

# Just Name Your Need

AMG and AMZ Synchronous Machines

PRODUCT REVIEW



**ABB**

# Just Name Your Need

# Power for

# Industries



## PRODUCT REVIEW

- 3 AMG and AMZ Synchronous Machines Type Designation Code
- 4 Global Experience
- 5 Power for Industry
- 6 Output Ranges
- 7 Key Features
- 8 Electrical Characteristics
- 9 Synchronous Generator Excitation System
- 11 Synchronous Motor Excitation and Protection System
- 12 Excitation by Brushless Exciter
- 13 Excitation by Slip Rings
- 14 Insulation
- 16 Windings & Stator
- 17 Rotor, Poles & Shaft
- 18 End Shield Bearing Frame
- 19 Intergrated Pedestal Bearing Frame
- 20 Bearings
- 21 Bearing Lubrication
- 22 Cooling and Enclosure
- 23 Terminal Boxes
- 24 Accessories
- 26 Testing
- 28 Documentation Provided by the Manufacturer
- ... Additional Information



# AMG and AMZ Synchronous Machines

You are reading the Product Review of AMG and AMZ synchronous machines made by ABB Oy in Helsinki, Finland. This Product Review presents our entire range and its technical information. The contents are designed to help you select the right machine for your application.

The type designation of the synchronous machines made by ABB Oy are AMG and AMZ. The single symbols of the designation code are explained below.

## Designation Code:

**A M Z 1250 M M 08 P S E A**

ABB code (1)

Production code (2)

Type of machine (3)

Frame size (4)

Frame length code (5)

Core length code (6)

Number of poles (7)

IC/IP combination (8)

Bearing type (9)

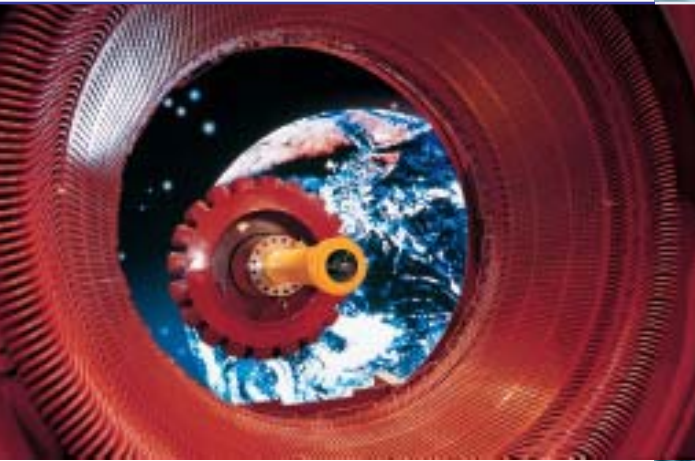
Type of excitation (10)

Mounting arrangement (11)

- (1, 2) **AM** Stands for **A**lternating Current **M**achines
- (3) **Z** Indicates the type of machine:  
**G** = generator, **Z** = motor
- (4) **1250** Frame size (shaft height in millimeters), always 4 digits, i.e. 0710 for 710 mm shaft
- (5) **M** Frame length
- (6) **M** Stator core length
- (7) **08** Number of poles, always 2 digits, i.e. 08 for 8 poles
- (8) **P** Stands for the IC/IP combination:  
**D** = open, **W** = open weather protected, **P** = pipe ventilated, **L** = air-to-water cooled, **A** = air-to-air cooled, **M** = other
- (9) **S** Bearing type:  
**A** = roller, **S** = sleeve, **C** = combination, **N** = no bearings
- (10) **E** Type of excitation:  
**B** = with brushes, **E** = brushless, **I** = no excitation (squirrel cage rotor), **M** = permanent magnet rotor
- (11) **A** Mounting arrangement:  
**A** = 2 bearings, feet raised, cylindrical shaft end  
**B** = 2 bearings, feet down, cylindrical shaft end  
**C** = 1 bearing, feet raised, flanged shaft end  
**D** = 1 bearing, feet down, flanged shaft end  
**E** = 2 bearings, feet raised, flanged shaft end  
**F** = 2 bearings, feet down, flanged shaft end  
**H** = no bearings, feet raised, no shaft  
**Z** = Azipod  
**M** = other

# Global Experience

ABB's excellent know-how in engineering and design is the result of more than 100 year's experience. Our manufacturing is continually being improved. Our medium voltage AC machines up to 15 kV are at work in practically all industries around the world.



Our specific know-how combined with our global resources and multi-domestic presence make ABB the first choice as a supplier of synchronous machines.



# Power for Industry

AMG and AMZ synchronous machines manufactured by ABB are used all over the world. We design our machines to suit our customers' applications.

