* The information provided in this Section is not subject to verification and non fulfillment of it is not subject to any kind of rights or remedies of the Customer whatsoever.

GENERATOR

Generator for Steam and Gas Turbine

- Features
- 260-600 MVA range
- World class efficiency with low maintenance design
- Multi-zone, indirectly cooled stator windings
- Roebelled stator windings with brazed solid end connections
- Radially ventilated stator core attached to frame suspended on two axial springs
- Epoxy-mica stator winding insulation system
- Radially ventilated and cooled rotor winding
- Low pressure “push” fans mounted at each end of the rotor
- Weather and sound proof cylindrical frame
- Performance Plus® segmented carbon shaft seal
- Circular shaped hydrogen coolers at each end of the generator
- Bolt-on, self-ventilated collector

As one of the main international market leaders in manufacture of synchronous generators, Siemens Power Generation has decades of experience in production of reliable and high efficiency generators. Continuous improvement in materials, insulation systems, cooling systems, design tools and methods, production automation, project management, and innovation have resulted in a world-class line of hydrogen-cooled generators. Modular design concepts provide high efficiency and reliable operation with low maintenance requirements.

The large hydrogen-cooled series of generators for 50 and 60 Hz applications are designed according to both IEC and ANSI standards. These generators cover a wide rating range of 260 to 600 MVA at line voltage levels from 12.5 to 24 kV.

Stator Core

Thin laminations of high grade, low loss silicon steel are consolidated to form the stator core. Each lamination is electrically insulated with high temperature capability material. The laminations are stacked to form the stator core with finger-plates and heavy end-plates at each end. Key bars and insulated through bolts are used to maintain core integrity and tightness. The resultant stator core assembly has long lasting tightness, mechanical ruggedness, and excellent heat transfer characteristics.

For most generators a patented system of bonded stator packs is used. These packs are made of short stacks of laminations that are pressed and vacuum pressure impregnated with epoxy. The number of core packs needed for a generator of a given length are then stacked to make the stator core.

Stator Winding

The stator winding is a two-layer, lap-wound winding. Each coil in the winding consists of two half coils which are completely formed before insertion into the stator slots. A half coil is made of multiple insulated strands, which are internally transposed within each coil side to eliminate the need for external series transpositions. Each half coil is connected either with another half coil or to parallel rings in order to form the stator winding.

Stator Winding End Turns

The stator end winding bracing is designed based on the RIGI-FLEX™ system where the coils are consolidated on a filament-wound conical structure with radial braces. The stator coil end turns are mechanically connected to this structure making a consolidated basket that withstands transient forces resulting from a three-phase short circuit. The end winding structure is mechanically decoupled from the core to allow thermal expansion and contraction of the assembly.

Stator Winding Insulation

Most generators windings are Global Vacuum Pressure Impregnated (GVPI) with a proprietary epoxy-mica insulation system. The stator core and winding are first vacuum treated and then immersed in epoxy resin for an impregnation cycle. The complete stator is then placed on rollers in an oven for uniform high-temperature curing. Numerous control measures are performed during evacuation, impregnation and curing for quality assurance. The GVPI system results in a stator winding with high dielectric strength and voltage endurance.

For some applications, based on design considerations, individual vacuum pressure impregnated (VPI) coils are used to assemble the stator winding.

Frame

The cylindrical frame is a heavy steel fabrication that supports the stator core and windings, bearing brackets, and rotor assembly. It rests on levelling devices (fixators) affixed to the foundation and it is secured with foundation bolts and axial and transverse anchors. Lifting trunnions and jacking points are provided for generator erection and alignment.

Stator Mounting

The stator core assembly is mounted to the frame by steel spring assemblies, isolating the frame and foundation from double line frequency core vibration. The spring suspension is also specially designed to limit torque build up experienced during power system faults.

Rotor Shaft

The cylindrical type rotor forging is made from nickel, chromium, molybdenum, and vanadium alloy steel using the vacuum degassing process. Forging materials are ultrasonically tested for compliance with rigid quality assurance specifications.

The rotor is machined from the one-piece alloy steel forging. Radial slots are machined in the shaft to accept the rotor winding coils. One low-pressure blower is mounted at each end of the rotor.

