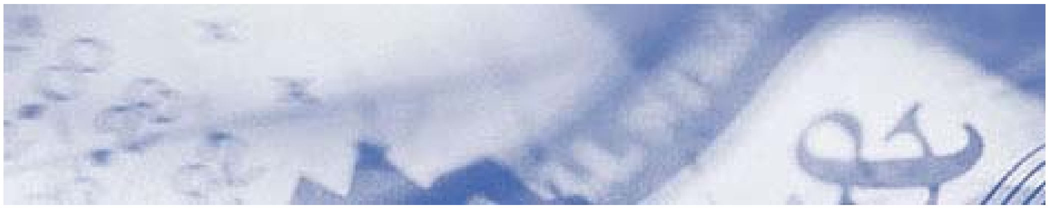

# Motor ABC

# For SIEMENS Low-Voltage Three Phase Motors

5.Edition 2004


Technical revised and translated by:

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# A

## Alternating load

One of the most frequent deviations from the duty types, defined in accordance with VDE 0530 is that the power demanded by the load is not constant during the intervals that the motor is under load. In this case, the power (current, torque) can be replaced by an average power (current, torque). This is the squared average value of the individual loads.

$$P_{mi} = \sqrt{\frac{P_1^2 \times t_1 + P_2^2 \times t_2 + P_3^2 \times t_3}{t_1 + t_2 + t_3}}$$

$$P_{mi} = \sqrt{\frac{P_1^2 \times t_1 + P_2^2 \times t_2 + p_3^2 \times t_3 \ldots}{t_1 + t_2 + t_3 \ldots}}$$

The maximum torque which occurs in this case may not exceed 80% of the stall torque. If the required higher power is a factor of 2 higher than the smallest power, then the average power is not accurate enough. In this case, the average current must be used for the calculation.

This average value generation is not possible for an S2 duty type (please inquire).

(also refer to Switched operation)

## Ambient temperature

All motors, in their standard version, can be operated at ambient temperatures of -20 °C to +40 °C.

Further, standard motors can be operated with a cooling medium temperature of up to 55°C and utilized according to temperature rise Class F. For motors with options C11, C12 and C13, the winding is already utilized to temperature rise Class F. However only one option is permitted and it may not be fed from an AC drive.

The motors have temperature rise Class F and are utilized according to temperature rise Class B. If this utilization is to be kept, and if the conditions change, the permissible output must be reduced (de-rated) corresponding to the adjacent table. SD01 automatically takes into consideration these factors and displays the reduced (de-rated) motor output.

| Kühlmitteltemperatur | Reduktionsfaktor |
|---|---|
| 40 ° C | 1,00 |
| 45 ° C | 0,96 |
| 50 ° C | 0,92 |
| 55 ° C | 0,87 |
| 60 ° C | 0,82 |

## Anti-condensation heating

For motors, where there is a danger that moisture condensation will form on the windings as a result of the climatic conditions, anti-condensation heating can be provided for an additional price. The anti-condensation heating increases the temperature of the air inside the motor by 6 to 7K higher than the ambient air temperature. This prevents moisture condensation forming inside the motor. The motors are always ready for operation. It is not permissible that the anti-condensation heater is switched-on during operation.

Version/design: Heating elements are fixed to the winding overhang.

Another possibility is to connect a voltage which is approximately 4 to 10 % of the rated motor voltage at stator terminals U1 and V1; 20 to 30 % of the rated motor current is sufficient to ensure that moisture does not condense.

## Asynchronous generator

If an asynchronous machine is to be operated as generator, then it must be driven above the synchronous speed with a negative rated slip. The reactive current required for magnetization must be externally fed-in for generator operation. There are two possibilities:

Operation in parallel with an existing line supply from which the magnetizing reactive power is drawn and into which the generated active power is fed.

Isolated operation with capacitor excitation. In order to keep the voltage constant, a saturation reactor is required. For standard three-phase motors, de-rating is required especially due to voltage stability.

