Three-phase asynchronous motors

for low voltage
with squirrel-cage rotor
Product specification

Series K11R, K21R and K22R

Introduction

Electrical drives in their many variations are now in use in every branch of industry. In most processes, they determine by virtue of their characteristics the economy of production. The three-phase asynchronous motors for low voltage from VEM motors GmbH meet the needs of operators with regard to all-round versatility, superior performance parameters, environmental compatibility and high standard of reliability. VEM motors are designed for the whole of European market and offer

- Economical performance, due to high motor efficiencies
- Versatility and reduction of stock due to series version in IP 55 degree of protection (higher degree of protection on request)
- Optional terminal box right-hand / on top / left-hand
- Increased lifetime, reliability and thermal overload capacity by series version insulation class F with thermal reserve (special version insulation class H on request)
- Environmental acceptability due to use of a low-noise bi-directional ventilation system
- Supply option complying with Eastern European standards
- Performance option of a classic IEC/DIN series and a progressive one based on the IEC 72 for attachment dimensions and frame sizes
- Attachment options for components as impulse sensors, tacho-generators, brakes, speed sensors and forced-ventilation units for accomplishment with recent control methods

Standards and regulations

The motors comply with the relevant standards and regulations and specifically with the following:

Title	DIN EN / DIN VDE	IEC
Rotating electrical machines, rating and performance	DIN EN 60034-1/11.95	IEC 34-1 IEC 85
Rotating electrical machines, methods for determining losses and efficiency	VDE 0530 p. 2	IEC 34-2
Totally enclosed three-phase induction motors with squirrel-cage rotor, type IM B3	DIN 42673	(IEC 72)
Totally enclosed three-phase induction motors with squirrel-cage rotor, type IM B5, B35 and B14	DIN 42677	(IEC 72)
Rotating electrical machines, terminal markings and direction of rotation	DIN VDE 0530 p. 8	IEC 34-8
Rotating electrical machines, symbols for types of construction and mounting arrangements	DIN EN 60034-7	IEC 34-7
Rotating electrical machines, built-in thermal protection	-	IEC 34-11
Rotating electrical machines, methods of cooling	DIN EN 60034-6	IEC 34-6
Rotating electrical machines, classification of degrees of protection provided by enclosures	DIN VDE 0530 p. 5	IEC 34-5
Rotating electrical machines, mechanical vibrations of certain machines	DIN EN 60034-14	IEC 34-14
Cylindrical shaft ends for rotating electrical machines	DIN 748 p. 3	IEC 72
Rotating electrical machines, Noise limits	DIN EN 60034-9	IEC 34-9
Rotating electrical machines, starting performance	DIN EN 60034-12	IEC 34-12
IEC standard voltages	DIN IEC 38	IEC 38

Furthermore, VEM motors comply with various foreign regulations which have been adapted to IEC 34-1

NF C 51	France	NBNC 51-101	Belgium
ÖVE M10	Austria	CEI 2-3, V1	Italy
SS 426 0101	Sweden	NEK-IEC 34-1	Norway
SEV 3009	Switzerland	BS 5000 BS 4999	United Kingdom of Great Britain

and the series KPER/K11R are also tested and available according to the regulations of Classification Authorities

Germanischer Lloyd	Det Norske Veritas
Lloyd's Register of Shipping	Russisches Register
American Bureau of Shipping	Bureau Veritas

With these standards and regulations, the following limits for temperature rise are valid:

Regulations	Temperature of cooling air	Permissible limits of temperature rise in K (measured by resistance method) Insulation class				
	°C	A	E	B	F	H
DIN EN 60034-1/ 11.95	40	60	75	80	105	125
IEC 34-1	40	60	75	80	105	125
Great Britain BS	40	60	75	80	105	125
Italy CEI	40	60	70	80	105	125
Sweden SEN	40	60	70	80	105	125
Norway NEK	40	60	-	80	105	125
Belgium NBN	40	60	75	80	105	125
France NF	40	60	75	80	105	125
Switzerland SEV	40	60	75	80	105	125
Germanischer Lloyd	45	55	70	75	100	100
American Bureau of Shipping	50	55	65	75	100	125
Bureau Veritas	50	50	65	70	90	110
Norske Veritas	45	50	65	70	90	115
Lloyds Register	45	50	65	70	95	110
Russ. Register [3)]	40/45	60	75	85	110	125

The series K11R/K10R and K20R/K21R are tested at VDE Prüf- und Zertifizierungsinstitut Offenbach and certified with VDE's EMC-label according to the certificate No. 94057 F.