Rotor Winding

The rotor winding is manufactured from high conductivity, creep-resistant silver-bearing copper. Conductive channels at the bottom of the slots provide ventilation paths from the ends of the rotor to radial cooling holes in the rotor winding copper. Conducting slot wedges hold the coils in the slots. The end turns are braced with epoxy-glass blocking and restrained by high strength alloy-steel forged retaining rings lined with epoxy-glass insulation. The slot wedges and retaining rings form the damper winding.

Hydrogen Coolers

Circular-shaped Omega™ coolers are located at each end of the generator frame. Adapted from proven finned-tube cooler technology, the circular shape allows easy access to all pipe ends for cleaning from below the generator frame. Each cooler consist of two sections, which are individually serviceable during operation. Internal joints and reverse chambers are eliminated, lowering the risk of leakages and increasing overall availability of the generator.

The circular design allows optimal utilization of the space available in the cylindrical frame, at the same time increasing efficiency due to lower ventilation losses. The coolers are factory assembled to reduce installation time. A cooler removal tool is supplied to be used during major generator inspections.

Bearings and Bearing Brackets

Two babbitt-lined journal bearings are supported by end-shield bearing brackets located at each end of the cylindrical frame.

The bearings are self aligning and force lubricated. They are optimized in size to minimize mechanical losses. Electrical insulation is provided to prevent shaft current flowing across the bearing. High-pressure lube oil is used to lift the rotor off of the bearing journal at standstill and low rotation speeds.

The end-shield bearing brackets are designed to contain hydrogen pressure and support the generator rotor. They are split horizontally on the axial centerline of the rotor to facilitate service. With end-shield bearing brackets, the generator can be shipped with inserted rotor, thereby reducing erection time.

Hydrogen Shaft Seal

The hydrogen shaft (or gland) seal prevents hydrogen gas from escaping the generator at the interface of the bearing bracket and the rotating shaft. The sealing function is normally provided by maintaining a defined flow of pressure oil between seal and shaft towards the hydrogen side of the seal.

Siemens utilizes the patented PerformancePlus™ seal technology with Carbon Graphite as seal material, completely eliminating potential rubbing damage of the rotor shaft in case of a total loss of seal oil pressure. Springs and the segmented design allow the seal to remain tight even without seal oil flow.

The advanced design of the seal also greatly reduces oil ingress into the generator by minimizing oil flow to the hydrogen side of the seal. Overall reduced required oil flows allow the optimization of seal oil system pump sizes, and also reduce contamination of the hydrogen filling with air, allowing the operator to maintain a high level of hydrogen purity for better generator efficiency.

Ventilation

At each end of the generator a shaft-mounted, low-pressure single-stage blower maintains the circulation of hydrogen cooling gas. On the low pressure side, hydrogen cold gas is drawn from the circular coolers and enters the stator and rotor end winding area. The gas flow is then divided between rotor and stator.

Rotor winding

The rotor winding is cooled by self pumping action. End winding cooling gas is exhausted into the air-gap at the ends of the pole faces. Axial channels at the bottom of the slots distribute cooling gas to radial passages that are spaced along the straight section of the rotor winding. The warm gas is then exhausted into the air gap through holes in the rotor slot wedges.

Stator Core and Winding:

A portion of stator gas flow cools the stator end windings (and on one end, the bushings), while the rest of the stator gas flow enters the air-gap at each end region of the stator. It combines with the rotor exhaust gas and then passes through radial ventilation ducts spaced regularly along the length of the stator core. The core cooling gas flow removes heat conducted into the core from the stator coils and losses occurring in the core itself.

Hot gas leaving the back of stator core and end winding area is guided to the coolers and recirculated by the blowers.

Static Excitation

A bolt-on collector is supplied with the generator.

Two forged-steel slip rings and a radial blower are mounted on the drive - through collector shaft. The brush rigging employs brush assemblies that are easily removable while the unit is on line. Graphite composite brushes are maintained in uniform contact with the rings by constant force springs. The collector set is covered by a housing fabricated from heavy-gauge steel. A combination of insulated, hydrogen-sealed axial and radial leads provides the electrical connection to the generator field winding through the shaft.