## Axial eccentricity

Tolerance N (normal) and tolerance R (reduced) are defined in DIN 42 955:

1. Radial eccentricity tolerance of the shaft end
2. Concentricity tolerance of the shaft end and the flange centering
3. Axial eccentricity tolerance for the shaft end and the flange surface

Regarding 3) Axial eccentricity tolerance for the shaft end and flange surface

| Mounting flange acc. to DIN 42 948 | | | Axial eccentricity tolerance for machines with | |
|---|---|---|---|---|
| Outer diameter a1 | | | Tolerance N (normal) | Tolerance R (reduced) |
| 80 | to | 140 | 0.08 | 0.04 |
| 160 | to | 300 | 0.10 | 0.05 |
| 325 | to | 550 | 0.125 | 0.063 |
| 660 | to | 800 | 0.16 | 0.08 |
| 1000 | to | 1150 | 0.20 | 0.10 |

(also refer to Radial eccentricity, Concentricity)

# B

## Balancing

After they have been manufactured, the rotors of Siemens standard motors are dynamically balanced with a half key.

This involves positive balancing, i.e. additional weights are attached. The VDI Directive 2056 and DIN ISO 2373 are fulfilled when this balancing method is used.

Guidelines/Directives and Standards to restrict the vibration severity were applied for the following reasons:

1. Component of noise generated by motors (environmental protection).
2. Reduction of the bearing lifetime as a result of mechanical bearing vibration.
3. Operating quality of the driven machines and equipment, e.g. machine tools
4. It is questionable whether disturbance-free operation is at all possible, e.g. as a result of inadmissible rotor movement (vibration amplitude) when passing through resonant frequency ranges, release of friction-locked connections due to vibrational forces etc.
5. Physical and physiological stress on human beings

(also refer to Vibration severity, Vibration displacement)

## Bearing design

The bearing design is especially important for perfect motor operation. The roller bearings used for the individual motor frame sizes can be taken from the tables showing the bearing assignment in the appropriate sections of Catalog M 11.

In order to be able to fulfill the requirements of state-of-the-art drive technology, Siemens standard motors have no-play, and are equipped with pre-loaded deep-groove ball bearings on the drive end. They can be installed in motors and are equipped with IM B3 and IM B5 in IM B6, IM B7, IM B8, IM V5, IM V6 or IM V1 and IM V3. They guarantee long lubrication intervals, low noise, low vibration operation and a nominal bearing lifetime of at least 40000 operating hours for coupling output. For drives with belt output, the deep-groove ball bearings can be replaced by roller bearings.

## Belt drive

The belt drive is used to couple 2 parallel shafts – the motor shaft with the shaft of the driven machine. It is also possible to change the speed by appropriately selecting the ratio between the two pulley diameters.

The belt must be pre-tensioned so that it can transmit the circumferential force through friction. The pre-tension factor states how much higher the actual tension load is than the circumferential force (cantilever force).

Today, flat belts are almost always manufactured out of plastic with an adhesive surface coating (e.g. chrome leather). The pre-tension factor lies between approx. 2 and 2.5.

For V belts the pre-tension factor is approximately 1.5 to 2.5.

The belts must be able to transmit the power at the specific circumferential velocity. The belt thickness and width are appropriately dimensioned. The belt supplier specifies the pre-tension factor. The preferred circumferential velocity for flat belts is about 35 m/s and for V belts, about 25 m/s.

Steel belt pulleys should be used for circumferential velocities exceeding 26 m/s due to the centrifugal force which occurs.

The existing cantilever force (belt tension) must be compared with the cantilever force permissible for the particular motor in order to select the correct motor size.

(also refer to Cantilever force)

## Brakes

The following braking methods are generally used for asynchronous motors:

### Mechanical braking:

This is generally realized using a mechanical brake mounted on the motor (brake motor). Shoe brakes are predominantly used for crane drives. These are released using a centrifugal brake operator.
The motor is not electrically stressed.

### Plug braking (also known as braking by reversal):

In this case, the drive is braked using the rotating field which, after changeover rotates in the opposing direction to the rotor.

### DC current braking:

The drive is braked using a DC current which is injected into the stator winding which is isolated from the line supply. The magnitude of the DC voltage depends on the required braking torque and the phase resistances of the motor.

