is increased by typically 0% to 5% as lagging reactive load current increases from 0% to 100%. The following four operating control modes with a bumpless transfer between modes are available to suit the site requirements:

- Sequence of events recording & oscillography, which is useful during commissioning diagnostics
- AVR automatic voltage regulation (with switchable reactive power droop compensation for basic parallel operation)
- Generator PF power factor control (for connection to large power system)
- Generator VAR reactive power control (for connection to large power system)
- Brushless exciter field current (manual mode) regulation

Other functions of the AVR include:

- Voltage soft-start build up
- Minimum and maximum excitation and stator current limiters

### Permanent Magnet Generator (PMG)

PMG supplies continuous power to the exciter through the voltage regulator in order to maintain up to 300% short circuit current from the alternator during a fault condition. It provides full exciter power, regardless of the generator voltage.

### Neutral Grounding Resistor (NGR)

The NGR acts to limit generator fault current to a low level when a phase-to-ground fault occurs. It also serves to protect the generator from excessively high magnetic stresses and temperatures caused by high fault currents. The NGR is time-rated.
Accessories

- Partial discharge sensor kits
- Bearing RTD (Resistance Temperature Detector)
- Space heater 50/60 Hz
- Large oversized fabricated steel main terminal box – frame mounted
- Fabricated steel neutral terminal box – frame mounted
- Surge Arrestors and/or Surge Capacitors
- Current and Potential Transformers
- Vibration monitoring equipment
- Water leakage detector
- Couplings
- Generator control and protection panel – optional
- Medium voltage switchgear – optional

Remote Monitoring and Diagnostics

GE’s comprehensive industrial machine monitoring strategy is designed to enhance the capabilities of industrial customers to reduce downtime and identify industrial machine failure before it happens. Elements of GE’s solution include:

- Continuous technical support through the GE Monitoring and Diagnostic (M&D) Center
- GE engineers with remote access to motor condition data can identify potential failures of industrial machines
- Advanced technology products designed to easily retrofit existing customer equipment and provide the highest levels of protection and reliability
- Installation and commissioning - prompt comprehensive service built upon GE’s years of field engineering experience, OEM product knowledge, and access to product information

Features

GE can provide a complete motor monitoring solution:

- Comprehensive motor condition monitoring
- Text message/email alerts
- 24-hour monitoring support
- 24-hour engineering support
- Warehoused condition data
- Web-based access for customer visualization of data
- Wireless transmission of data

Benefits

- Wireless network reduces installation (cabling) costs
- Predictive maintenance intervals streamline maintenance schedules based on actual operating conditions
- Reduced maintenance costs
- Increased machine productivity
- Increased operating efficiency
- Minimize risk of catastrophic damage to equipment
- Quick installation with minimal disruption to operations
- Minimal footprint - installs on any accessible DIN rail
Testing

Test Capability
GE has world-class test facilities. Extensive experience in the performance of rotating machinery with all forms of fixed and variable speed drives has been accumulated.

Each machine is tested at the factory before shipment for installation in the field, thus reducing set-up time.

- In-Process Testing
  Rotor impedance, surge test; AC dielectric tests, prior to VPI

- Running Tests According to International Standards:
  NEMA MG1/IEEE 115, IEC 60034-1 & 60034-2 or ABNT 5052

- Short Circuit Test
  Up to 130% of rated stator current

- No Load Saturation Test
  Up to 125% of rated stator volts

- Short Circuit Ration (SCR)
  From test data

- Mechanical Run
  Including vibration analyses using velometers; dynamic balancing

- Efficiency
  Segregated loss method per IEEE 115

- Insulation Resistance & Polarization Index

- Dielectric Tests
  In the stator, rotor and brushless exciter

- Lubrication System
  Functional tests

The Right Choice

Power Solutions Team
Experienced application engineers are available to solve your toughest generator system challenges.

Installation, Start-up & Commissioning

- Experienced engineers/technicians available to support site erection, installation and commissioning

- Long term service agreements including remote monitoring and maintenance assistance

- Parts center supports your local needs and helps assure your up-time requirements.

For more information, please contact your GE sales representative.

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