Static excitation equipment draws its power from the plant auxiliary system. It provides the field current to the collector, with the voltage regulator controlling the field current level.

Generator Delivery

A generator assembly consisting of major components is delivered to the power plant site. The assembly includes generator cylindrical frame, spring-mounted stator, bearing brackets, rotor, circular coolers, and instrumentation wired terminal boxes. The generator is cocooned for preservation during shipment and site installation. Other major components delivered separately are auxiliary skids, collector assembly, and terminal bushings.

Field Installation

The generator frame feet are set on the foundation piers using simple fixators (i.e. leveling devices). This method reduces generator alignment time significantly.

Transverse and axial anchors maintain the alignment position.

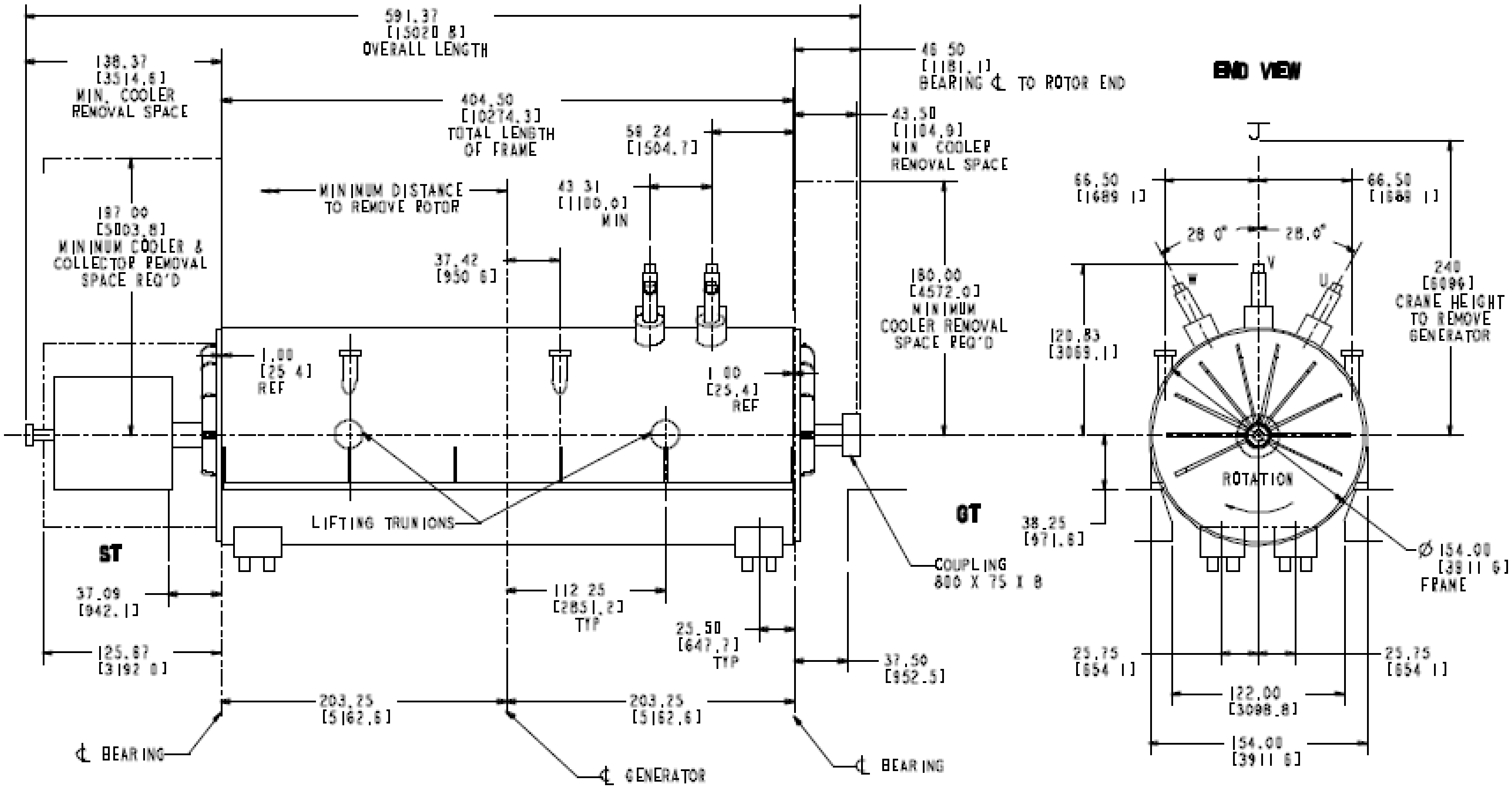
Generator Auxiliaries

Hydrogen Gas System

During normal operation, this system maintains the required pressure and purity of the hydrogen cooling gas inside the generator frame. Filling/pressurizing with hydrogen before startup, and depressurizing and purging for maintenance are operations supported by the gas system. Major components of the system are regulating valves to maintain hydrogen pressure, Dual Tower Gas drier to remove moisture, and gas purity analyzer. The gas supply can be either from individual bottles or a bundled/bulk type source.

Seal Oil System

This auxiliary system provides pressure and cooling oil to the shaft seal that prevents hydrogen from escaping at the interface of rotor and frame. Emergency seal oil backup pumps automatically ensure continuous operation of the seal oil supply. Pumps and motors in the seal oil system are conservatively rated for dependability. A loop seal in the generator bearing oil drain line provides protection against hydrogen contamination of the bearing lubrication oil supply. The lube seal tank is kept at a vacuum pressure to remove dissolved gases from the oil. Other major components are redundant Seal Oil Filters and Seal Oil Coolers.



SGen5-2000H		
DESCRIPTION	APPROX LBS	APPROX KGS
TOTAL GENERATOR WITH COLLECTOR	776000	351984
GENERATOR ASSEMBLED	757000	343375
COLLECTOR ASSEMBLED	19000	8618
FRAME, CORE, AND STATOR WINDING	557000	252655