## PRODUCT REVIEW

### **SYNCHRONOUS MACHINES operate in:**

- **Power Plants**  
Generators
- **Marine**  
Propulsion Motors, Generators, Azipods,  
Cycloconverter Motors
- **Chemical, Oil and Gas Industries**  
Reciprocating Compressors, Extruders
- **Metal Industries**  
Coilers, Edgers, Mill Stand Motors,
- **Mining Industry**  
Crushers, Grinders, SAG and Ball Mills, Hoists,
- **Mineral Processing Industries**  
SAG and Ball Mills
- **Pulp and Paper Industry**  
Chippers, Refiners, Grinders
- **Water**  
Pumps
- **Special Applications**  
Wind Tunnel Motors, Condensers, MG-sets

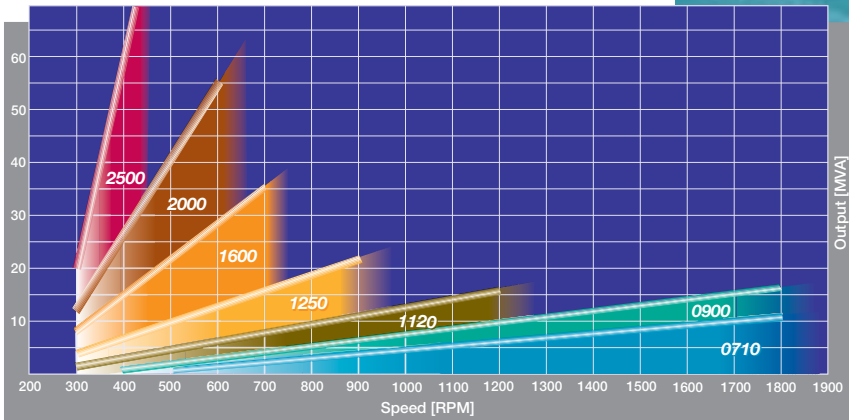


# Output Ranges

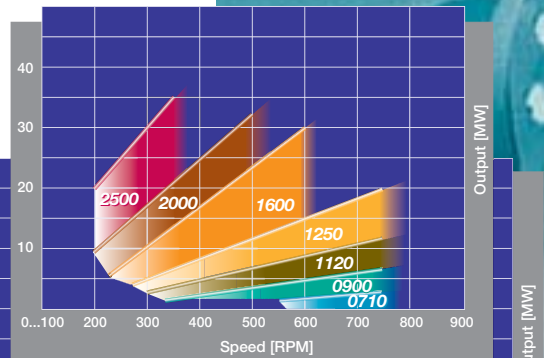
ABB offers you one of the most comprehensive ranges of synchronous machines, AMG and AMZ. Our research and development ensures the best solution for each purpose.

## Typical Output Ranges at Different Speeds

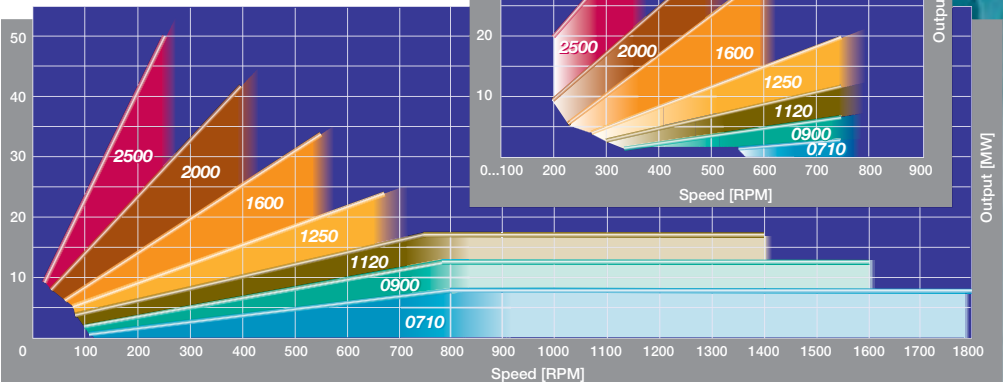
### AMG Generators



### AMZ Motors for Fixed Speed



### AMZ Variable-Speed Motors







## Key Features

The ABB way to design and manufacture is unique. It provides numerous benefits to both the end user and ABB. It saves energy, cuts operating costs, and means more output for the same investment.

### PRODUCT REVIEW

#### Efficiency

Optimized synchronous machines of a smaller size save money by cutting energy consumption and shortening payback times. Higher quality also means higher reliability.

#### Vibration Tolerance

All synchronous machines are designed to withstand vibration. AMG generators withstand vibration of up to 20 mm/s RMS. This gives synchronous machines a longer mechanical life.

#### Mounting

Single and two bearing designs ensure that our synchronous machines are suitable for all purposes and easy to install.

#### Cooling

Vertical air outlets make it easier to collect heat from the roof. This saves money and helps to keep the surroundings clean. Air-to-water, and air-to-air heat exchangers are optimized for each machine.