### Capacitor braking:

This is a version of DC current braking. A capacitor is connected to the line supply through a small rectifier which keeps it continually charged. When the motor is powered-down, the capacitor is switched across the winding and generates a field which significantly brakes the motor. This technique is not often used.

### Short-circuit braking:

The motor terminals are isolated from the line supply and short-circuited. The magnetic field, generated by the high short-circuit current which flows, brakes the motor.

### Regenerative braking:

In this case, the motor operates as a generator and regenerates into the line supply. This type of braking is mainly used for vehicles as braking is only possible up to a maximum of the synchronous speed.

All of the electrical braking types listed above have the advantage over mechanical braking systems that they operate wear-free. Their disadvantage is that the motor is thermally stressed and only acts while the motor is actually spinning (electrical braking cannot be used as a holding brake).

(also refer to Plug braking)

## Brake lining wear

The energy WB, when braking, increases the temperature of the brake and results in brake lining wear. The brake manufacturer does not know the braking energy for each braking operation in a particular application. This is the reason that the brake manufacturer specifies the thermal and mechanical limits of the brake as a sum of the possible braking energy in nm. These include:

The lifetime of the brake lining

The intervals at which the air gap between the brake lining and frictional surface must be adjusted

The maximum possible braking energy per hour

The maximum braking energy for each braking operation

For these limits, the user is most interested in the maximum number of braking operations. This can be obtained by dividing the braking energy for each braking operation (WB).

The braking energy per braking operation:

The braking energy WB comprises the energy of the moment of inertia WKin to be braked and energy WL, which must be expended in order to brake against a specific load torque:

WB = WKin + WL (Nm)

a) Energy in the moment of inertia

$$W_{Kin} = \frac{J \times n^2}{182{,}4} (Nm)$$

n = motor speed before braking (RPM)

J = total moment of inertia (kgm²)

In order to obtain the total moment of inertia, all moments of inertia, before they are summed, must be referred to the motor speed nN:

$$J_{bez} = J \times \left(\frac{n}{n_N}\right)^2$$

b) Energy when braking against a load torque:

$$W_L = \frac{\pm M_L \times n \times t_{Br}}{19{,}1} (Nm)$$

| | | | |
|---|---|---|---|
| ML | = | load torque: | positive, if it opposes braking<br>negative, if it supports braking |
| tBr | = | braking time | |

## Built-in motors

Built-in motors generally comprise a stator assembly with winding and the rotor assembly without shaft. Furthermore, an external fan and rating plate can also be supplied.

The built-in motor can be directly mounted in the load to be driven. In order to achieve the specified operational performance, the standard cooling conditions must be maintained. Built-in motors can be supplied in higher unit quantities and also in special versions, e.g. with shaft according to a customer's drawing and freon-resistant winding.

# C

## Cantilever force - Radial force

This force acts transversely at the centerline of the motor shaft end.

The cantilever force for belt drives is calculated from the circumferential force multiplied by the pre-tensioning factor which depends on the mechanical arrangement.

The permissible cantilever forces for the individual motor frame sizes and speeds are specified in Catalog M1.

The permissible cantilever force can be increased for motors with deep-groove ball bearings by replacing the drive end bearing by a cylindrical roller bearing.

(also refer to Belt drive)

## CEMEP definition

CEMEP = European Committee of Manufacturers of Electrical Machines and Power Electronics

Involves pole numbers 2 and 4

Output range from 1.1 kW to 90 kW

Eff 1 High Efficiency

Eff 2 Improved Efficiency

Efficiency is calculated according to IEC 60 034-2

The motors are labeled on the rating plate and the packaging. 4/4 and 3/4 efficiencies are documented. Only manufacturers with the appropriate CEMEP license may stamp their motors.