GENERATOR ROTOR	130000	58968
COOLER WEIGHT DRY	11000	4990
HEAVIEST PIECE FOR SHIPPING/LIFTING	753000	341561

DESIGN DIMENSIONS ARE IN INCHES.
DIMENSIONS IN [ ] ARE MILLIMETER EQUIVALENTS.
DIMENSIONS/WEIGHTS PROVIDED FOR PROPOSAL PURPOSES WITHOUT OBLIGATION.

DISTANCES FROM ℄ GENERATOR REQUIRED FOR THE FOLLOWING OPERATION		
DESCRIPTION	INCHES	MILLIMETER
TO REMOVE GENERATOR ROTOR STRAIGHT OUT	698	17678
TO REMOVE GENERATOR ROTOR BY SKEWING	N/A	N/A

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PART I.D.
4840A45

Starting Frequency Converter

The gas turbine is started up via the generator with the aid of the starting frequency converter. The speed is increased to ignition speed solely by motoring operation of the generator and then by the starting gas turbine process with controlled fuel supply until the gas turbine cycle produces enough power to increase the speed further.

A starting frequency converter (SFC) is used to assist start-up and operates the generator in synchronous start-up as a synchronous motor. When selecting the converter, the required generator together with its excitation system is assigned to the relevant starting frequency converter.

During start-up with the starting frequency converter the set points for the static excitation equipment (field voltage, etc.) of the generator is defined by the starting frequency converter.

Power Section

The power section of the starting frequency converter consists of the following components:

- Supply via the starting frequency transformer
- Two fully controlled three-phase bridge connections, line-side converter and the generator-side converter
- Decoupling of the line-side converter from the generator-side converter with DC link reactor in the DC link
- Line-side and generator-side voltage limiter
- Radial fan for heat dissipation
- The thyristor bridge will be synchronized via a voltage transformer in medium voltage field, which requires a three phase Y Y voltage transformer connection with 100V secondary voltage

Closed-Loop Control

The line-side converter operates in rectifier operation and directs the active power taken from the power supply to the DC link. The closed-loop control consists of closed-loop speed control with lower-level closed-loop current control and a gating unit set which provides the ignition pulses required to control the converter.