Progressive correspondence between output and size

VEM three-phase motors with squirrel-cage rotor are available in two type series, both based on IEC 72 as regards dimensions and frame sizes (type co-ordination see tables of Motor selection data). The **K11R / K21R / K22R** series is designed as a classic IEC/DIN series, i.e. fixing dimension and correspondence of output as specified in DIN 42673 / DIN 42677. The **K10R/K20R** series is based on a progressive output correspondence in comparison to these DIN standard. With the same frame size, it offers an output up to two stages higher.
The variations of the output correspondence derived from both series can also be supplied as a special series.

Design versions

Shaft height	Series	Material of Housing	Material of End-shields	Material of Feet	Foot mounting
63 up to 112	KPER / K21R	Grey cast iron			Bolt-on
132 up to 280	K11R / K21R				
315	K11R / K21R				
355	/ K22R				Cast-on
56 up to 100	KPR / K20R				
112 up to 250	K10R / K20R				Bolt-on
280 up to 315	K10R / K20R				Cast-on

Cooling and ventilation

Motors are equipped with radial plastic, sheet steel or aluminium alloy fans which cool the motor, whatever is the direction of rotation (IC 411 according to DIN EN 60034-6).

When installing the motors, care must be taken that a minimum distance from the fan cover to the wall (dimension Bl) is maintained.

Types	Materials		
	Fan	Fan cover	
K21R 56 - 112	plastic[1)]	Sheet steel	plastic [2)]
K21R 132 - 225	plastic	plastic	
K21R 250 - 315L	plastic	Sheet steel	
K21R 315LX2, 4	Cast aluminium alloy	Sheet steel	
K22R 355	Cast aluminium alloy	Sheet steel	
K20R 56 - 100	plastic [1)]	Sheet steel	plastic [2)]
K20R 112 - 200	plastic	plastic	
K20R 225 - 315L	plastic	Sheet steel	
KPER 132/160 EExe II	plastic [1)]	Sheet steel	
KPER 180 - 315 EExe II	Cast aluminium alloy	Sheet steel	
K11R 132 - 160, 180 M4, L6, 8	plastic [1)]	Sheet steel	plastic [2)]
K11R 180 M2, L4, 200	Cast aluminium alloy [4)]	Sheet steel	plastic
K11R 225 - 315	Cast aluminium alloy [4)]	Sheet steel	

[1)] on request at extra charge cast aluminium alloy option.
[2)] option for special versions at extra charge
[3)] 2-pole: unidirectional fan
[5)] sizes 225 up to 315L, 4- and 6,8-pole plastic fans

Vibration behaviour

The permissible vibration intensities of electric motors are specified in DIN EN 60034-14.
The vibration intensity stage N (normal) is achieved or bettered by VEM motors in the basic version. The vibration intensity stages R (reduced) and S (special) are available at extra charge and depending on the type. Please consult the manufacturer.

According to DIN EN 60034-14 the following intensities are recommended:

Vibration intensity stage	Speed range rpm	Limits of vibration velocity (mm/s) in frequency range 10 up to 1000 Hz sizes		
		80 - 112	132 - 200	225 - 400
N (normal)	600-3600	1,8	2,8	3,5
R (reduced)	600-1800	0,71	1,12	1,8
	> 1800-3600	1,12	1,8	2,8
S (special)	600-1800	0,45	0,71	1,12
	> 1800-3600	0,71	1,12	1,8

All rotors are dynamically balanced with the half key inserted. This balancing is documented on the rating plate with the letter H after motor No., balancing with full key inserted on request, designation in then F after motor No.

Bearings / bearing lubrication

VEM motors are equipped with bearings from excellent manufacturers. The bearings have a nominal service life of at least 20.000 h for maximum permissible load conditions. Without additional axial loading, for coupling service the nominal bearing service life is 40.000 h.

