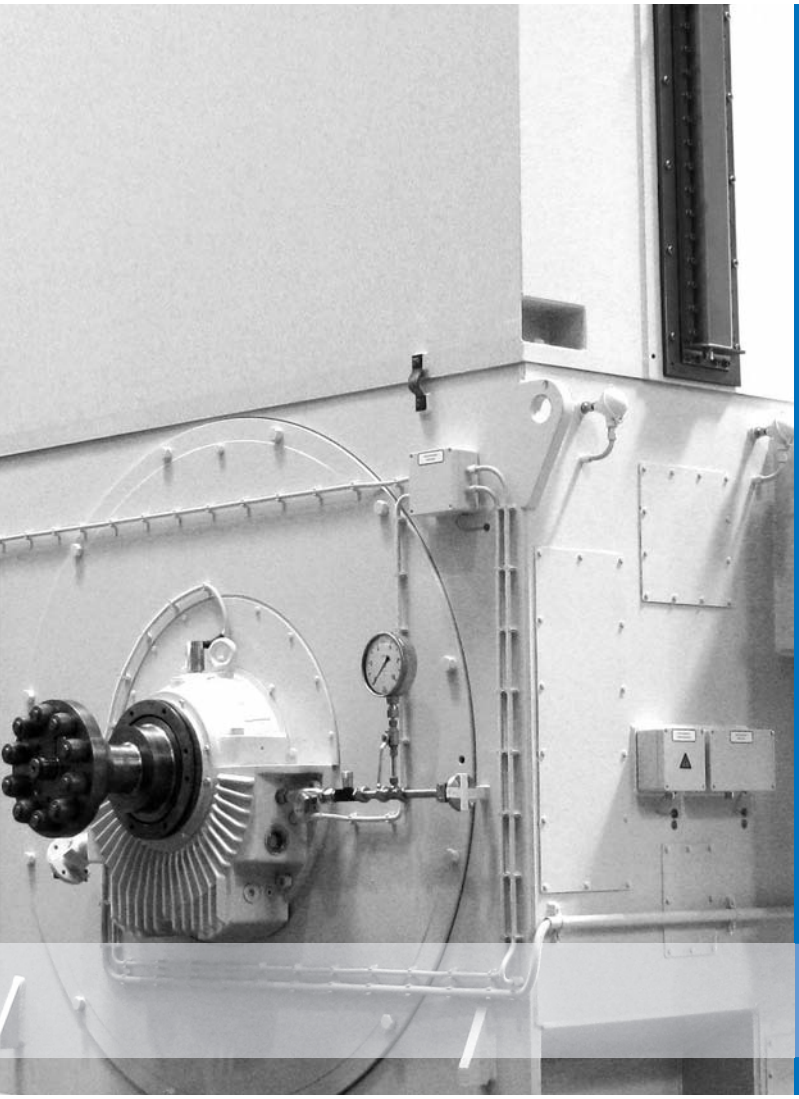
ELECTRIC DRIVES

FOR EVERY DEMAND



Three-phase high-voltage asynchronous motors

Cage rotors, slip ring rotors

www.vem-group.com

Catalogue 2015

Introduction

Three-phase, high-voltage asynchronous motors are proven, high-performance drives for all branches of industry. Different types of protection and cooling make them suitable for universal implementation. VEM offers the right solution with machines that are competitive and in line with market requirements for every application. They are durable and are characterised by ease of maintenance, modular design, high energetic parameters and low noise emissions.
All motors are configured on a customer-specific basis to satisfy the special application criteria. Extensive know-how in the plant and continuous further development in collaboration with institutes and universities also contribute to the high quality of the products.
Because the machines can be operated on inverter, they enable customer-specific solutions that offer maximum productivity, maximum efficiency and the highest level of reliability.

For decades, high-voltage machines bearing the VEM trademark have proven themselves in a wide variety of applications. As drives for pumps, compressors, rotary kilns and mills, in mining applications, the chemicals and petrochemicals industry, in steel mills and rolling mills and in the areas of environmental engineering and power engineering. Another advantage: The possibility of operation on the inverter –for significant cost savings over the entire service life.
The catalogue contains general technical explanations. We will discuss special requirements with you separately. We request that prospective customers contact our distribution department or the VEM sales offices and agencies.

The products included in this catalogue are a component of the interactive catalogue. The electronic catalogue supports you in selecting and configuring the VEM products and offers you the possibility of printing out data sheets and enquiries.
Additional information: www.vem-group.com

Note:
We strive to continually improve our products. Designs, technical data and illustrations can change. Designs, technical data and illustrations are only binding after written confirmation from the supplying plant.

Motors presented in this catalogue are shown as examples and they can include special equipment that is available at an extra charge.