The line side converter will be synchronized via a voltage transformer in medium voltage field, which requires a three phase Y Y voltage transformer connection with 100V secondary voltage.

The generator-side converter operates as an inverter in load-controlled operation. The maximum delay angle is altered as a function of the speed and the DC link current.

The current in the generator-side converter is commutated by the machine’s terminal voltage. The DC link current is switched from one stator winding to the next so that a rotating field is established in the three-phase stator winding which turns the rotor synchronously.

The machine voltage is not sufficient for commutation in the generator-side converter in the range from zero speed to a minimum speed. The process of DC link pulsing during which the line-side converter is briefly controlled in inverter operation causes the current in the DC link to become zero and the blocking ability of the thyristors is re-established.

The rotor position is determined by the induced voltages in the stator winding so that a rotor position encoder is no longer necessary. All the required data values are measured or, as is the case for the actual speed value, derived from the measured variables.

Open-Loop Control

The open-loop and control-loop equipment for the starting frequency converter is housed in an exciter cabinet. This static excitation equipment and the starting frequency converter must therefore be placed next to each other. The starting frequency converter always communicates with the instrumentation and control equipment in the control room via the static excitation equipment provided.

Three different criteria symbolize faults:

- Tripping: Always triggers starting frequency converter to trip in the event of faults
- Warning: Signals faults without interrupting operation
- Not ready: Blocks switching on

The actual values for turbine-generator speed and current in the DC link can be displayed both locally and in the control room.

Operating Modes

The starting frequency converter is designed for four gas turbine starts in sequence. After this, a cooling down time of at least 2 h must be observed.

The starting frequency converter is designed for the following operating modes:

Grid start:	Normal start-up at rated output up to approx. 70% rated speed.
Washing:	The turbine-generator unit is turned at a various speed between 23.3 to 26.7% of rated speed to clean the compressor blades.
Purging:	Ignitable gases are flushed out of the HRSG of combined-cycle units at a various speed between 23.3 to 26.7% for a duration of max. 10 minutes.

Power Supply

The starting frequency converter is fed via the SFC transformer from the medium-voltage supply of the power plant’s auxiliary power supply system.

Technical Data

For technical data of the starting frequency converter please refer to section 4.2.

Static Excitation Equipment

The exciter energy is fed via slip rings to the rotor winding from a static exciter.

Power Section

The exciter comprises an exciter transformer and a thyristor assembly in a three-phase fully controlled bridge connection.

The power section also includes a field suppressor, which allows the exciter current to decay after inverter operation in the bridge circuit.

The thyristors in the bridge branches are protected by fuses.

Over voltage protection for the generator rotor is provided on the DC side. The power section is forced air cooled by redundant fans.

Closed-Loop Control

The closed loop control for generator voltage comprises two redundant digital automatic voltage regulators. Each automatic channel includes its own manual controller for field current control, the manual channel is used for emergency operation or commissioning.