#### Design

A high degree of standardization means short delivery times.

#### Overload margin

Our synchronous machines will withstand overloads according to standards or specific requirements.

#### Corrosion Protection

Anti-corrosion protection ensures that the machines can be used in any installation, even in chemical plants.

# Electrical Characteristics

The electrical engineering of our synchronous machines is based on a thorough knowledge of the rules of physics as they apply to all interactions between the driven machine and the electric network.

## Electrical optimization

Modern state-of-the-art software permits the analysis of all normal and abnormal conditions affecting the electric network or the driven machine. Electrical characteristics are optimized to meet each customer's specific needs and requirements.





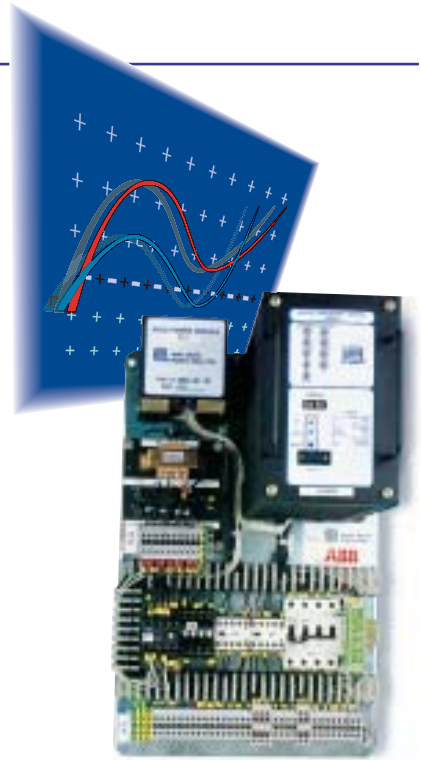
# Synchronous Generator Excitation System

Our generators are designed for self-excitation, and need no external sources of excitation.

## PRODUCT REVIEW

### The synchronous generator excitation and regulation system includes the following main components:

- Three phase brushless exciter with rectifying diode bridge to supply DC current to the field windings.
- Automatic voltage regulator (AVR) to keep the terminal voltage, or the power factor, constant at a preset level under varying load conditions. Both analog and digital AVRs are available
- For installations requiring an AVR backup arrangement, configurations with two AVRs (one in operation and the other on stand-by) are available. Changeover between the AVRs can be automatic or manual.
- Three-phase voltage transformer to supply excitation power and actual value measurement (feedback) to the AVR.
- Current transformers to the supply excitation power in short-circuit situations.



A digital AVR installed on its mounting plate

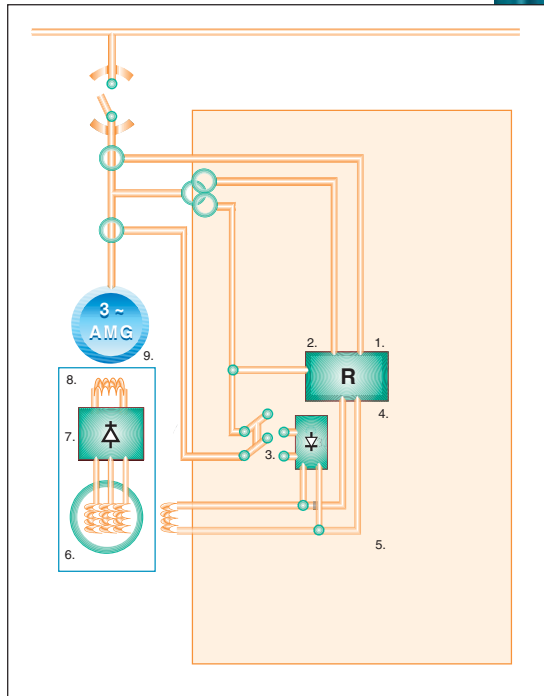
# Synchronous Generator Excitation System

The main features of the synchronous generator excitation and regulation system include:

- Automatic start-up. No external power source is required for initial excitation at start-up.
- Power factor control or voltage control with reactive droop compensation.
- A frequency fall-off feature preset to start reducing the voltage when the frequency falls below 90% of the rated frequency.
- Excitation for sustained short circuit.
- Protection against over-voltage
- Excitation current limiter
- Static accuracy is better than  $\pm 1\%$  at all symmetric loads.
- Stepless voltage setting range  $\pm 10\%$ .