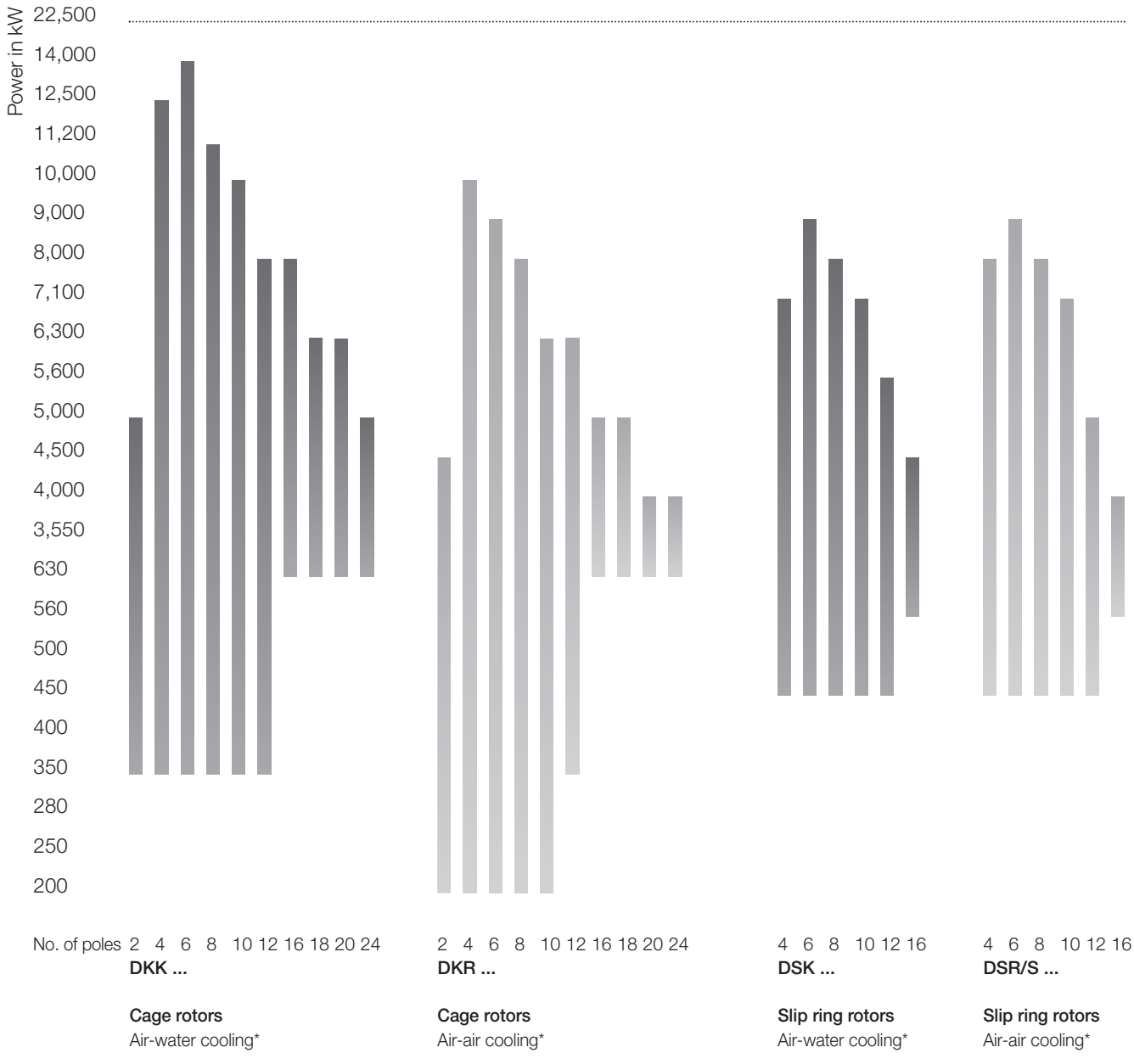
Table of contents

Product range overview

1

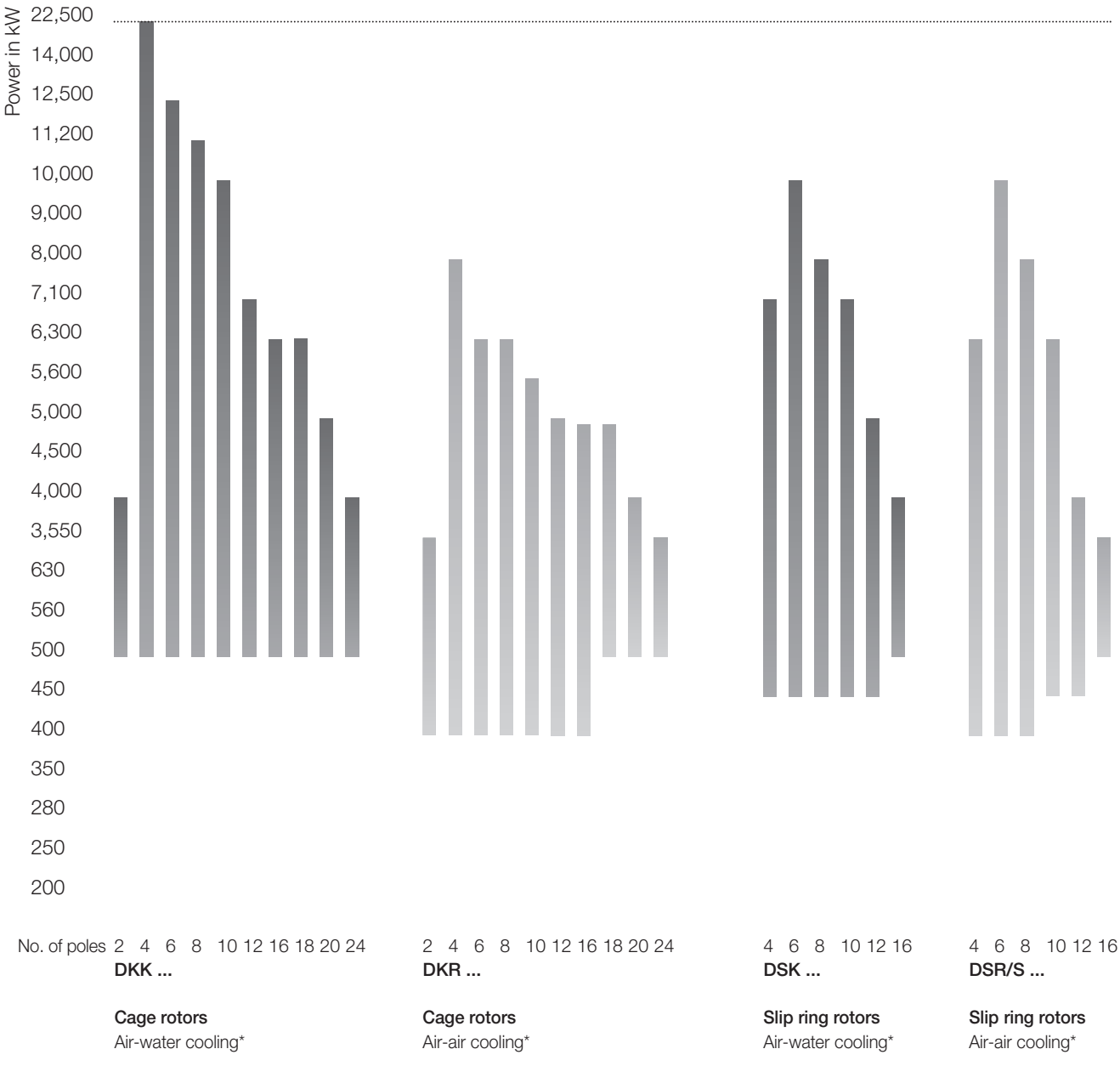
Product range overview

Three-phase high-voltage asynchronous machines 6 kV; 50 Hz; F/B

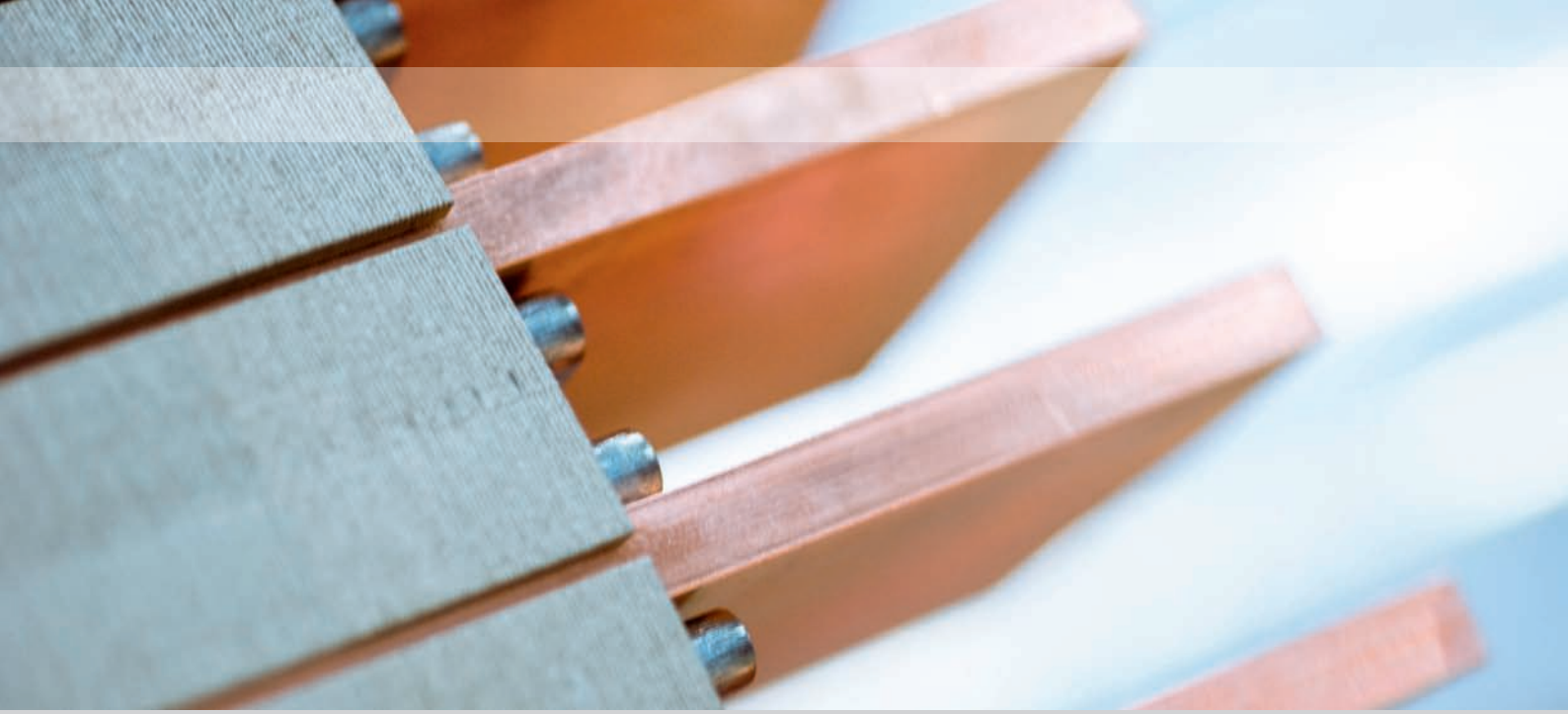


*Other capacities are available on request

Three-phase high-voltage asynchronous machines 10 kV; 50 Hz; F/B



*Other capacities are available on request



Type designation
Standards and regulations

2

Type designation

The Sachsenwerk type designations are comprised of letters and numerals.

Letters	Place	1-5
Numerals	Place	6-9
Numerals/letters	Place	10-14
	(variable, depending on machine type)	

Place	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	D	K	K	E	R	6	3	2	1	4		W	E	

1 **Current type**
D Three-phase - alternating current

2 **Machine type**
K Three-phase - asynchronous - squirrel cage motor
S Alternating current - asynchronous - slip ring motor without brush lifting device
B Alternating current - asynchronous - slip ring motor with brush lifting device

3 **Cooling type, protection rating**
E Open-circiuit cooling / self-cooling without superstructure (IP 00; IP 10; IP 20; IP 21; IP 22; IP 23)
A Open-circuit cooling / self-cooling with superstructure (IP 23; IP 24)
F Open-circuit cooling / self-cooling pipe connection withinternal fan (IP 44; IP 54; IP 55)
L Open-circuit cooling / forced cooling additional ventilation unit or pipe connection (IP 00; IP 10; IP 20; IP 21; IP 22; IP 23; IP 24)
B Open-circuit cooling / forced cooling pipe connection (IP 44; IP 54; IP 55)
R Closed-circuit cooling / self-cooling with air-air cooler (IP 44; IP 54; IP 55)
B Closed-circuit cooling / self-cooling with air-water cooler (IP 44; IP 54; IP 55)
S Closed-circuit cooling / forced cooling with air-air cooler with additional ventilation unit (IP 44; IP 54; IP 55)
M Closed-circuit cooling / forced cooling with air-water cooler with additional ventilation unit (IP 44; IP 54; IP 55)

4 and 5 **Design type**
(coded) Bearing arrangement, deviating voltage and frequency, Ex-protection, model, heavy starting, etc.

6 and 7 **Height to shaft centre**
(coded)

8 and 9 **Length of iron lamination**
(coded)

10 and 11 **Number of poles**

12 to 14 **Supplemental letter for rework level and special conditions**

Standards and regulations

The motors meet the requirements specified in the applicable DIN standards and DIN VDE regulations. For the basic versions, these are particularly DIN EN 60034 (VDE 0530) or IEC 60034 with their parts:

Part 1 Rating and performance
DIN EN 60034-1 (VDE 0530-1) - IEC 60034-1
Part 2 Methods for determining losses and efficiency ...
DIN EN 60034-2-... (VDE 0530-2-...) - IEC 60034-2-... (multiple parts)
Part 5 Classification of degrees of protection
DIN EN 50272-2 (VDE 0530-5) - IEC 60034-5
Part 6 Classification of cooling method
DIN EN 60034-2-... (VDE 0530-6) - IEC 60034-6
Part 7 Classification of types of construction
DIN EN 60034-2-... (VDE 0530-7) - IEC 60034-7
Part 8 Terminal markings and direction of rotation
DIN EN 60204-1 (VDE 0530-8) – IEC 60034-8
Part 9 Noise limit
DIN EN 60204-1: (VDE 0530-9) - IEC 60034-9
Part 14 Mechanical vibration ...
DIN EN 60034-14 (VDE 0530-14) - IEC 60034-14
Part 15 Rated surge voltages ...
DIN EN 60034-15 (VDE 0530-15) - IEC 60034-15
Part 18 Functional evaluation of insulation systems ...
DIN EN 60034-18-... (VDE 0530-18-...) - IEC 60034-18-... (multiple parts)
Part 24 Online detection and diagnosis of potential failures at the active parts of rotating electrical machines and of bearing currents - Application guide (IEC/TS 60034-24:2009); German version CLC/TS 60034-24:2011
Part 25 AC machines when used in power drive systems - Application guide (IEC 2/1689/CD:2012
Part 27 Dielectric dissipation factor measurement on stator winding insulation of rotating electrical machines (IEC/TS 60034-27:2006); German version CLC/TS 60034-27:2011
Part 29 Equivalent loading and superposition techniques - Indirect testing to determine temperature rise (IEC 60034-29:2008); German version EN 60034-29:2008

DIN IEC 60072-2 Dimensions and output series for rotating electrical machines
Part 2: Frame numbers 355 to 1000 and flange number 1180 to 2360 (IEC 60072-2:1990)

as well a

DIN ISO 10816-...
Evaluation of machine vibration by measurements on non-rotating parts...
(multiple parts)
DIN ISO 21940-3
„Mechanical vibration - Shaft and fitment key convention
DIN ISO 1940-1, DIN ISO 21940-14 and DIN ISO 21940-3
„Requirements imposed on the balancing tolerances of rigid rotors ... „

For explosion-proof machines the basic safety requirements are ensured through standard-compliant design:

DIN EN 60079-0 (VDE 0170-1) – IEC 60079-0
DIN EN 60079-2 (VD E0170-3) – IEC 60079-2
DIN EN 60079-7 (VD E0170-6) – IEC 60079-7
DIN EN 60079-15 (VDE 0170-16) – IEC 60079-15
DIN EN 60079-31 (VDE 0170-15-1) – IEC 60079-31

On request, delivery is possible in accordance with other standards, e.g.: the forthcoming IEC standards, the special regulations of the industry, such as the German supplemental delivery agreements for high-voltage electric motors in power plants (ZLM - Zusätzliche Liefervereinbarungen für Hochspannungs-Elektromotoren in Kraftwerken), or the Shell specification and standards issued by marine classification societies.

Electrical design

Voltage and frequency

In the basic design the motors are dimensioned for the rated voltage 6 kV and the rated frequency 50 Hz.

Voltage and frequency fluctuations during operation are possible with the definitions in IEC 60034-1, Section 7.3.

Motors for voltage ranges ≤ 3.3 kV have higher, motors for voltage ranges > 6.6 kV have lower rated outputs with the same models.

Power and heating

The rated outputs specified in the product range overvew-apply for continuous operation (S1) at rated frequency, rated voltage, installation elevation ≤ 1,000 m above sea level and a cooling air inlet temperature of max. 40°C or cooling water inlet temperature of max. 27°C. The maximum effective temperatures correspond to insulation class B in accordance with IEC 60034, measured using the resistance method.