The versions
- fixed bearing N-end
- without fixed bearing
- life lubrication
- relubrication device
- heavy bearing arrangement D-end (for increased lateral forces)
- easy bearing arrangement

and the
- bearing schedule
- disc spring and wave washer schedule
- V-Ring schedule
- figures of bearing arrangements
- flat grease nipples

are shown in the bearing arrangement tables. Fixed bearing D-end is possible on request. Any grooved ball bearings have disc springs and wave washers, respectively, thus they are pre-loaded. This is not true for versions with cylindrical roller bearings.

The version ”fixed bearing N-end” is possible for motors ”without fixed bearings”.
Motors with life lubrication are also available with a degree of protection IP 56.

Motor sizes 56 – 160 are fitted with life-lubricated bearings. For motors from size 180, depending on the useful life of grease, bearings must be regreased in good time so that the scheduled bearing service life is reached. Under normal operating conditions, the grease packing will last for 10.000 hours of operation with 2-pole version and for 20.000 hours of operation with versions from 4-pole upwards without being renewed. For motors fitted with relubrication device and working under normal operating conditions, the grease will last for 2.000 hours of operation with 2-pole version and 4.000 hours of operation with 4- and more-pole version. The standard grease is a KE2N-50 type according to DIN 51825.

Use of cylindrical roller bearings

Using cylindrical roller bearings (heavy bearing arrangement), relatively high radial forces or masses can be accepted at the motor shaft end, e.g. belt drives, pinions or heavy couplings.
The minimum radial force at the shaft end must be at least a quarter of the permissible one. Account must be taken of permissible shaft end loading. Both these values are found in the diagrams.

Important to note:
Radial forces below the minimum value can lead to bearing damage within a few hours. Test runs in no-load state are only permissible for a short period.

If the specified minimum radial forces cannot be met, we recommend the use of grooved ball bearings (easy bearing arrangement). Bearing change on request.

Bearing and shaft end loads

Due to the international standardization of asynchronous motors, the dimensioning of bearings and shaft is only variable within close limits, therefore, VEM has selected a design optimum.

Permissible shaft end loads

The size of the permissible shaft end loading is determined by the following principle:

- permissible bending of the shaft
- shaft end fatigue strength
- bearing service life

A nominal bearing service life of 20.000 hours is taken as a basis.

Fig. 1 shows the load diagram.

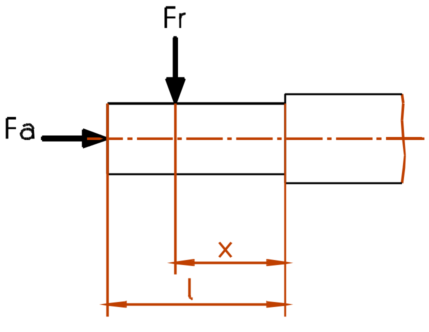

Figure 1
F_r = radial shaft end loading
F_a = axial shaft end loading
l = shaft end length
x = distance of application point of F_r from the shaft shoulder

The type-related data for the permissible axial shaft end load F_a and the permissible radial shaft end load $F_{r0,5}$ (at the application point x : l = 0,5) , $F_{r1,0}$ (at the application point x : l = 1.0), for the basic version and for heavy bearing arrangement and in horizontal and vertical types of mounting are found in the tables.
The given permissible loads are valid for practically vibration-free motor mounting an load action planes according to Fig. 1.

The loads F_r and F_a depend generally on the used transmission members, i.e. on the axial and radial forces arising from these transmission members and their weights.

The calculation of forces is done by using formulas of mechanics, e.g. for belt pulleys:

$$F_r = 2 \cdot 10^7 \cdot \frac{P}{n \cdot D} \cdot c$$

with
F_r = radial force in N
P = motor output in kW (transmission output)
n = nominal motor speed
D = belt pulley diameter in mm
c = pre-tension factor as stated by the belt manufacturer

In practice F_r does not always act at x : l =0,5. The conversion of permissible radial force within the range of x : l = 0,5 up to x : l =1,0 can be done by linear interpolation.