A typical example of an AVR-assembly for a brushless synchronous generator:

1. Generator current signal
2. Generator voltage supply
3. Booster supply
4. Automatic regulator
5. Rectifier
6. Exciter
7. Rotating rectifier
8. Field windings
9. Stator windings



# Synchronous Motor Excitation and Protection System

## PRODUCT REVIEW

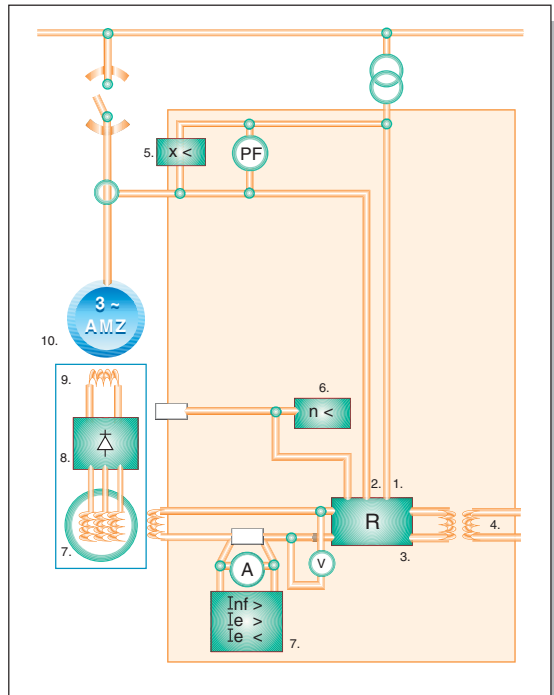
The main features of the synchronous motor excitation and protection system include:

- Power factor control or reactive power control
- Automatic or manual control
- Pull-out protection
- Rotating diode monitoring (short circuit and cut-off)
- Excitation over and under-current protection
- Starting time supervision
- Excitation current limiter
- Stator current limiter
- PQ-limiter for under-excitation
- Setpoint high and low limiters
- Stall protection based on speed measurement during start

WARNING !!!  
HIGH VOLTAGE  
11000V

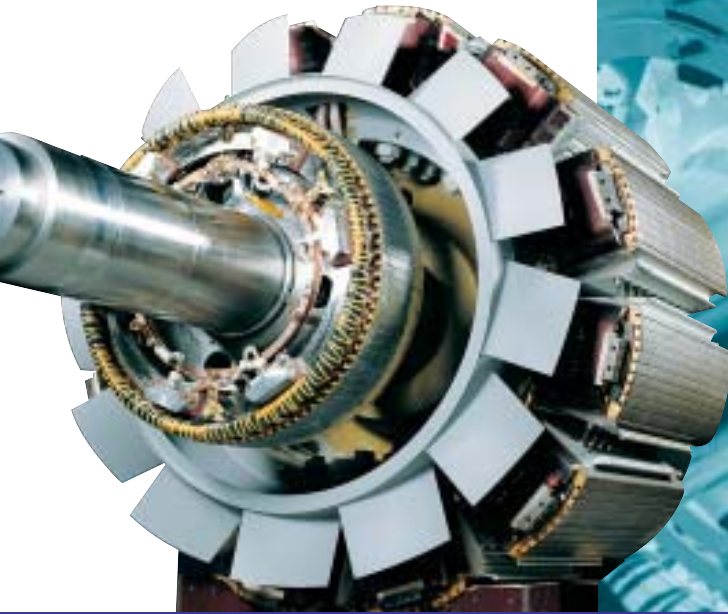
A typical example of an excitation system for a brushless synchronous motor:

1. Motor voltage signal
2. Motor current signal
3. Automatic regulator
4. Excitation power supply
5. Pull-out protection
6. Stall protection
7. Exciter
8. Rotating rectifier
9. Field windings
10. Stator windings



# Excitation by Brushless Exciter

Both brushless excitation, and excitation with slip rings and brushes are available. Brushless excitation is typically used in generators and fixed-speed motor applications. Explosive environments demand brushless excitation.



PRODUCT REVIEW

The exciter rotor windings are wound with enameled wire, impregnated, shrunk-fit to the shaft, and secured with a key. The exciter is mounted inside the motor frame, with access through removable inspection covers.

# Excitation by Slip Rings

Excitation with slip rings and brushes is typically used with variable-speed motors. The slip rings are installed separate from the main motor interior, with access through removable inspection covers.

## Flange-mounted slip ring

The slip rings, and the mounting flange or hub are usually made of steel, and are normally mounted as a single unit. Slip ring units with brass rings, as well as split flange mounted units are available on request. The slip ring unit is equipped with brass connection pins, facilitating installation. The excitation current is transferred to the slip rings by brushes.



## Hub-mounted slip ring



# Insulation

The insulation system used in all our synchronous machines is the MICADUR®-COMPACT INDUSTRY (MCI) system. The MCI insulation system is based on the Vacuum-Pressure Impregnation (VPI) method, which has

successfully demonstrated its dependability over many years in thousands of machines of all types and has achieved worldwide recognition for its excellence.

## Insulation Fabrication Process

Our standard practice is to insulate wound stators and rotors as complete units. This ensures that both the insulation and the mechanical properties of the windings are excellent – which means that they can easily withstand prime-mover-induced vibrations and the mechanical stresses caused by transients, such as short-circuit.