Differences CEMEP-EPACT

## CEMEP EC project

SIEMENS

### 1.1. EU Project Background

**Background - Introduction of efficiency classes acc. to CEMEP**

- After the example set by the USA with the EPACT law, the EU is now taking the initiative in cooperation with CEMEP[1)] to implement measures for improving the efficiency levels of electrical drives. Motive: To reduce the emission of $CO_2$.
- CEMEP prescribes efficiency classification for 2-pole and 4-pole motors in the power range from 1.1 to 90 kW. Efficiency is subdivided into three classes so that 2 characteristics define the three classes:
  - "eff1" (High-efficiency motors)
  - "eff2" (Improved-efficiency motors)
  - "eff3" (Standard motors)

[1)] CEMEP = European Commitee of Manufacturers of Electrical Machines and Power Electronics; Efficiency determined as before according to EN 60034-2

## Centrifugal test

According to VDE 0530, all motors must be able to withstand 120 percent of the rated speed (if the motor is capable of various speeds, then 120 percent of the highest rated speed).

For motors, which under certain circumstances, can be driven by the coupled driven load, then, unless otherwise agreed, the centrifugal speed must correspond to the runaway speed of the motor-driven load aggregate or at least 120 percent of the highest rated speed.

## Concentricity

Tolerance N (normal) and tolerance R (reduced) are defined in DIN 42 955:

1. Radial eccentricity (also known as concentricity) tolerance for the shaft end
2. Concentricity tolerance for the shaft end and the flange centering
3. Axial concentricity tolerances for the shaft end and the flange surface

Regarding 2)

| Mounting flange according to DIN 42 948 Centering diameter b1 | Concentricity tolerance for motors with tolerance N | Concentricity tolerance for motors with tolerance R |
|---|---|---|

| | | | | |
|---|---|---|---|---|
| 50 | to | 95 | 0.08 | 0.04 |
| 110 | to | 230 | 0.10 | 0.05 |
| 236 | to | 450 | 0.125 | 0.063 |
| 465 | to | 680 | 0.16 | 0.08 |
| 880 | to | 1000 | 0.20 | 0.10 |

(also refer to Radial eccentricity, Axial eccentricity)

## Cooling types

a) Classification of cooling types

1) Non-ventilated, without fan (e.g. 1LP, IC40 motors)

2) Self-ventilated using a shaft-mounted fan or a fan driven by the rotor (e.g. 1LA, IC41; 1RA, IC01 motors)

3) Forced cooling using a separately driven fan or using another cooling medium which is separately pumped or displaced (e.g. 1PP, IC 46 motors)

b) Classification according to the mode of operation of the cooling

1) Internal cooling (e.g. 1RA motors)

2) Surface cooling (e.g. 1LA motors)

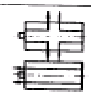
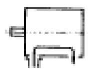
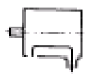
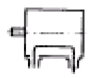
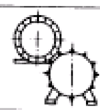
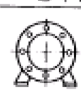
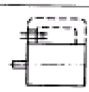
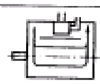
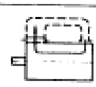
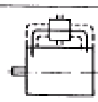
3) Closed-circuit cooling using an intermediate cooling medium which flows through the motor and heat exchanger.

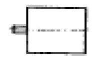
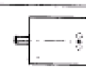
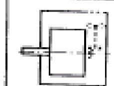
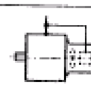
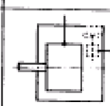
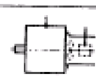
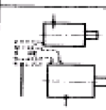
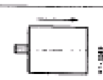
4) Liquid cooling (e.g. 1MM motors)

5) Direct conductor cooling using either gas or liquid for extremely large machines (motors and generators)

c) Several cooling types can be combined with one another.

DIN IEC 34, Part 6 has two systems for coding the cooling types. Both start with the letters IC (= International Cooling). For "full coding", the IC letters are followed by two blocks, each comprising one letter and two digits: e.g. IC W37 A71. For air-cooled machines, the German Draft Standard recommends that users preferably apply the "simplified coding", which only has two digits after the letters IC. The first digit describes the type of cooling medium circulation and the second digit defines the type of drive to move or pump the cooling medium.