If the calculated shaft loading exceeds the permissible ones, then the drive members must be changed. Among others, this will be:

- selection of a larger belt pulley diameter
- use of V-belts instead of flat belts
- selection of other pinion diameter or skew angle of the toothed wheel
- selection of other coupling versions

Generally, care must be taken that the resulting load application point of F_r is not outside the shaft end.

Noise behaviour

Noise measurement is carried out according to DIN EN 23741/23742 at design output, design voltage and design frequency. In accordance with DIN EN 60034-9, the spatial mean value of the measurement area sound pressure level L_{pA} measured at a distance of 1 m from the machine outline is stated as noise intensity in dB (A).

The A-sound power level L_{WA} across the measurement area dimension L_S (d = 1 m) is also quoted with

$$L_{WA} = L_{pA} + L_S \qquad \text{(dB)}$$

The measurement area dimensions are independent from the machine geometry and are for

		L_S (dB)
size	63 - 132	12
	160 - 225	13
	250 - 315	14
	355	15

The tabular value + 4 dB (A) applies as an approximate value for motors in 60 Hz version. Binding data for 60 Hz are available on request. The noise values for basic types are quoted in tabular form. For special versions, please refer to the manufacturer.

Paint finish

Normal finish

- Adapted for climate group ”moderate” according to IEC 721-2-1
  - Weather-protected and non-weather-protected locations, open-air conditions, short-time up to 100 % relative humidity at temperatures up to + 30 °C, continuously up to 85 % relative humidity at temperatures up to + 25 °C

Finish system
Sizes 56 - 112
- all components except plastic members (terminal box, fan cover) and aluminium terminal box: prime plastic paint, layer thickness ³ 30 µm
- finish coat water-soluble varnish with layer thickness 30 µm up to 60 µm
- Special version 2K-varnish, layer thickness ³ 30 µm

Sizes 132 - 355
- prime coat plastic resin / zinc phosphate, layer thickness ≥ 30 µm
- finish coat 2K-(separate-application) polyurethane varnish, layer thickness ≥ 30 µm

Special finish

- Adapted for group of climates ”world wide” according to IEC 721-2-1
  Non-weather-protected locations, open-air conditions, in aggressive atmospheres (chemical industries, sea environments), short-time up to 100 % relative humidity at temperatures up to +35 °C, continuously up to 98 % relative humidity at temperatures up to +30 °C.

Finish system
Sizes 56 - 112
- prime plastic paint, layer thickness ≥ 30 µm
- finish coat 2K-varnish, layer thickness ≥ 60 µm

Sizes 132 - 355
- prime coat plastic resin / zinc phosphate, layer thickness ≥ 30 µm
- second coat on separate-application base, layer thickness 30 ≥ µm
- finish coat 2K (separate-application) polyurethane varnish, layer thickness ≥ 30 µm

Standard colour:
RAL 7031 blue grey

Further special coating systems
- version for excessive thermal stresses
- version for excessive chemical and radiation stresses
- systems on customer’s request

Shaft ends

According to IEC 34-7, the definition of the motor ends is as follows:

D-end (DS):
Drive end of the motor

N-Seite (NS):
Non-driving end (opposite to the drive end)

Centre holes according to DIN 332, sheet 1 and 2, Form DS.

For sizes 56 – 112, keys and key-ways are according to DIN 6885 sheet 1, Form B, and for the sizes 132 - 355 according to DIN 6885 sheet 1, Form A. Key length for sizes 132 – 355 are according to DIN 748 p. 3 Draft. Dec. 91.

Thread for press-on and dismantling devices:

Shaft end diameter	thread
for 9 mm	M3
for 11 mm	M4
for 14 mm	M5
for 19 mm	M6
for 22 mm	M8
for 24 mm	M8
for 28 mm	M10
> 28 up to 38 mm	M12
> 38 up to 50 mm	M16
> 50 up to 85 mm	M20
> 85 up to 130 mm	M24

The motors are always supplied with the key fitted.

The second shaft end can transmit the full power rating with coupling output. The power transmission capability by belt, chain or pinion drive for the second shaft end is available on request. The drive elements used, such as pulleys or couplings, are to be balanced with a balance grade of at least G 6.3 according to DIN ISO 1940, p. 1, with half key inserted.