## The VPI Process

After the stator or rotor has been wound, the entire construction is dried to expel all moisture and solvents from the insulation.

Under vacuum, all air and moisture is removed from the voids and pores of the insulation.

The windings are immersed in a low-viscosity epoxy resin.

High pressure in the tank forces the resin into the very smallest of pores.

The resin in the windings is cured in an oven at high temperatures, to produce a stable, high-quality insulation.



All our synchronous machines have insulation designed to Class F requirements, with the maximum hot-spot temperature limit of 155°C.



## MICADUR®-COMPACT INDUSTRY (MCI) insulation system

### ■ **Excellent reliability:**

Years of dependable operational experience in a wide variety of applications.

### ■ **Proven system:**

Since 1977, tens of thousands of our machines have been insulated using the MCI-system and are operating successfully all over the world.

### ■ **Outstanding performance:**

Mica insulation combined with special epoxy resin applied with the VPI process ensures long-life performance.



# Windings & Stator

Windings are made using the well-established VPI technique, in which the insulation is based on the use of mica. The mica-insulated conductor is first wound into coil loops, which are then spread to form the coil.

## Windings

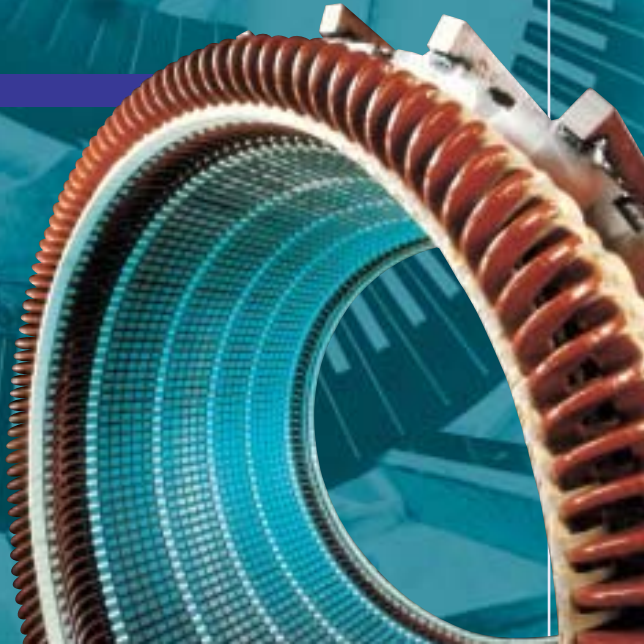


The coils are insulated with glass-fibre-reinforced mica-tape. The mica-tape is applied by special taping machines to ensure high quality. Each coil is individually voltage tested.



## Stator

The stator core is built from stacked, high-grade, low-loss laminated electric sheet steel, insulated on both sides with a heat-resistant inorganic coating. Radial cooling ducts in the stator core ensure uniform and effective cooling of the stator.

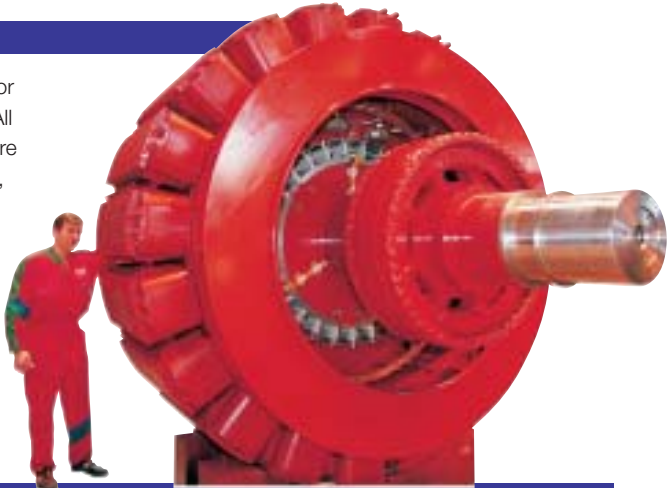


# Rotor, Poles & Shaft

## Rotor

The rotor comprises a shaft, a hub for larger machines, and salient poles. All rotor assemblies are vacuum pressure impregnated (VPI) as complete units, to ensure excellent insulation and mechanical strength.