Motors with an insulation class F temperature-rise limit are available. Transnorm motors of cooling type IC411 are executed in thermal classification F.

Deviations from the rated values of the cooling air temperature and the installation elevation result in a percentage change of the maximum possible output in accordance with Fig. 1.

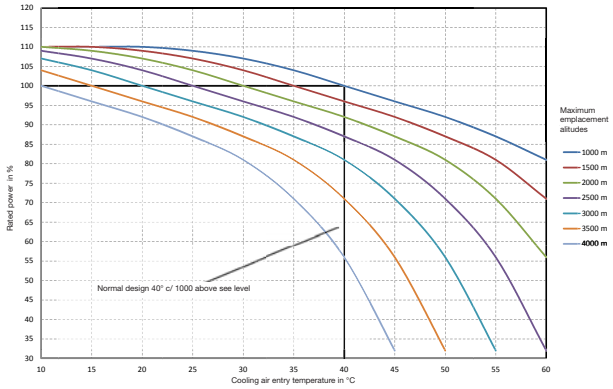


Fig. 1 Influence of the installation elevation and the cooling air inlet temperature on the permissible output

Constant rotational speeds

The rated rotational speeds cited in the product range overview apply for operation with rated voltage, rated frequency and rated output (tolerances in accordance with IEC 60034-1).
Acceleration of the machines occurs at 1.2x idle speed. This applies for 50 Hz machines as well as for other frequencies. For higher acceleration numbers please contact us.

Variable rotational speeds/speed regulation

Slip ring motors with inverter infeed in the rotor circuit

An inverter is used in the rotor electrical circuit of the slip ring motors that regulates the rotational speed through a supplemental voltage with minimal loss. The frequency of the supplemental voltage is adapted to the rotor slip frequency of the asynchronous machine (sub-synchronous converter cascade SSCC).

Due to the harmonics of the inverter when operating on an SSCC a reduction of the rated output of the motors of approx. 5% is necessary. Note that with reduced rotational speed of the drive motor, the heat dissipation decreases if self-cooling is used. Consequently, if rotational speed is reduced the torque must be reduced in accordance with Fig. 2.

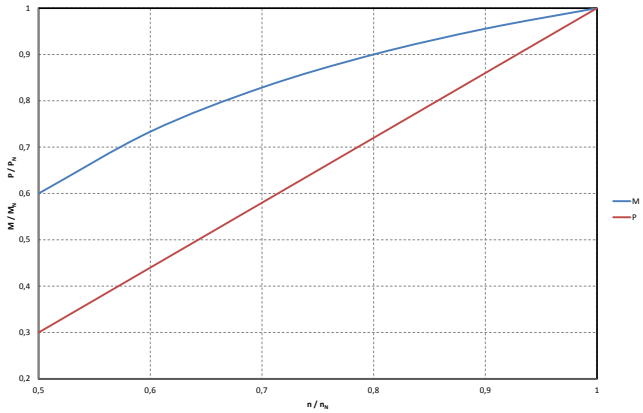
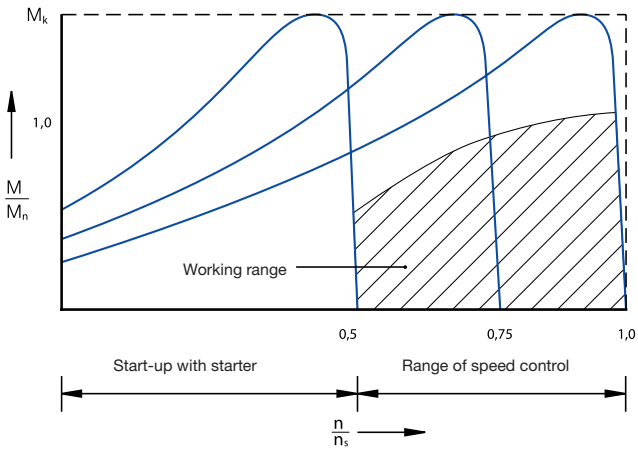


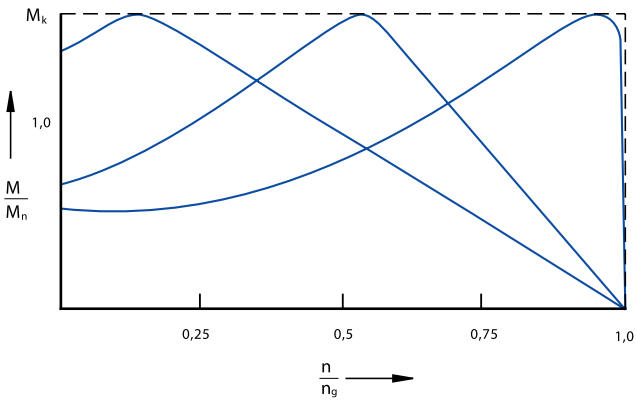
Fig. 2 Power reduction and torque reduction at rotational speed control using an SSCC

Slip ring motors over 2 MW must be further reduced in their capacity output due to the current displacement in the rotor winding at rotational speeds under 70% n_n.
The advantages of rotational speed regulation with sub-synchronous converter cascade are:

- Minimal losses because the slip power is fed back into the grid
- Cost-effective because the necessary inverter capacity at a low adjusting range (e.g. 0.7 n_n to 1.0 n_n) is lower than it is with a stator circuit feed.
- Relative load-independent rotational speeds as opposed to a rotational speed controller with slip resistors in the rotor circuit (see Fig. 3).



a) With sub-synchronous current converter cascade



b) With slip resistance

Fig. 3 Load characteristics of asynchronous motors with slip ring rotors

Squirrel cage motors with inverters

In the stator current circuit of the squirrel cage motors either a self-commutated current, or self-commutated voltage frequency converter is used.
The VEM motors are specially adapted for the respective inverter operation and the respective drive task, this means, that depending on the inverter type and the specific requirements, the insulation is adapted and the rated output is optimised through the respective inverter. For the most part, the mechanical design corresponds to that of the standard machines.
In the case of inverter-fed machines, it is necessary to specify the inverter design in your enquiry.

The windings of the machine are preferably designed as complete former wound coils, or in special cases as Roebel bar windings and impregnated in a vacuum pressure impregnation technique (VPI). Thanks to an extraordinarily high original quality of the winding wires used, through which, as compared to the regular winding structure for round wire winding, and the associated favourable voltage distribution within the coils, and the advantages of the VPI technique for impregnating the winding head, an extremely high level of safety is achieved relative to the voltage peaks that are possible in inverter operation.

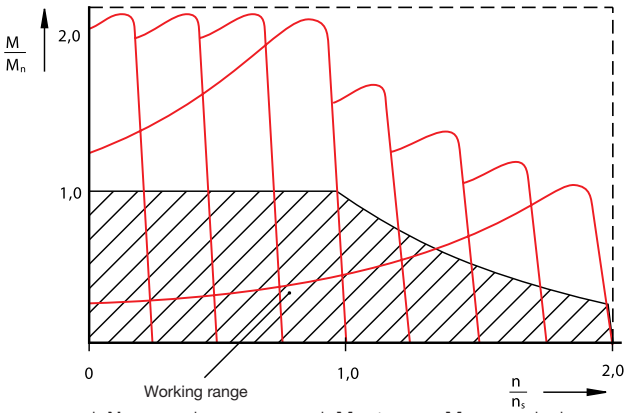
Operation of motors on frequency inverters results in a higher noise level than is the case with sinusoidal grid parameters.

According to IEC 60034-9, the guide values in this regard are:

Inverter type	Increase in the noise level L_{PA} in d
I-inverter U-inverter (pulse frequency <700 Hz)	1 - 4 1 – 15

For inverter operation the increase in the noise level, among other things, depends on:
- Pulse frequence
- Pulse patter
- Output filter

The advantages of rotational speed regulation of squirrel cage motors with frequency inverters are:
- Optimal adjustment of rotational speed and torque of the motor to the technological requirements of the work machine
- Optimal efficiency over an extremely broad capacity range and rotational speed range.
- Power feed from the grid with an excellent power factor (U-inverter)
- Energy injection into the grid can be implemented
- Good synchronicity for multi-motor drive
- High rotational speed constancy at variable load
- Large rotational speed range with minimum losses is possible (see Fig. 4)



n = speed, $\mathbf{N_s}$ = synchronous speed, **M** = torque, $\mathbf{M_N}$ = nominal torque

Fig. 4 Torque characteristic of asynchronous motors with cage rotors at frequency-voltage control

For all inverter-fed motors, to avoid bearing currents, a bearing is insulated, if feed occurs through I-inverter or U-inverter, with a motor-side output voltage up to 690 V. For motors operated on medium-voltage inverters, use of two insulated bearings and an earthing brush, if there are no other specifications.

Motors for work machines with relatively constant moments, e.g. mill drives, compressor drives and rolling mill drives are frequently equipped with an external air unit.

Start-up

Asynchronous motors with cage rotors

Normal start-up
All outputs that are specified in the product range overview, permit direct start-up on the grid. This simple start-up procedure should always be used, if allowed by the grid conditions or the machines to be driven.

The size of the machines is determined through:
- The level of the rated power
- The loss energy that must be stored in the motor during run-up

This is the kinetic energy that is required for acceleration of the work machine, the motor rotor, and additional mass. The motor types cited in the product range overview are dimensioned for normal start-up procedures. They can accelerate work machines to the rated rotational speed with constant square resistive torque curves (see Fig. 5). In this process, a ratio of maximum torque of the work machine to nominal torque of the motor of 0.9 at square resistive torque, is assumed. For motors with an output > 7 MW a throttled start-up is the basis. In this regard the voltage drop in the grid must not exceed a maximum of 10%.

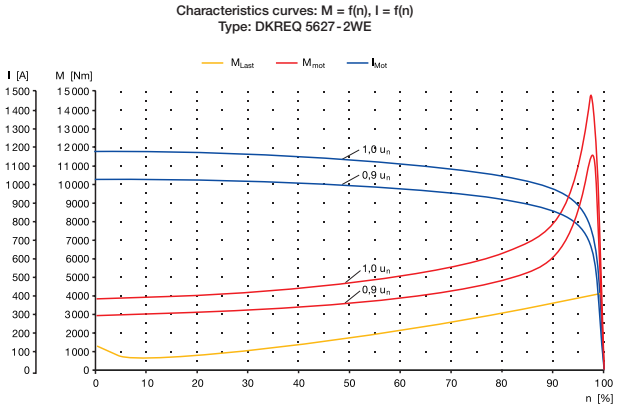


Fig. 5 Torques and start-up characteristic of a 2-pole motor during start-up

If lesser resistive torques load the motor at start-up, then higher voltage drops in the grid are also possible.
The motor torque / motor current decreases more markedly than the square / linear ratio line voltage to rated voltage due to the saturation.

For example:

$$M_{70\%} = \left(\frac{M_{70\%}}{U_{100\%}}\right) \cdot A \cdot M_{100\%}$$

A = Korrekturfaktor, dabei ist A < 1

The time period for start-up is determined through the total moment of inertia, the rated rotational speed and the acceleration torque (motor torque - passive torque of the work machine).