Design voltage and frequency

In the basic version, motors are supplied for the following design parameters:

230/400 V Δ/Y	50 Hz
400/690 V Δ/Y	50 Hz
690 V Δ	50 Hz
460 V Δ	60 Hz

The motor can run without changing the design output on mains in which the voltage at the design frequency diverges by ± 5 % from the nominal value (design voltage range A), in these mains the frequency can diverge by ± 2 % from the nominal value.

The above standard voltages according to DIN IEC 38 are taken as the design point.
Special voltages and frequencies on request.

Design voltage range, design frequency range

(special version)

Motors to be used for mains voltage as specified in DIN IEC 38 with the total tolerance of ± 10 % are to be selected according to the corresponding design voltage listed in the technical tables. The design voltage range limited by U_U and U_O is also given there.
When the motors are connected to voltages between 95 % and 105 % of the design voltage range – this corresponds to the mains voltage value according to DIN IEC 38 with ± 10 % - already at the voltage range limits of range A (see DIN EN 60034-1/11.95) and without taking into account the permissible tolerances, the maximum permissible temperature rise of the stator winding may be exceeded by approx. 10 K. For sizes K21R 56 – 112 / K20R 56 – 100, the current at the upper voltage limit U_O is settled at such point, that the motor protective switch does not trip at normal set-up 1,05 x I_N under no-load conditions plus 5 % tolerance.

Design output

The design output applies for continuous operation as specified in DIN EN 60034-1/11.95, at a coolant temperature of 40 °C and an altitude above sea level of ≤ 1000 m, design frequency 50 Hz and design voltage. The series K11R/K21R and K10R / K20R have thermal reserves which permit, depending on types, the following overloads in continuous operation:
- up to 10 % above the rated output at 40 °C coolant temperature or
- rated output up to 50 °C coolant temperature
- rated output at an installation altitude of up to 2.500 m above sea level

These conditions apply only alternatively, when both apply, the output must be reduced. With motors in the marine version, the output is reduced by 5 % for each 5 °C by which the specified coolant temperature is exceeded, as specified in classifications rules; higher outputs on request.

Motor torque

The design torque in Nm given at the motor shaft is calculated by

$$M = 9550 \cdot \frac{P}{n}$$

with P = design output in kW
n = speed in rpm

In the Motor selection data tables, starting torque, pull-up torque and pull-out torque are given as multiples of design torque.
If the voltage deviates from its design point, the torques change about quadratically. The classified characteristics of torque behaviour are given in the Motor selection data tables.

Ambient temperature

All VEM motors in the basic version can be used at ambient temperatures from -35 °C up to +40 °C.

Overload capacity

In compliance with DIN EN 60034-1, all motors can be exposed to the following overload conditions:
- 1,5 times the rated current for 2 min,
- 1,6 times the rated torque for 15 s (1,5 times for $I_A / I_N > 4,5$)

Both conditions apply to design voltage and design frequency.

Design efficiency and design power factor

Efficiency η and power factor cos φ are stated in the Motor selection data lists .

Restarting with residual field and phase opposition

Restarting after mains failure against a 100 % residual field is possible for all motors.

Motor protection

The following motor protection versions are available as an option:
- motor protection with PTC thermistor sensors in the stator winding
- bimetallic temperature sensor as NC contact or NO contact in the stator winding
- resistance thermometer for monitoring the winding or bearing temperature on request

Special duties

Special duty types, as intermittent, short-time duty or electrical braking procedures are possible on request.

Pole-changing motors

Pole-changing motors are according to the load torque characteristics of driven machine designed for
- drives with a constant load torque
- drives with a quadratically increasing torque.

The intended application is stated in the Motor selection data lists. The motors can only be designed for one operating voltage, e.g. 230 V, 400 V or 660 V and are in every case intended for direct starting via the pole sequence. 60 Hz version and special voltages according to IEC 38 are possible.