After impregnation, the complete rotor assembly is dynamically balanced on two planes. All rotors are designed to withstand over-speed specified in international



## Poles



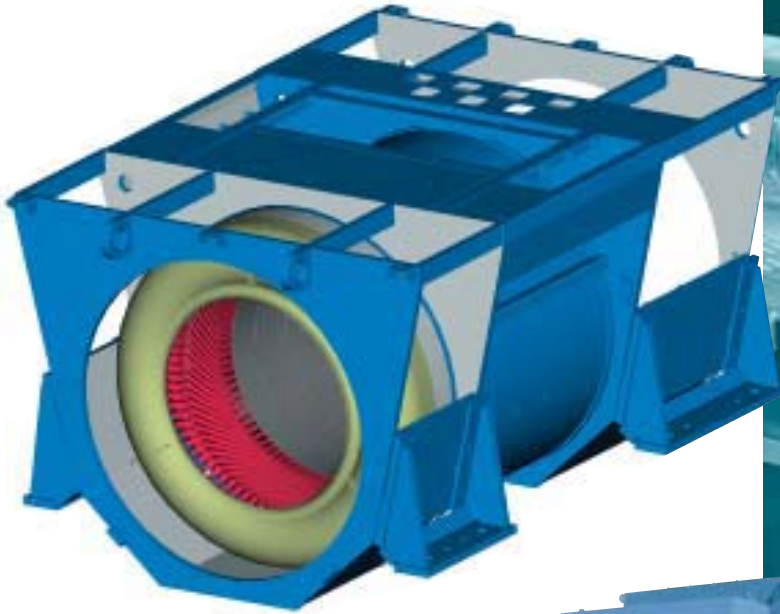
The poles are normally manufactured from 2 mm laminated steel sheet. The sheets are pressed together with inserted steel bars, which are welded to the ends plates. The poles are secured to the shaft or hub by bolts from above or below, or by means of a dovetail connection. The poles are equipped with a copper or brass damper winding, as well as a field winding of either enamelled copper wire or flat copper bars.

## Shaft

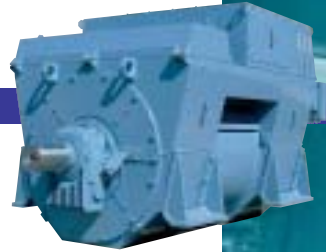
The shafts are manufactured from forged or rolled steel and machined to exact specifications. Rotors for machine frame sizes 1250 and greater are normally equipped with a separate hub attached to the shaft with a shrink-fit. The shaft ends are normally cylindrical or flanged.



# End Shield Bearing Frame



Frame

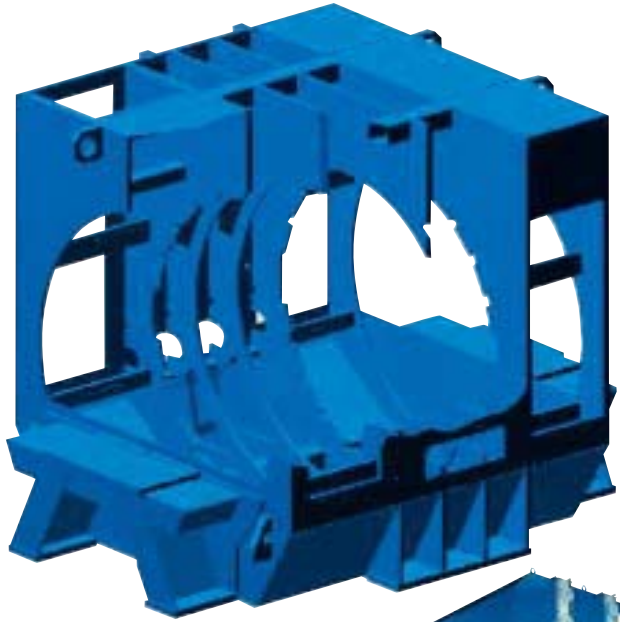


- Frames 0710, 0900, and 1120 are of modular type. The stator core is welded into a cylinder, after which the end-modules are welded to the stator core. The bearings are flange-mounted on the end-shields.

- The stator core, end modules and end-shields are made of fabricated steel, and the design easily withstands vibration.



# Intergrated Pedestal Bearing Frame



## Frame

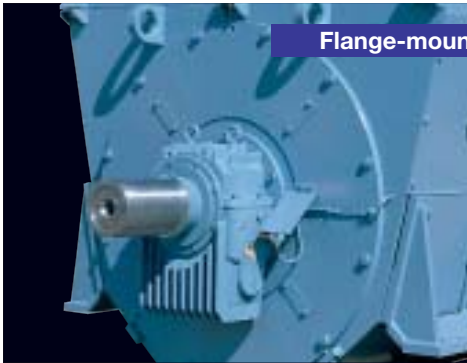
- Frames 1250, 1600, 2000, and 2500 are full-frame models, with stator frames made from fabricated steel. The bearings are mounted on pedestals integrated with the frame for installation as a single unit.
- Frames with separate pedestal bearings are available on request. These machines can be equipped with soleplates or base frames. The various parts of these machines, i.e. rotor, bearings, and accessories, are normally assembled on site.

# Bearings

The most common construction is spherically-seated sleeve bearings with either forced or self-lubrication. Roller bearings can be used in certain appli-

cations. An oil sight-glass and temperature detectors are standard on all sleeve bearings.