It results in:

$$t_a = \left(\frac{J_{ges} \cdot n_N}{M_{Beschl.}}\right) \cdot 0.105$$

t_a = start-up time (s)
J_{tot} = total moment of inertia (kgm^2)
n_N = rated rotatonal speed (min rpm)
$M_{accel.}$ = Acceleration torque (Nm)

For an initial rough calculation it suffices to graphically estimate the acceleration torque.
Precise calculations are executed with the aid of iterative procedures.
In the basic design, the switching frequency is up to 1,000 switching cycles per year, if nothing to the contrary is agreed. The motors with cage rotors, height to shaft centre 355 mm to 800 mm are suitable for automatic grid changeovers without residual voltage restrictions. These must be specified by the purchaser.

High-inertia starting
If the drive tasks impose higher requirements on the direct start-up of the motors with cage rotors, such as high moments of inertia or high load torques at increased voltage drop, the motor must be specially configured.

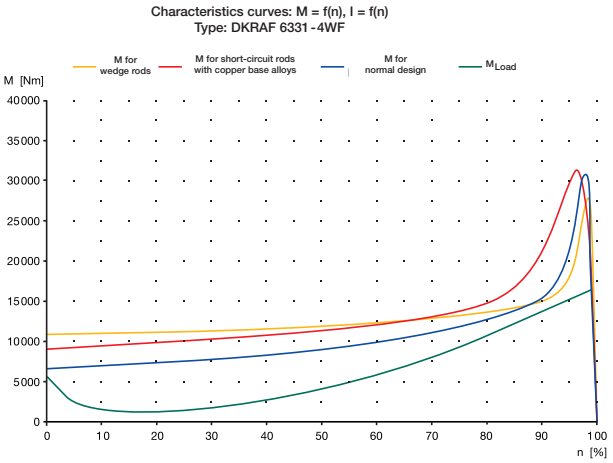


Fig. 6 Torque characteristics for different squirrel cage rotor designs

Greater torques can be realized through use of different copper alloys or bar shapes in the rotor.

Start-up via starter transformers

If particularly low start-up currents are needed due to weaker networks, this start-up procedure is used. In this regard it must be ensured that the passive torque of the work machine has low values (throttling) at the time of start-up.

Start-up via start-up inverter

This start-up procedure is used when the passive torque of the work machine cannot be throttled during start-up, high moments of inertia must be accelerated, and/or requirements are imposed on the limitation of the start-up current.

Asynchronous motors with slip ring rotors

These are designed for difficult start-up conditions. With the aid of resistors in the rotor circuit, the motor current as well as the motor torque can be adjusted in broad ranges during start-up.
The motor torque can be stepped through external discrete supplemental resistors, as in Fig. 7.

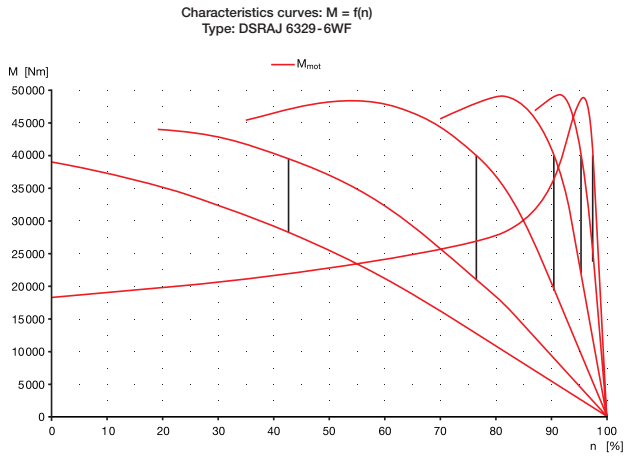


Fig. 7 Torque at start-up of a slip-ring motor with supplemental resistor

If a constant motor current is required over the entire start-up procedure, then variable liquid starters must be used. Through regulated electrode drives in the liquid starter, current and torque can be adjusted in narrow limits, so that long start-up times are possible even at high motor outputs.

After run-up has occurred, for starter slip ring motors, with the aid of an automatic brush lift-off device (option) it is possible to short-circuit the rotor circuit and lift the brushes off of the slip rings. For slip-ring rotors, grid changeovers and grid interruptions must be avoided.

Structural description

4

Cast construction (to height to shaft centre 710 mm)

The motor series to height to shaft centre 710 mm, is based on a modular design principle.
The construction consists of the following parts: A cast housing for accommodating the laminated stator core, two pot bearing plates of grey cast iron and two bearing heads. These construction elements are bolted axially, one below the other. A contiguous centring of the assemblies relative to each other means that a gap inspection is not necessary, even after dismounting. Guides arranged radially assure a precisely tangential positioning of the bearing plates with the stator housing, after dismounting.
The laminated stator core is fixed in place in the housing via a press fit, and subsequently wound.
In model IM V1 the drive-side pot bearing plate has an integrally cast flange for set-up of the motor.

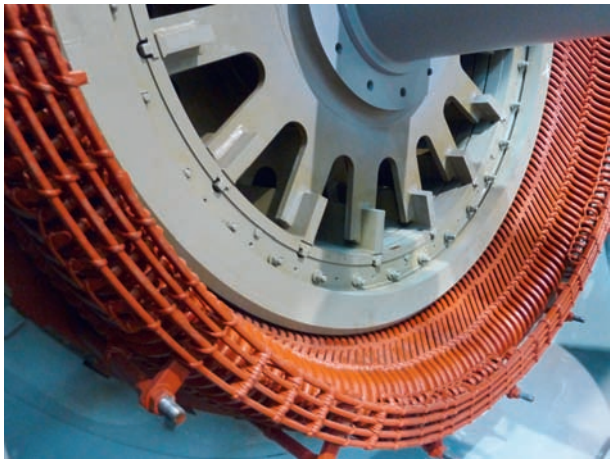
Welded construction (from a height shaft centre of 800 mm)

The stator housing consists of a welded construction. The bearing plates are designed as discs and they accommodate the bearing heads. The laminated stator core is shrink-fit into the stator housing. A feather key is used to accommodate the short-circuit torque.
A contiguous centring of the assemblies relative to each other means that a gap inspection is not necessary, even after dismounting.

Stator winding

The three-phase, two-layer winding rests in the open slots of the bundle of laminations. The complete former wound coils are manufactured of flat copper wire insulated with mica film.
The main insulation of the coils consists of low-binder mica glass-fabric tapes. To avoid corona discharges, a low-ohm protective mica coating is applied in the slot part, and a high-ohm protective mica coating is applied on the slot outlet.

The completely insulated coils are fixed in place in the slots via slot closures. The switch connections are brazed. The stator winding is impregnated via epoxy resin under vacuum pressure (insulating system VEMoDUR® VPI-155).

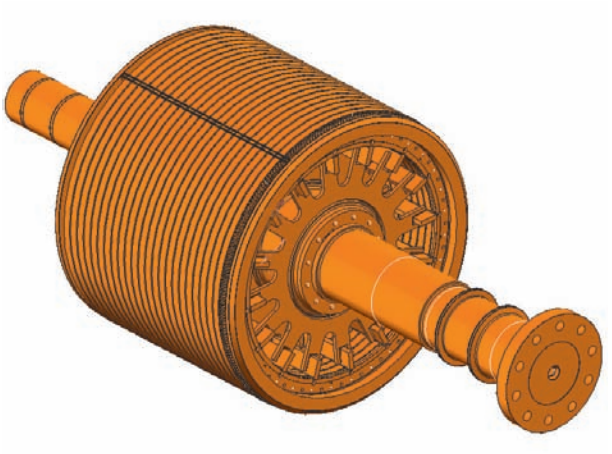


Rotor construction

Depending on the machine size the rotor is constructed as solid shaft or welded spline shaft. The laminated rotor core consists of dynamo sheet blanks or overlapped layered dynamo sheet segments. The stack of sheets is braced axially through round billets.

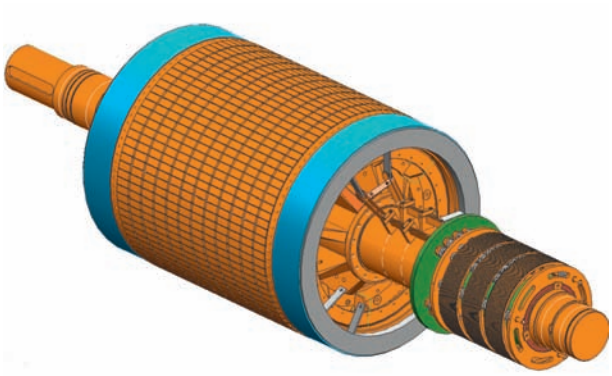
Short circuit rotor

Without exception bar rotor windings are used. The copper or copper alloy rotor bars are axially soldered to the short-circuit rings inductively. If mechanically required, 2-pole rotors, are additionally designed with non-magnetic shrink rings or the connection to the short circuit bar is established with the short circuit disc through special wedging.



Slip ring rotor

The rotor winding consists of a two-layer rotor winding is impregnated with epoxy resin through vacuum pressure (insulation system VEMoDUR®-VPI-155).
The winding heads are intercepted through glass bandages to protect against centrifugal forces. The winding ends are routed to the slip ring bolts. The slip rings are designed free-flying on a hub and are reciprocally insulated through porcelain insulators. The slip rings themselves are made of stainless steel. Thanks to spiral-shaped slotting of the running surface, the cooling effect is increased, at the same time the slots keep the running surface of the brush clean.



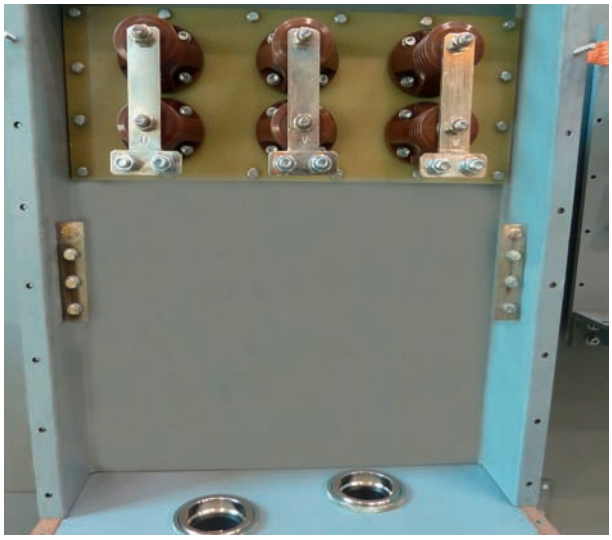
Winding connections

Junction box for stator

The junction boxes are executed with an IP 55 protection rating. The divided junction box consists of a welded construction and has a pre-determined break point in the lower part for pressure relief in the event of a short circuit.

The position of the junction box for model IM B3 is possible either on the right or left.