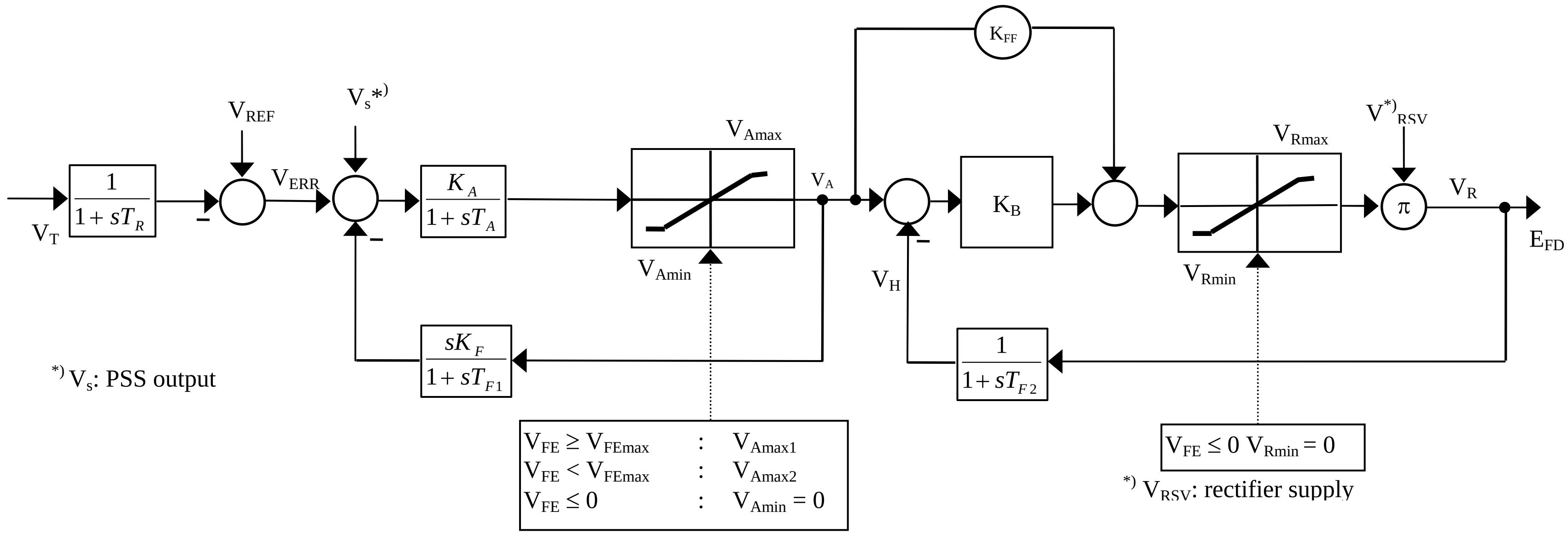
When connected to the grid and automatic mode is selected, the generator voltage set point will be held within the generator capabilities. 100% represent the generator rated terminal voltage.

The limitations of the automatic channel ensure that the generator is operated within its load limits when connected to the grid. The following limitations are included:

- Stator current limitation
- Max. rotor current limitation (field forcing)
- Over excitation limitation (field current)
- Under excitation limitation
- V/f limitation
- Settable droop for reactive power
- Reactive power control

A Power System Stabilizer (PSS) is a feature of the closed-loop control.

Block Diagram Voltage Controller Siemens Type– (for information only)



T_A = 1 ms	K_A = 4000	E_{FDmax}= 8,366 p.u.	V_{Amax2} = 8,366 p.u.
T_{F1} = 400 ms	K_F = 12,8 ms	V_{FEmax}= 5,959 p.u.	V_{Amax1} = 5,108 p.u.
T_{F2} = 100 ms		K_B = 1	V_{Rmax} = 8,366 p.u.
T_R = 12 ms		K_{FF} = 1	V_{Rmin} = -6,688 p.u.

Power Supply

Power is fed to the exciter via an exciter transformer from the generator bus duct between the generator isolator and the generator transformer.

Operation

The standard mode of communication between the exciter and the operating equipment is via a bus connection. The standard telegram from the exciter equipment to the instrumentation and control equipment consists of 39 words of 16 bits each, and in the opposite direction of 23 words of 16 bits each. The telegram from the I&C to the exciter equipment contains all the commands and set points. Actual values, operational signals and alarms are transferred from the exciter equipment to the I&C. The I&C control signals for SFC are included in the SEE telegram.

An operator control panel is installed locally. Local operation or control room operation can be selected using the key switch on the exciter.

In normal operation, the set points are entered in the control room. Here, actual values and alarms are also received. A detailed fault definition is displayed on the local operator panel.

Technical Data

For technical data of the static excitation equipment please refer to section 4.2

SFC and SEE Dry Type Transformer (MBJ and MKC)

The transformers for the starting frequency converter and for the static excitation equipment are GEAFOL ® cast-resin transformers.

Main Characteristics

The SFC and SEE transformers are tree-phase, two-winding power transformers with the following design:

– Three limb core
– Dry-type insulation
– AN cooling system
– Aluminum foil HV windings and aluminum strip LV windings.
– Temperature detectors in each phase for warning and trip
– Tapping links on the HV side which can be disconnected under de-energized condition
– Installed in metal enclosure with IP23DH rating. For outdoor installation, the housing is rated IP23DW.

Technical data

For technical data of the SFC and SEE transformers please refer to section 4.2.