## PRODUCT REVIEW



**Flange-mounted sleeve bearings**

A flange-mounted sleeve bearing is attached to the end-shield, which is, in turn, attached to the stator frame. This permits easy alignment of the synchronous machine. Flange-mounted sleeve bearings are standard with frame sizes 0710, 0900, and 1120.



**Integrated pedestal sleeve bearings**

These are sleeve bearing that are attached to an integrated pedestal attached to the stator frame. This permits easy one-piece installation and reduces vibration levels, by shortening the shaft and stiffening the pedestal. Integrated pedestal sleeve bearings are standard with frame sizes 1250,1600, 2000 and 2500.



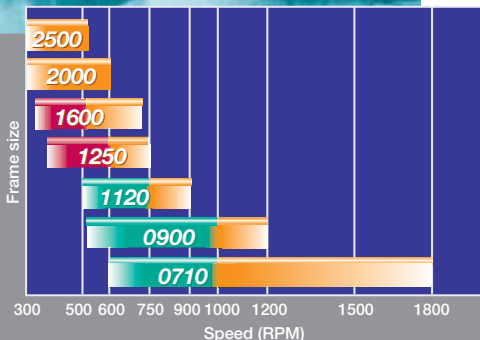
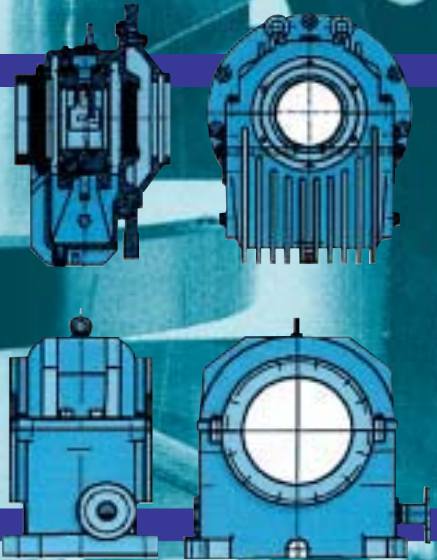
# Bearing Lubrication

## Self-lubrication by oil rings

The lubricating oil is picked up by the internal surface of the oil ring, and is transferred directly to the shaft. Frictional heat is dissipated by radiation and convection only. Therefore the ambient temperature must be taken into account during design, to ensure adequate natural cooling.

## Flood lubrication by an external oil supply

The lubricating oil is circulated by an external oil supply system and, if necessary, cooled by a separate unit. This is sometimes necessary when ring lubrication of the bearing is insufficient, due to specific rotational speed requirements and high frictional losses.



## Recommended Sleeve Bearing Types

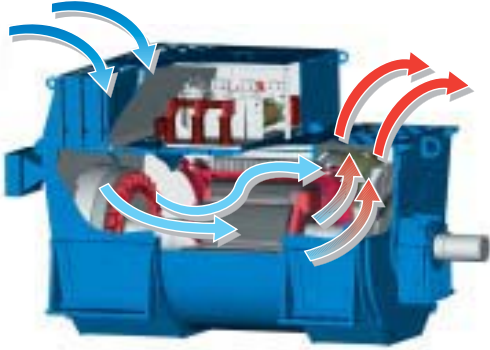
- Self lubricated as standard.  
Flood lubricated upon request.
- Flood lubricated as standard.  
Self lubricated available at additional cost.
- Flood lubricated as standard.  
Self lubricated not available.

(at a maximum ambient temperature of 40°C)

# Cooling and Enclosure

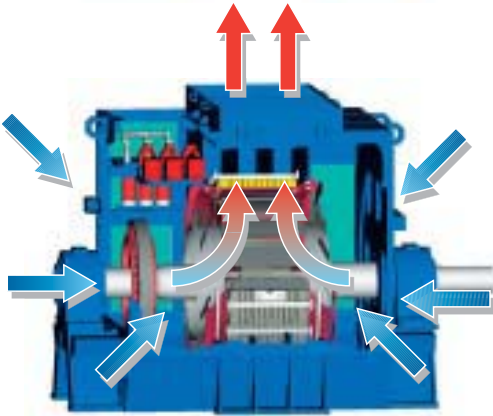
There are three commonly used cooling arrangements: open air, air-to-water, and air-to-air.

## Open air cooling



Open air cooling can be used where the air in the immediate environment is relatively clean and there is adequate air circulation. The cooling air is drawn in through air filters, passed through the active parts of the synchronous machine, and then exhausted to the environment.

## Air-to-water or air-to-air cooling



Air-to-water cooling, or air-to-air cooling, is used when the immediate environment prevents the free circulation of the cooling air. The heat exchangers are made from high-quality, corrosion-resistant materials and can be easily removed. The synchronous machines is totally enclosed with air-to-water, or air-to-air cooling, and has shaft-mounted or independent electrical fans, to move the air through the cooling unit.