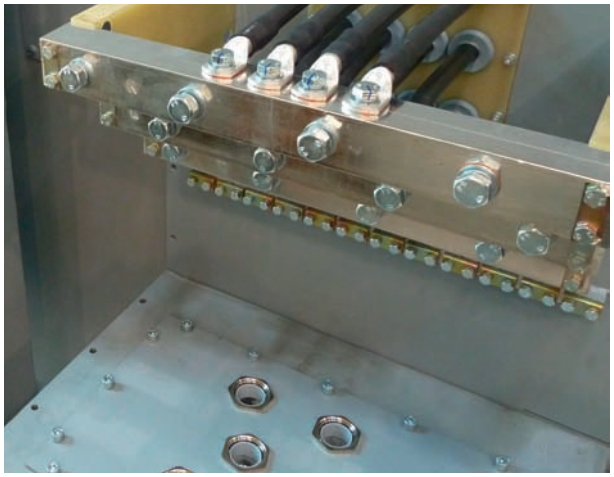
If not otherwise agreed, the cable entry is from below. In the basic design, junction boxes are available for voltage levels 6 kV and 10 kV to 400 A and 800 A respectively.
The neutral point can be routed out into a second junction box on the opposite side.
Special designs with current converters, surge protection, and increased short-circuit resistance to 50 kA for up to 0.3 s are possible.



Example of a rotor junction box

Junction box for rotor connection (≤3 kV)

The rotor junction box consists of a welded construction and is designed for a protection rating of IP 55. The connection cables are routed on busbars. The busbars are connected with the brush bridge through cables.



Example of a rotor junction box

Bearings

Roller bearing

The motor bearings are attached based on the principle that the fixed bearings are arranged on the drive side (D-side) and the floating bearings are arranged on the N-side.
The standard design is the design with deep-groove ball bearings on each side; the deep-groove ball bearing is pre-tensioned with compression springs.
For machines starting with height to shaft centre 710 mm, on the D-side a double bearing (fixed bearing), consisting of a cylindrical roller bearing and a deep-groove ball bearing, is arranged; the N-side only has one cylindrical roller bearing.
The fixed bearing accommodates any axial forces that occur. The mathematical nominal service life (L_{h10}) of the bearing is ≥ 50,000 hours.
Designs with special bearing arrangements to absorb greater radial and axial forces are possible on request.
In the standard design the bearings are sealed to the inside and the outside through gap-type seals. They are maintenance-free and they protect against ingress of dust and spray water.
For special implementation conditions, designs with labyrinth seal or double labyrinth seal are possible.

Initial lubrication of the bearings with lithium-saponified grease in accordance with DIN 51825 occurs in the plant.

To avoid excessive lubrication of the bearings, all bearings are fitted with a grease quantity regulator. In the bearing housing old grease is separated via LAG baffle plate and centrifugal discs. The old grease is removed via a grease collector in the outer bearing cover.

The bearings can be re-lubricated through lubricating nipples.

The bearings can be re-lubricated without interrupting motor operation. The appropriate re-lubrication intervals and quantities are specified on an instruction plate adjacent to the lubricating nipple.
Starting at height to shaft centre 500 mm, all motors have an insulated bearing on the N-side to prevent harmful bearing currents. On request the smaller sizes can also be designed with an insulated bearing.

Slide bearing

The slide bearings are designed as centre-flange or side-flange bearings and are bolted onto the centring element of the bearing plate.

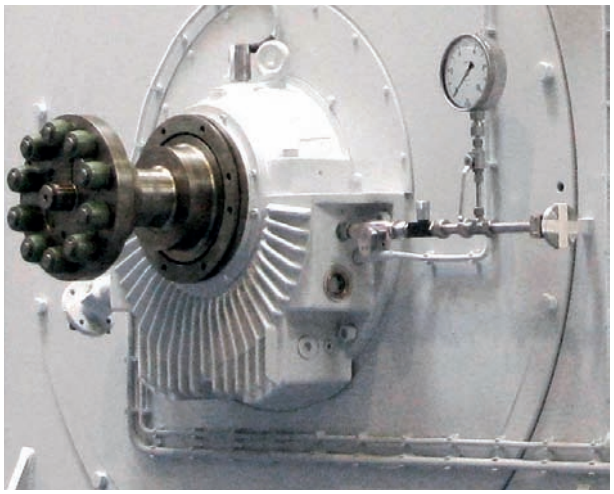
The bearings have a housing that is divided horizontally, a divided bearing shell cast with bearing metal, a lubricating ring and various seals. In its basic version, the bearing has an IP 44 protection rating.

Higher protection ratings (IP 54) are achieved through additional seals.

The slide bearings are normally designed as floating bearings, and do not absorb axial forces.
They can be delivered in many different designs depending on the respective requirements, for example with ring oil lubrication, flushing oil lubrication, hydrostatic shaft lift, water cooling, insulation, as well as fixed bearings.

On request, oil systems that may be required can be offered.

Motors of model IM V1 have a combined pressure bearing and guide bearing on top. On the bottom they are equipped with a guide bearing. On customer request, the arrangement of supporting bearing and guide bearing on the bottom, as well as a second guide bearing on top can be implemented.

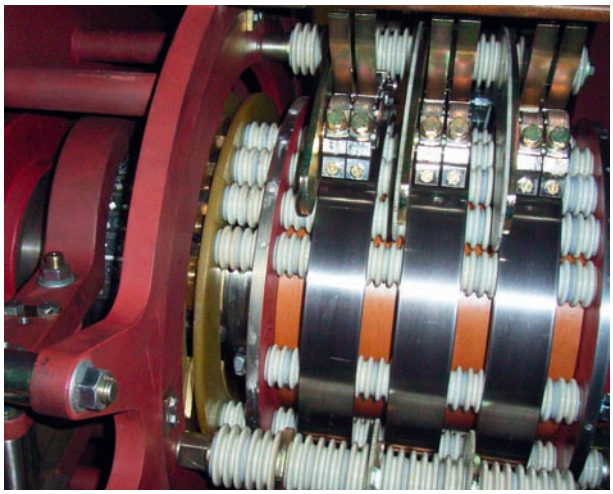


Short circuiting and brush lift-off device

Slip ring motors starting at height to shaft centre 400 can be equipped with a short-circuit and brush lift-off device.

A short-circuiting and brush lift-off device is used to operate a slip ring motor as a short-circuit rotor motor after run-up occurs.

For the motor design with short-circuiting and brush lift-off device, the winding ends of the rotor winding are routed to a special slip ring that has a brass segment on each phase. These brass segments are short-circuited via a short-circuiting hub, that is arranged axially on the motor shaft so that it slides, and it has flexible contact pieces. The brush bridge has brush holders that can be lifted off of the slip ring via levers. The short-circuiting and brush lift-off device is driven by a worm gear motor arranged laterally on the motor. Two inductive sensors supply the signals for the controller of the short-circuiting and brush lift-off device, which must be arranged externally.



Short-circuiting and brush lift-off device

Cooling

Interior air guidance

The interior air circuit is driven by radial or axial fans arranged on the shaft. The air is guided either axially or radially depending on motor size and rotational speed.
When using radial fans with independent direction of rotation, you must pay attention to increased noise emissions and lower efficiency.

Air-water cooling (IC 81 W)

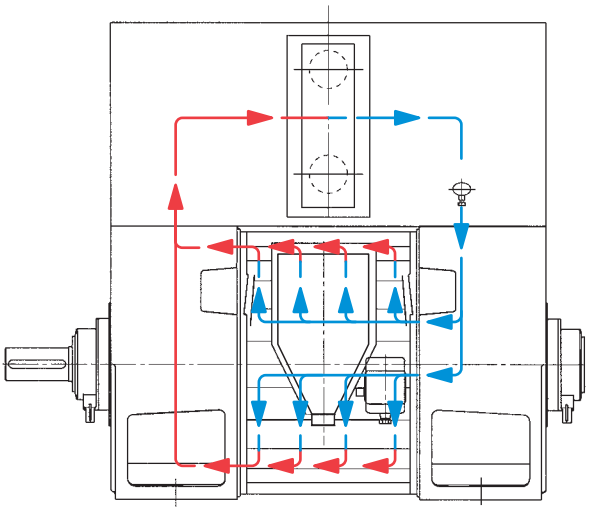
With air-water cooling, the motor exhaust air flows through a hood that is designed as a welded construction The air-water heat exchanger is arranged as an insert element in the hood. It is designed as a finned-tube heat exchanger. The material selected for cooling tubes and water chambers is based on the quality of the cooling water. Double-tube coolers can be used for special applications. The interior cooling circuit must be separated from the environment through sealing measure in accordance with the degree of motor protection.

Thus the motors are suitable for set-up in media, whose air is not sufficiently clean for cooling, or where the machines must be protected against external influences, such as weather or atmosphere.

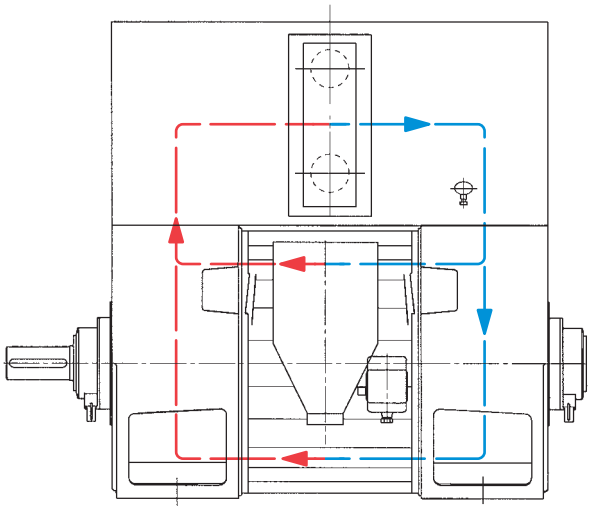
Redundant cooler designs, as well as water-side regulators and monitors of the water and air can be implemented on request. A leak detector is available for cooler monitoring.

Likewise, integration of acoustic insulation measures in the recirculated air housing is possible.

For air-water cooling, the interior coolant circuit can also be driven by a separate ventilation unit in the cooler hood. Through this measure the motor satisfies the cooler type IC 8 A6 W7 requirements and is suitable for variable rotational speeds.



Radially ventilated motor with air-water cooling



Axially ventilated motor with air-water cooling

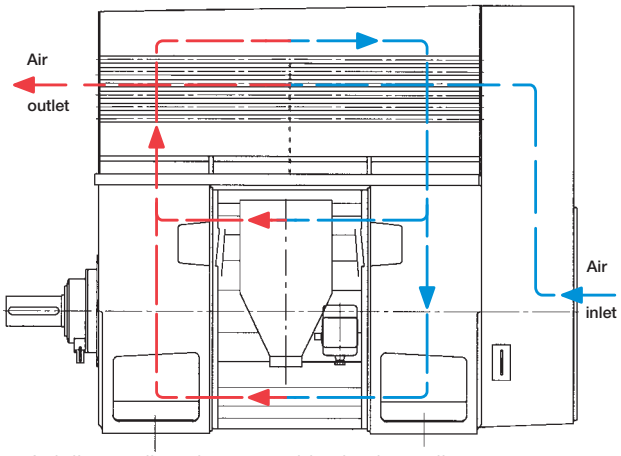
Air-air cooling (IC 611)

With air-air cooling, the motor exhaust air flows through a hood that is designed as a welded construction In this hood there are aluminium tubes that are rolled into the facing sides of the hood on their ends. This structure forms the air-air heat exchanger. The motor exhaust air flows around the aluminium tubes in this process it is re-cooled through the secondary air flow within the tubes. The secondary air flow is displaced by an N-side fan arranged on the motor shaft.