| First identification figure | | |
|---|---|---|
| 0 |  | Machine with free air inlet and outlet |
| 1 |  | Pipe-ventilated machine<br>One inlet duct |
| 2 |  | Pipe-ventilated machine<br>One outlet duct |
| 3 |  | Pipe-ventilated machine<br>Inlet and outlet duct |
| 4 |  | Totally-enclosed fan-cooled machine<br>(Coolant is the ambient air) |
| 5 |  | Machine with built-in heat exchanger<br>(Coolant is the ambient air) |
| 6 |  | Machine with built-on heat exchanger<br>(Coolant is the ambient air) |
| 7 |  | Machine with built-in heat exchanger<br>(Coolant is not the ambient air) |
| 8 |  | Machine with built-on heat exchanger<br>(Coolant is not the ambient air) |
| 9 |  | Machine with the heat exchanger arranged separately |

| Second identification figure | | |
|---|---|---|
| 0 |  | Natural cooling |
| 1 |  | Self-cooling |
| 2 |  | Self-cooling by ventilation equipment not arranged on the shaft |
| 3 |  | Separate cooling by ventilation equipment built directly onto the machine<br>Drive depending on the machine |
| 5 |  | Separate cooling by ventilation equipment built into the machine<br>Drive independent of the machine |
| 6 |  | Separate cooling by ventilation equipment built directly onto the machine<br>Drive independent of the machine |
| 7 |  | Separate cooling by ventilation equipment not built directly onto the machine<br>Drive independent of the machine,<br>or by forced air from the supply system |
| 8 |  | Cooling by relative displacement, e.g. cooling by moving the machine through the coolant, or cooling by the main air draught. |

(also refer to Shaft-mounted fan)

## Couplings

Shaft couplings are used to couple two coaxial shafts, e.g. to couple a motor shaft to the shaft of the driven load.

**Rigid couplings**
e.g. sleeve coupling or when the two shafts are bolted together through the coupling flange which does not allow the shafts to move relatively to one another. This must be taken into account by selecting the appropriate bearing design.

**Torsionally stiff couplings**
prevents relative rotary motion of the two shafts with respect to one another but allows the two shafts to shift as a result of alignment faults (e.g. beveled gear couplings).

**Elastic couplings**
have elastic intermediate elements, e.g. rubber blocks, rubber elements, steel springs, involute helical gears or other elastomer parts which are partially deformed when torque is transmitted or when the coupled shafts move with respect to one another.

**Starting couplings**
these couplings reduce the starting torque.

**Electromagnetic multiple-disk couplings**
these couplings can be opened and closed during operation.

**Safety couplings**
these only permit a specific torque to be transmitted. When this torque limit is exceeded, they must slide, for example, when implemented in the form of slipping couplings.

## Cos phi

cos phi is an angular function. This determines an angle between 0 and 90° by which the motor current lags the motor voltage.

$$\cos phi = \frac{\text{power input}}{\text{apparent power}}$$

cos phi is also known as power factor. It is included with the motor technical data and can be taken from the Catalog for the rated output.

Nominal values for cos phi at partial load for standard Siemens motors are specified in Catalog M 1.

Approximate values of cos phi with the motor in an unloaded condition (no-load):

| Output | 2 pole | 4 pole | 6 and 8 pole |
|---|---|---|---|
| 1 - 20 kW | 0.26 – 0.16 | 0.26 – 0.12 | 0.17 – 0.09 |
| 20 - 132 kW | 0.19 – 0.11 | 0.08 – 0.06 | 0.10 – 0.06 |

Refer to the voltage drop along the feeder cable for values of cos phiA (with the rotor locked).

(also refer to Reactive power, Reactive current, Voltage drop in the feeder cable)