## Enclosure

Standard enclosures include the following degrees of protection: IP21, IP23, IP44, P54, and IP55. Purging and pressurizing equipment is also available.

# Terminal Boxes

## PRODUCT REVIEW



Side-mounted cable entry point.



Terminal box for auxiliaries and detectors.

### The locations of the terminal boxes in different frame sizes:

- In frame sizes 0710, 0900, and 1120, the terminal box is located on top as standard, and can be designed to allow cable entry from either the right or left side of the machine. The standard method of cable entry is from below the box, but alternative arrangements are available on request.
- In frame sizes 1250, 1600, 2000, and 2500, the terminals are usually located inside the frame, or in a terminal box on the side of, or under the machine. The main terminals are brought in through an undrilled gland plate.
- In all types of synchronous machines, the auxiliary terminal boxes are located separately from the main terminal box. All auxiliaries and detectors are wired to separate boxes.



Transformers mounted on a mounting plate inside a top-mounted terminal box.

# Accessories

## Standard accessories, included

- Bearing(s) with oil sight-glass
- Main terminal box
- Auxiliary terminal box
- Pt-100 elements for stator winding and bearing temperature monitoring
- Anti-condensation heaters
- Jacking screws



Cooling air filters

## PRODUCT REVIEW



Leakage detector and cooling air temperature detector



Jacking screw



Pt-100 bearing temperature detector and oil sight-glass

## Optional Accessories and Tools

- Pt-100(s) for air temperature monitoring
- Heat exchanger leakage indicator
- Cooling water flow control systems
- Bearing lubrication oil system, with circulation oil pumps, oil filter(s), oil cooler, pressure and oil-flow switches
- Hydrostatic jacking for slow speed operation and starting
- Foundation bolts, sole plates, base frames and grouting moulds
- Shaft extension for rotor installation and maintenance

## Special Accessories and Tools

- Disc brakes
- Vibration detectors and monitoring devices
- Position indicators
- Stator shifting devices
- Barring gear
- Lifting beam
- Lifting lugs
- Hydraulic jacks, torque wrenches



Lifting beam



Speed measurement unit including absolute encoder and pulse tachometer



Barring gear



# Testing

Testing is intended to check the properties and performance of the machine and verify that they comply with the customer's requirements. The standard test programmes are divided into three

parts: routine tests, type tests, and special tests. The routine test programme is carried out on every machine and is included in the price of the machine. The type test is normally

## Routine Tests (1-16) and Type Tests (1-22)

1. Visual inspection
2. Air gap measurement and clearance check of sleeve bearings
3. Insulation resistance measurement
4. Winding resistance measurement
5. Checking of temperature detectors and space heaters
6. Terminal markings and direction of rotation
7. Axial play for unlocked bearing
8. Bearing run
9. Vibration measurement
10. No-load point
11. Short-circuit point
12. High-voltage tests
13. Over-speed test for generator
14. Tests on voltage regulators fitted on synchronous generators
15. Tests on excitation cubicle of synchronous motors (50/60 Hz)
16. Insulation resistance measurement
  
17. Moment of inertia
18. No-load curve
19. Short-circuit curve
20. Heat run test (temperature rise test) / IEC 34-1 + IEEE 115
21. Zero-power factor test
22. Losses and efficiency



performed in addition to routine tests on one machine of a series of similar machines, or at the request of the customer. The special test programme is specified by the customer and/or

classification societies. Unless otherwise specified, all tests are performed according to standard IEC 34.

## PRODUCT REVIEW



### Special tests

1. Sound-level measurement / ISO 3744
2. Sudden short-circuit test / IEC 34-4 + IEEE 115
3. Measurement of the shaft voltage
4. Wave-form measurement / IEC 34-1 + IEEE 115
5. Load switching on / off test
6. Starting of the synchronous motor
7. Polarization index / IEEE 43

# Documentation provided by the manufacturer of synchronous machines AMG and AMZ

## PRODUCT REVIEW

### Documentation

- Technical specification
- User's manual

### Drawings and Diagrams where applicable

- Dimension drawing
- Cross section drawing
- Shaft with rotating masses drawing
- Bearing drawing
- Heat exchanger drawing
- Connection diagram
- Layout of connections drawing
- Main terminal box drawing
- Auxiliary terminal box drawing
- AVR connection diagram
- Rectifier bridge drawing
- Excitation panel single line diagram
- Excitation panel lay-out drawing
- Excitation panel circuit, wiring and cabling diagrams
- Brush gear and brush drawing
- Tachometer drawing
- Packing and transportation drawing
- Removing of transport locking and rotor positioning drawing
- Rotor installation and removal drawing

### Manufacturing Information

- Quality plan
- Manufacturing schedule
- Test program
- Test reports