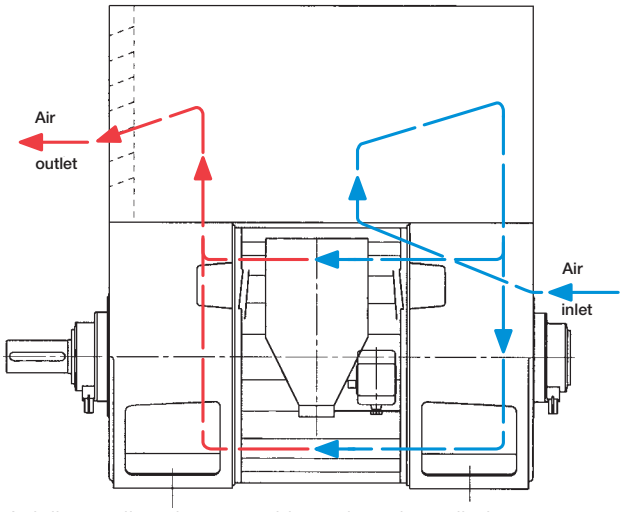
The secondary fan is covered by a hood with intake opening. The interior cooling circuit must be separated from the environment through sealing measures in accordance with the degree of motor protection. With the air-air cooling the interior cooling circuit and the secondary air flow are driven by separate ventilation units. Through this measure the motor satisfies the cooler type IC 8 A6 A6 requirements and is suitable for variable rotational speeds.

Enclosed ventilation (IC 01)

With the enclosed ventilation, the cooling air is suctioned in via a hood. The motor exhaust air, sealed off from the motor intake air, is blown out of the same hood on the D-side. The hood is designed as a welded construction. It is used to separate the air flows between warm air and cold air. Enclosed ventilation can be used in cases where the ambient air is suitable for machine cooling. Through the use of a separate ventilation unit for the cooling air flow, the motor satisfies the cooling type
IC 0 A6 A6 requirements and thus it is suitable for variable rotational speeds.



Axially ventilated motor with air-air cooling



Axially ventilated motor with enclosed ventilation

VEMoDUR insulation system

VEMoDUR insulation system

The operational reliability of electrical machines is crucially determined by the quality of their winding insulation. Technical solutions that comply with international standards in their quality parameters and thus ensure products with high reliability and a long service life, are and have been characteristic of the insulation technology from VEM at all times. The VPI technique is used for the insulating elements of high-voltage machines in all capacity ranges.
The associated insulation system

VEMoDUR

has been developed in the Sachsenwerk and tested in accordance with [1]. Due to decades of operational experience, it is also available as a reference system for future comparative functional evaluations in accordance with [2]. The components of the insulation system, consisting of winding insulation and main insulation with a high mica proportion, as well as epoxy resin, are optimally matched. During the impregnation process, the insulation is subject to a continuous monitoring system; characteristic values, such as:

- Viscosity of the resin
- Impregnation and curing temperature
- Pressure holding times
- Underpressure and overpressure, as well as
- TE level measurements

are verified and documented. The curing of the insulation is occurs with rotation.

The VPI process guarantees high mechanical strength of the winding heads, in particular and outstanding dielectric strength. This particularly applies for the breakdown voltages. Rated surge voltages in accordance with [3] are guaranteed with great security for all generators.

The insulation system is characterised by a high climate resistance, i.e. the winding is not sensitive to moisture and aggressive atmospheres.

In the course of individual tests, electrical intermediate tests and final tests are performed to verify the insulation resistance, including the surgetest and partial discharge test. On customer request, these test steps can be separately agreed and executed.

[1] IEC 60034-18
[2] VEM publication „Long-Term Thermal Stability of the Insulation system VEMoDUR®-VPI-155
[3] IEC 60034-15:2010-02

Explosion-proof motors

Explosion-proof motors

Special regulations and ordinances apply for set-up of motors in areas subject to explosion hazard. Areas subject to explosion hazard can be divided into zones in accordance with EN 60079-10. Equipment, i.e. also the electrical machines must have specific types of ignition protection depending on the zone.

The type of ignition protection is verified in accordance with EC Directive 94/9/EC (ATEX Directive) through testing performed by a recognised testing authority (notified body) that issues an EC type examination certificate or a conformity certificate.
For machines of ignition protection classes Ex nA, Ex pz and Ex tc, in accordance with the ATEX Directive an EC conformity certification is also sufficient.

VEM offers the following types of ignition protection:

For areas subject to explosion hazard with gases or fumes:

- Excess pressure enclosure — Ex px or Ex pz (in accordance with IEC 60079-0 and IEC 60079-2)
- Increased safety — Ex e (in accordance with IEC 60079-0 and IEC 60079-7)
- Non-sparking device — Ex nA (in accordance with IEC 60079-0 and IEC 60079-15)

for hazardous areas with dusts:

- Protection through enclosure — Ex tb or Ex ct (in accordance with IEC 60079-0 and IEC 60079-31)

For machines with rated voltages U_N ≥6 kV a system test for the complete insulation system under an ignitable atmosphere is required for for the ignition protection class Ex e and Ex n. For the insulation system VEMoDUR®-PI-155 the appropriate test reports from the notified body testing authority PTB-Braunschweig are present for 6.6 kV – and 11 kV stator windings.

Quality assurance
Documentation
Shipping, Packaging and Installation
Service

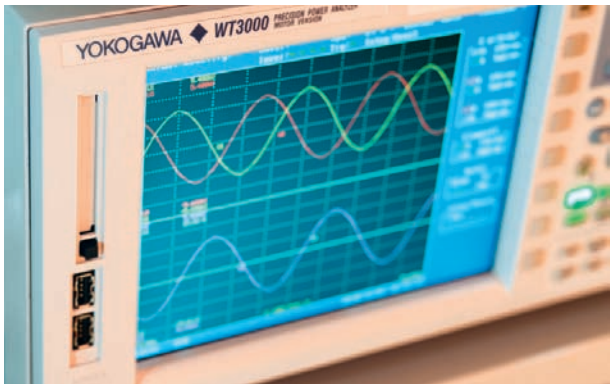
Quality assurance

A uniformly high quality of our products, a high level of customer satisfaction and sustainable processes are part of our corporate policy and are elementary components of our philosophy and behaviour.

VEM's quality management system is an integrated management system, consisting of the certified systems in accordance with IRIS Revision 02 (International Railway Industry standard), in accordance with
DIN EN ISO 9001:2008 and in accordance with
DIN EN ISO 14001:2009.

Our quality assurance organisation monitors the complete manufacturing process of our products, starting with development, extending to goods receipt inspection and the production process, to final test and delivery of the machine. Our more than 50 experts with their know-how, for example in the 3D measurement chamber, are available to us for this.

At the end of the assembly process, every machine is subjected to an internal final test in one of our test bays. The scope of each test is determined from the applicable standards and directives, customer requirements and internal requirements of the various technical departments.
We differentiate between a standard test „routine test" in accordance with IEC 60034-1 and an extended test, „type test".
Depending on the type of project, tests are monitored and approved by classification associations, monitoring authorities or independent third parties. Customer acceptances are possible on request.



In our modern, large machine test bay, load tests are possible with up to 6 MW continuous load in a broad rpm range. The frequency-variable infeed with a voltage range from 400 V to 15 kV permits us to make optimal adaptations to the test requirements of a wide variety of machine designs. Extensive measurement equipment enables us to execute special tests, such as thermal imaging, structure-borne sound measurements or partial discharge diagnostics.

The results of the tests are documented in a test log or test report. With delivery release, each machine gets a 3.1 certificate in accordance with EN 10204 as part of the documentation. The most important test results are summarised in a clear and understandable manner in the certificate.

Documentation

Unless otherwise agreed, the documentation „Operating and Maintenance Manual" contains the documents cited below:

- Safety instructions
- EC Declaration of Incorporation
- Description / technical data
- Dimensional drawing - motor
- Dimensional drawing - cable connection
- Connection diagrams
- Installation / assembly
- Commissioning
- Operation
- Maintenance
- Service
- Spare parts list
- Test certificate / log book
- Supplemental operating manuals (options, third-party suppliers)

Additional documentation must be contractually agreed.

Documentation is provided in two copies with delivery of the product.

It is available in the languages of the European Community.

For additional copies, an extended scope of documentation or translations in other languages, VEM will invoice for the added costs.

Packaging, shipment and installation

The type of packaging depends on the structural design of the machines and the agreed transport and storage conditions.

All packaging requests in accordance with the HPE Directive can be implemented. In this regard cooperation partners are available to us who pack the in their facilities or in VEM's facilities.

Shipping can be executed in assembled as well as disassembled status , depending on dimensions, mass, and contractual conditions. Years of collaboration with special companies guarantees successful transport, even of the most bulky parts.

We recommend having the required installation and commissioning service performed by our specialised personnel.

If the customer executes the tasks on his own or commissions a third party, execution of the tasks must be appropriately documented. This can be documented in chapter 9 of the provided VEM Operating and Maintenance Manual or in another form.

However, liability and warranty on the part of VEM are excluded if this verification cannot be provided.

Service

With delivery of your drive, our customer service organisation is available to you as the point of contact. The team supports you as owner of high-quality machines and systems with a broad palette of service offerings.

Test facility services and contract manufacturing
Due to our modern and high-performance testing technology we are in a position to offer you extensive test facility services such as individual tests, type tests and system tests, as a neutral partner. On request we also execute special tests as part of product developments. Our enterprise has the necessary specialists and extensive experience with test requirements of a wide variety of acceptance organisations in Germany and abroad. We prepare detailed test plans pursuant to your enquiry.

Mechanical analyses for status and fault diagnostics
Knowledge of the current status of technical equipment, as well as knowledge of possible failure prior to the occurrence of damage increase the service life and prevents expensive failure and repair time. In this regard, VEM prepares and evaluates vibration analyses, which in addition to the motors and generators, also include your plant-specific environment.

Installation and commissioning
The increasing complexity of machines and systems, dealing with the on-site conditions and work under high scheduling pressure can only be managed by experienced specialists. Our outside installation team satisfies these requirements worldwide, again and again.
Together with you, we work out procedure plans for your project, act on site with qualified personnel for installation or supervisory tasks, and are at your side with engineering support until successful commissioning. Detailed reports and measurement logs substantiate the quality of the executed tasks.

Technical services
We support you within the framework of the limitation period for liability for defects, and in addition offer you selected service modules to always keep your equipment available after commissioning. Object-based service agreements define the concrete type and scope of our services.
Our team works closely with the internal technical departments, such as calculation and design. Our team can advise you in all questions concerning drive and associated peripheral equipment.

On-call service
You can reach us Monday to Friday from 08:00 to 17:00, holidays excepted. You can make an agreement with us for more extensive on-call service.

Maintenance
Experienced employees are available to you for working out service and maintenance schedules. We would be pleased to handle the necessary tasks on your drives.