Pole-changing is achieved by
- two separate windings in the stator, e.g. 6-4pole
- one winding in Dahlander circuit, e.g. 8-4pole
- two separate windings, both in Dahlander circuit, e.g. 12-8-6-4pole

Whereas with the winding in a Dahlander circuit, it is only possible to have a speed ratio of 1:2 , two separate windings offer other speed variations, but with lower outputs in relation to the basic version, correlation between output an dimensions on request. Y or Δ circuits are used for two separate windings, Δ/YY or Y/YY for winding according to Dahlander principle.

The following circuits are obtained with the individual variations in the number of poles:

Number of poles	Connection	Basic version
4-2, 4-2L	Δ/YY,Y/YY	4pole[1)]
8-4, 12-6	Δ/YY	6pole
8-4L, LF	Y/YY	4pole
6-4	Y/Y, Δ/Δ	6pole
6-4LF, 6-4L	Y/Y, Δ/Δ	4pole
8-4-2	Y/Δ/YY	6pole[1)] up to K11R 160M
8-4-2	Y/Δ/YY	4pole[1)] up to K11R 160L
8-6-4	Δ/Y/YY	6pole
12-8-6-4	Δ/Δ/YY/YY	6pole

[1)] From K11R 132 / K10R 112, these motors have the 2pole ventilation system.
[2)] not always for K21R 63 – 112 / K20R 56 - 100.

Star circuit for the highest pole number (lowest speed) is possible, if the operation circuit is Δ.
Other pole number combinations are also available.
The same type range of pole-changing motors are available in the design version K10R/K11R and K20R/K21R without extra charges.

Tolerances - electrical parameters

According to DIN EN 60034-1/11.95 the following tolerances are permissible:

Efficiency (indirect calculation)	-0,15 (1-η) for $P_N \leq 50$ kW -0,1 (1-η) for $P_N > 50$ kW
Power factor	$\frac{1-\cos\varphi}{6}$ at least 0,02, maximum 0,07
Slip (at rated load and operating temperature)	± 20 % for $P_N \geq$ 1kW
Starting current (in the planned starting connection)	+ 20 % without restrictions downwards
Starting torque	- 15 % and + 25 %
Pull-up torque	- 15 %
Pull-out torque	- 10 % (after the application of this tolerance M_K/M at least 1,6)
Moment of inertia	± 10 %
Noise level (sound pressure level)	+ 3 dB (A)

These tolerances are permissible for the values assured for three-phase asynchronous motors, taking the necessary manufacturing tolerances and material variations of the raw material into account.

The standard contains the following notes on this:

1. A guarantee for all or any of the values shown in the table is not mandatory. In tender, the guaranteed value for which permissible deviations should apply must be expressly specified. The permissible variations must correspond to those stated in the table.
2. "Guarantee": In some countries, a distinction is drawn between guaranteed values and typical or declared values.
3. If a permissible deviation applies only in one direction then the value in other direction is not limited.

Tolerances - mechanical parameters

Dimensional short sign acc. to DIN 42939	Meaning of the dimension	Fit or tolerance
a	Spacing of feet fixing holes in axial direction	± 1 mm
a_1	Diameter or width across corners of attachment flange	- 1 mm
b	Spacing of feet fixing holes across axial direction	± 1 mm
b_1	Diameter of flange spigot	up to diameter 230 mm j6 up to diameter 250 mm h6
d, d_1	Diameter of the cylindrical shaft end	up to diameter 48 mm k6 from diameter 55 mm m6
e_1	Pitch circle diameter of attachment flange	± 0,8 mm
f, g	Maximum width of the motor (without terminal box)	+ 2 %
h	Shaft height (lower edge foot to shaft centre line)	up to 250 mm -0,5 > 250 mm -1
k, k_1	Overall length of the motor	+ 1 %
p	Overall height of the motor (lower edge foot, housing or flange to highest point of the motor)	+ 2 %
s, s_1	Diameter of fixing holes of foot of flange	+ 3%
t, t_1	Lower edge shaft end to upper edge key	+ 0,2 mm
u, u_1	Key width	h9
w_1, w_2	Centre of first attachment hole to shaft end shoulder	± 3,0 mm
	Distance shaft shoulder – flange face, fixed bearing D-end	± 0,5 mm
	Distance shaft shoulder – flange face	± 3,0 mm
	Motor weight	-5 up to +10 %