Inspection
In the course of inspections, we assess the actual status of your drives from the mechanical and electrical aspects. We determine the causes of abnormal wear, derive necessary consequences and draw up spare parts recommendations. If the machines are operated and maintained as prescribed, a guarantee extension can be agreed.

Repair
As an economical alternative to the new drive, we offer high quality repair and refurbishment of electrical machines, which are usually executed in our plant.

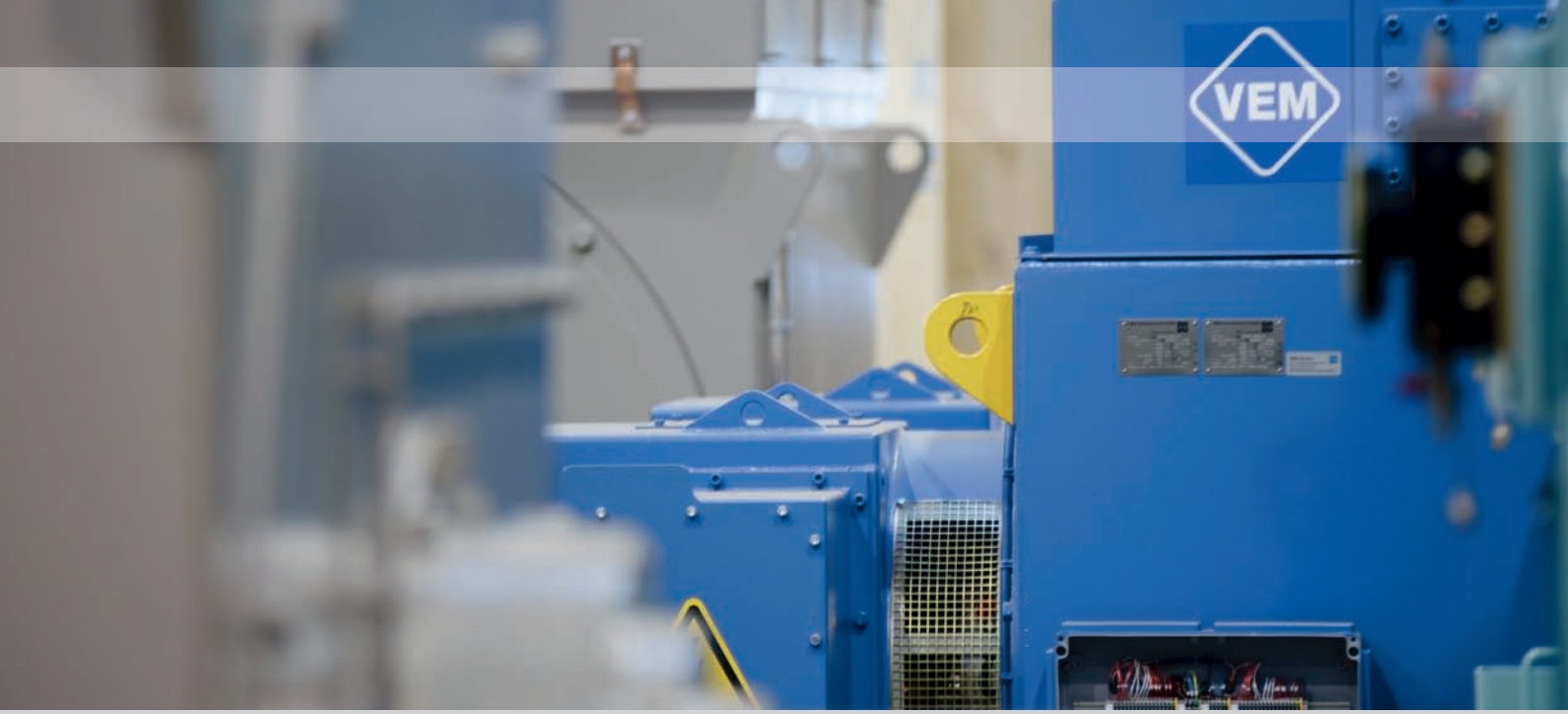
Training
We train your personnel on site or in our plant.

Spare parts supply
Our competent team is your point of contact for all technical and commercial questions concerning spare parts procurement and stocking. A spare parts stock on site is helpful for fast service in the event of damage. In this regard we would be pleased to prepare a suitable recommendation for you. On request we can also keep your spare parts stock in our Dresden plant.

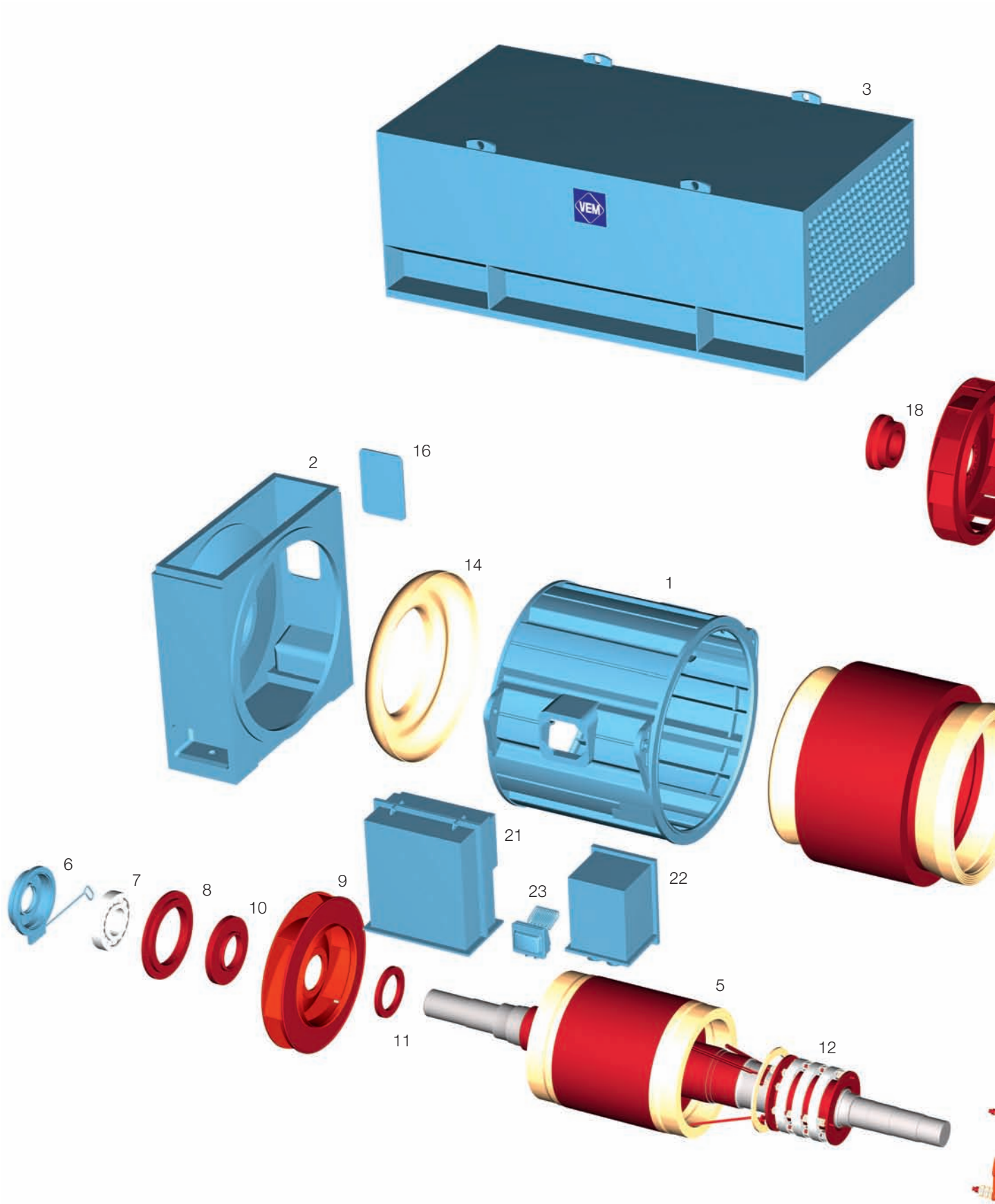
General instructions

If not expressly otherwise requested and offered, the machine/s will be designed as follows:

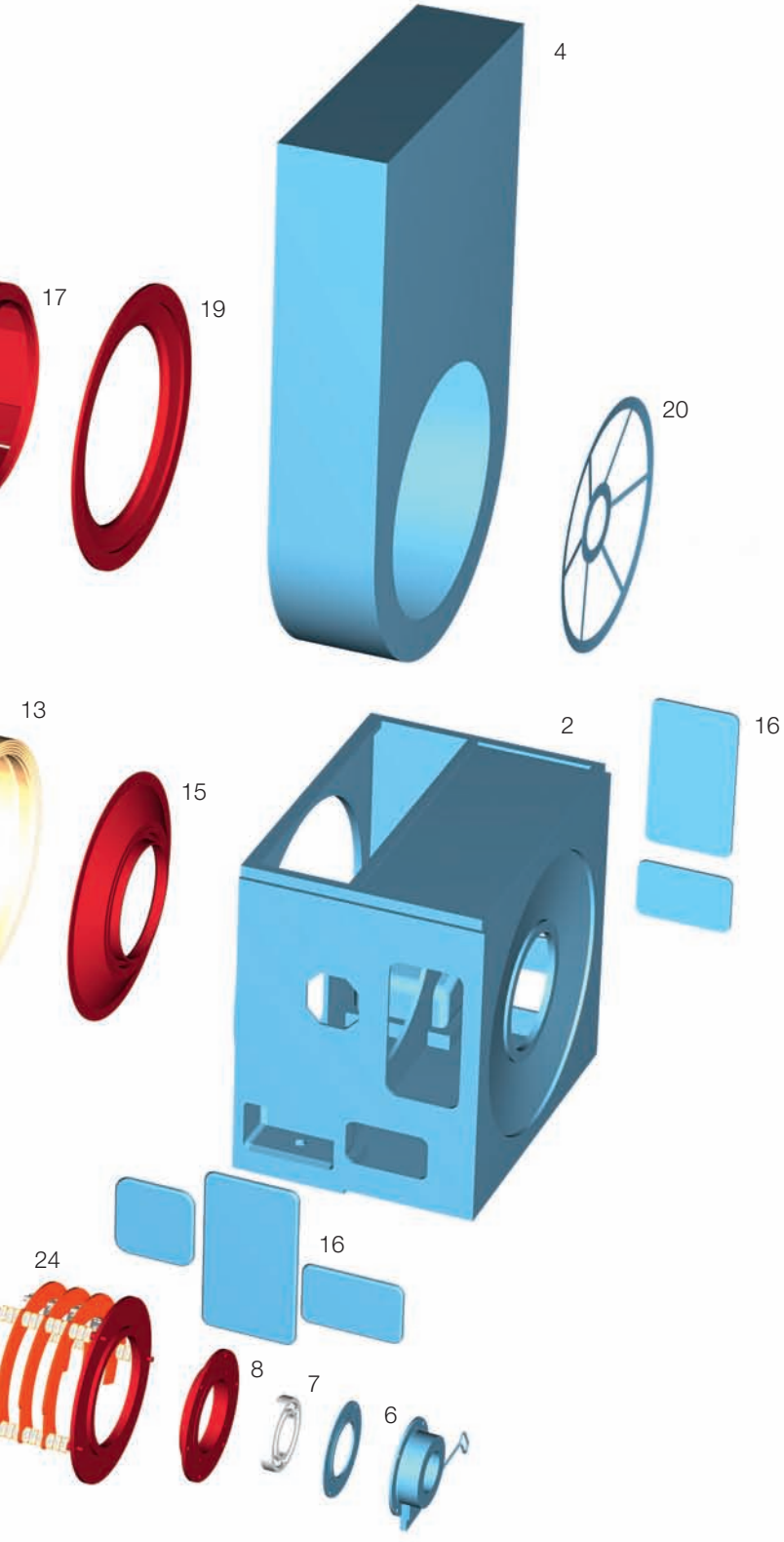
- Manufacturing is executed with the VEMoDUR insulation system.
- The paint finish is executed in accordance with Sachsenwerk standard SW-N 170-004, which is based on DIN EN ISO 12944/31-8 DIN 55928 Part 8+9 and other applicable standards.
- The machine's direction of rotation is right, looking at the drive end (DE). The junction box is arranged on the right.
- The cooler is on the machine and water connection is arranged on the left looking at the drive end (DE).
- Water cooler to the connection flange without water-side monitoring.
- Without cable stuffing box
- PT 100 for winding and bearings in 2-conductor circuit without triggering device, starting at the junction box connection in 2-conductor, 3-conductor and 4-conductor design.
- Mechanical vibrations correspond to the limit values specified in IEC 60034-14 and are verified in the in the VEM test bay.
- Vibration monitoring occurs without analysis device.
- VEM requires the use of an insulated coupling.



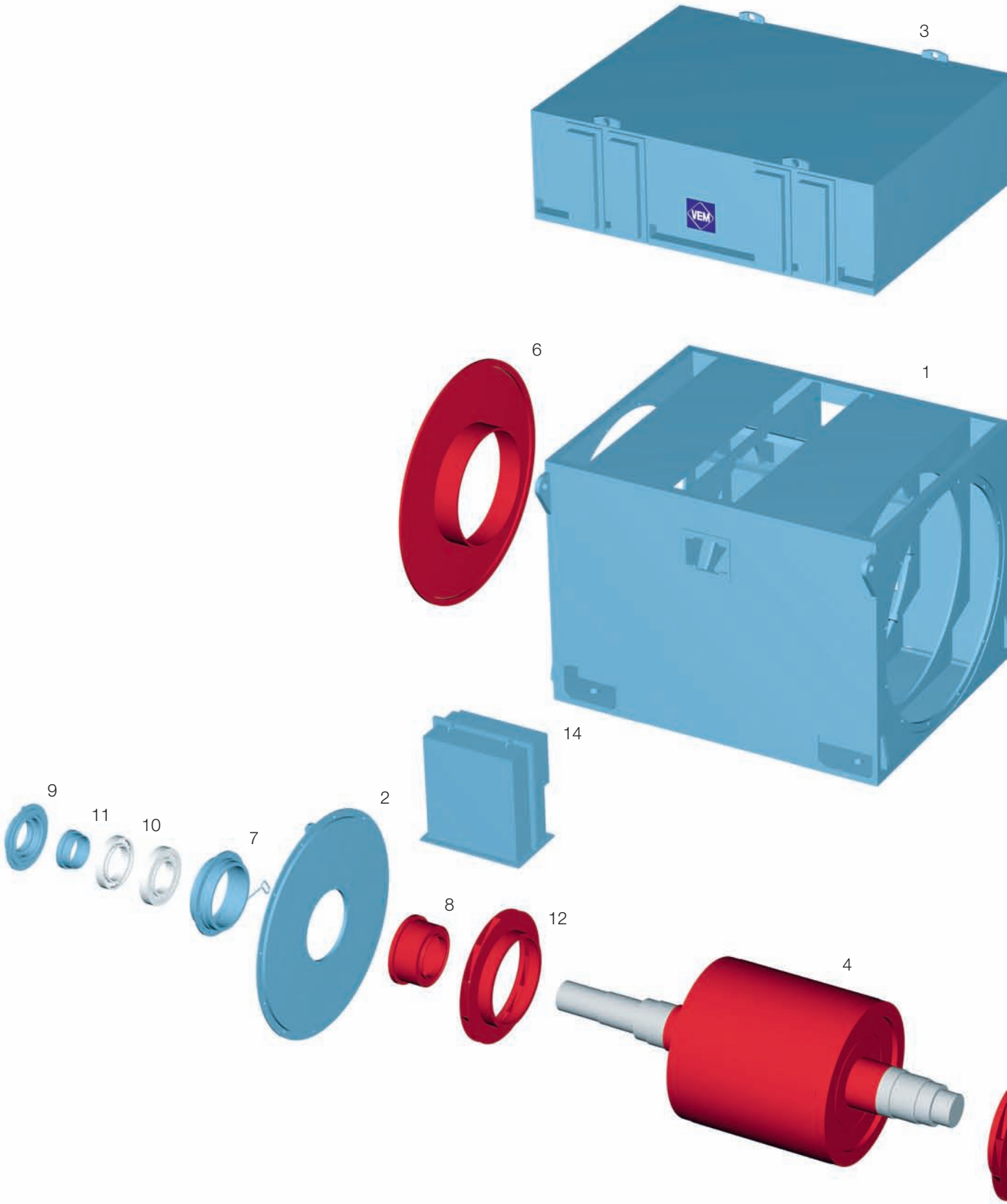
Schematic diagram


3
VEM
18
2
16
14
1
21
6
7
8
10
9
23
22
5
11
12

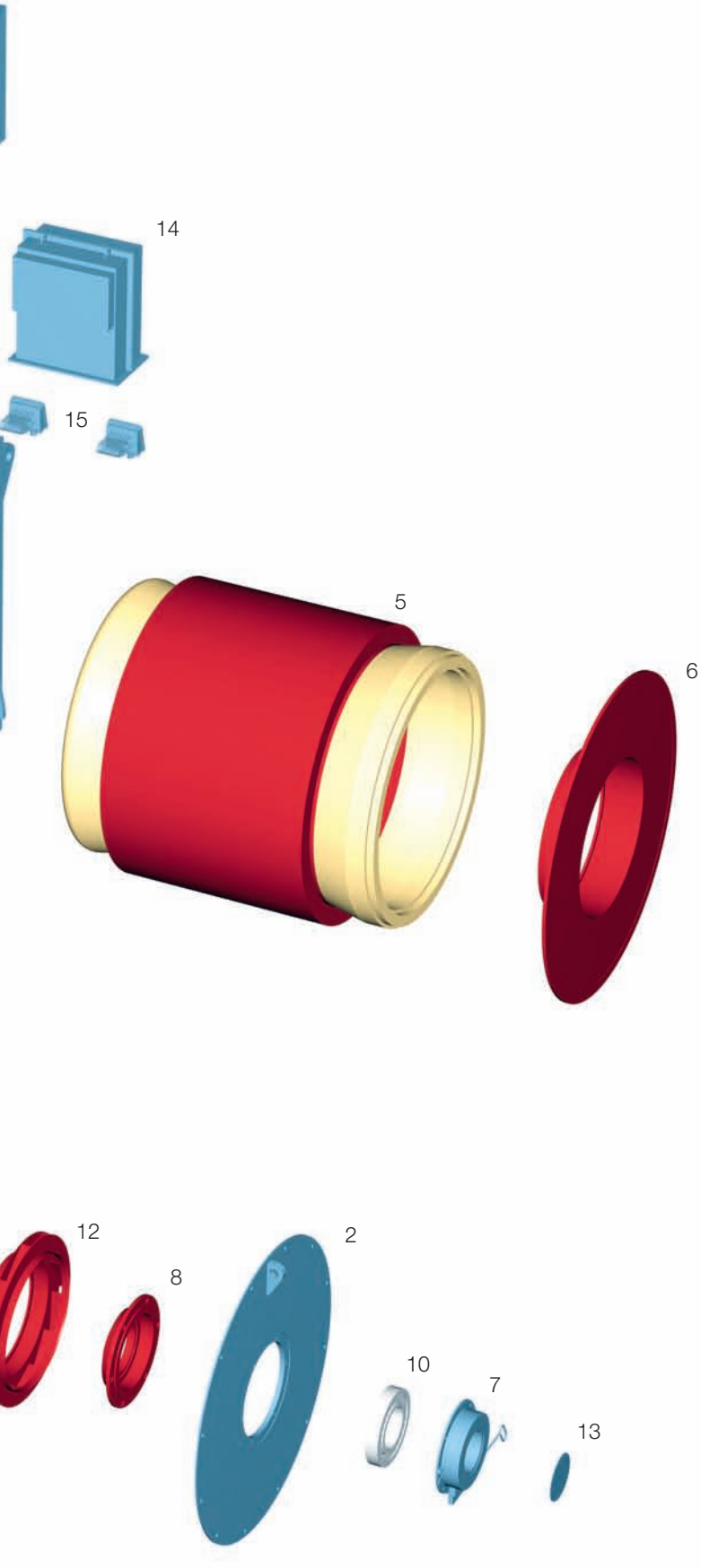
Three-phase high-voltage asynchronous motor with slip ring rotor, air-air cooled, cast-iron housing



1 Housing
2 Bearing plate
3 Heat exchanger
4 External fan housing
5 Rotor with winding
6 Bearing housing with external bearing cover and grease unit
7 Roller bearing
8 Inner bearing cover
9 Interior fan
10 Fan¨hub
11 Balance ring
12 Slip ring body
13 Laminated stator core with winding
14 Air baffle plate
15 Sealing ring
16 Cover
17 External fan
18 Fan hub for external fan
19 Air baffle plate
20 Intake grille
21 Cable junction box (stator)
22 Cable junction box (rotor)
23 Anti-condensation heater
24 Brush bridge


3
6
1
14
9
11
10
7
2
8
12
4

Three-phase high-voltage asynchronous motor with cage rotor, air-water cooled, welded housing



1	Housing
2	Bearing plate
3	Heat exchanger
4	Cage rotor
5	Laminated stator core with winding
6	Air baffle plate
7	Bearing housing with grease unit
8	Inner bearing cover
9	Outer bearing cover
10	Roller bearing
11	Bearing bushing
12	Fan
13	Cover
14	Cable junction box
15	Anti-condensation heater

VEM/04-003 E/0415 printed in Germany. Subject to change.

VEM Holding GmbH

Pirnaer Landstrasse 176
D-01257 Dresden

Telephone: +49 351 208-0
Telefax: +49 351 208-1028

VEM Sales
Specialist division low voltage

Telephone: +49 3943 68-0
E-Mail: motors@vem-group.com

Specialist division high voltage

Telephone: +49 351 208-0
E-Mail: sachsenwerk@vem-group.com

Specialist division drive systems

Telephone: +49 30 9861-2104
E-Mail: transresch@vem-group.com

Detailed information
on our website.

www.vem-group.com