## Cradle dynamometer

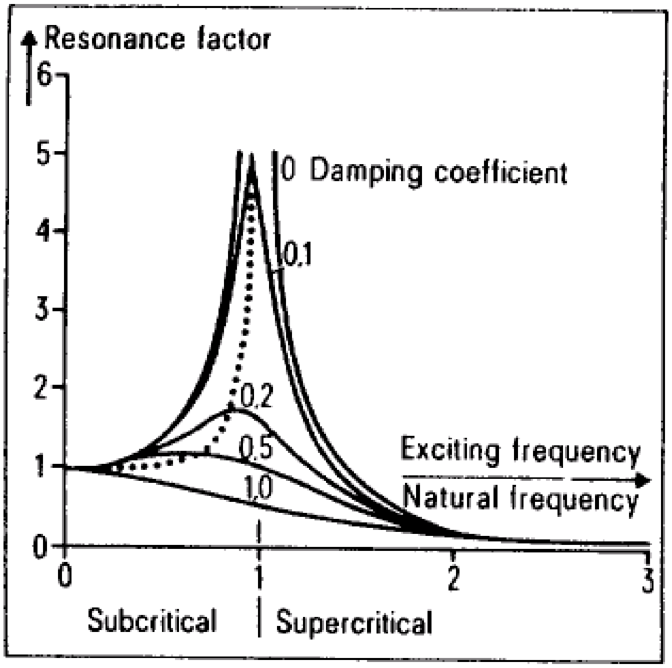
This is implemented, to a large extent, as a DC generator.

It is used to measure torques on test stands. It is mainly used to check the torque and operating speed of internal combustion engines.

In some cases, the cradle dynamometer must operate with extremely high speeds, e.g. up to 10.000 RPM, corresponding to the speeds of the internal combustion engines.

## Critical speed

If the speed, at the forced surge frequency, is the same as the natural system frequency, resonance occurs and the subsequent stressing can be uncontrollably high.




Lateral vibrations (bending vibration)

A motor rotor can be considered to be an elastic shaft with a flywheel, whose center of gravity is eccentric to the center line due to the imbalance (however small). The centrifugal force is proportional to the square of the speed and increases this eccentricity. The force of reaction, which is proportional to the elasticity opposes this. The bending of the shaft becomes uncontrollably high in a certain speed range – the critical speed. The bend disappears when the speeds increase further – above-critical.

Lateral vibration (bending vibration) does not have to be taken into account when standard motors are used in the usual speed ranges.

Foundation vibration

For unfavorable motor mounting, in exceptional cases, periodic surges (small) which occur with the motor rotational frequency (e.g. caused by imbalance) can coincide with the natural frequency of the mounted system.

Torsional vibration

The rotating mass of the motor, elastically coupled with the driven load, can be considered to be a two-mass system which is capable of torsional vibration. Resonance can occur, if, under worst case conditions, periodic surges (e.g. which occur for reciprocating compressors, damaged gearwheels, etc.) are present, whose surge frequency is the same as the natural system frequency.

(also refer to Foundation vibration, Vibration severity)

## CSA Canadian Standards Association

These regulations only apply for Canada.

The CSA regulations essentially correspond to the US regulations in accordance with NEMA (National Electrical Manufacturers Association), which are known under the EEMAC name (Electrical and Electronic Manufacturer of Canada) as a result of the few differences.

For motors, there is no difference between NEMA and EEMAC

CSA requires that all electrical equipment, which is installed in Canada, is certified. Most of the Siemens motors have this CSA certification.

NEMA motors with CSA certification have the following rated motor voltages: 230V/460V, 460V, 575V at 60 Hz.

The voltage tolerance is + 10 %.

The rating plate must be in English.

## Customer benefits of energy-saving motors

**SIEMENS**

### Kundennutzen von Energiesparmotoren

#### Vorteile auf einem Blick

- Komplettes Produktspektrum für Energiesparmotoren nach CEMEP/ EPACT
- Motorauswahl wird erleichtert durch Wirkungsgradklassifizierung (EFF1/EFF2)
- Gleicher Motor erfüllt EPACT und EFF1 Wirkungsgrade bei 1LA9
- EPACT-Motoren gibt es auch mit NEMA-Abmessungen (Mexiko)
- Betriebskosten werden reduziert durch Wirkungsgradoptimierung
- Umwelt wird entlastet durch $CO_2$-Reduktion
- höhere Motorlebens- und Schmiermittelgebrauchsdauer durch niedrigere Motortemperatur bei EFF1-Motoren
- hohe Überlastreserve im Dauerbetrieb (SF 1,15 bei 1LA9/ 1LG6)
- Alle Motoren sind umrichterfest bis 500 V
- integraler Bestandteil von Totally Integrated Automation (T.I.A.) über Frequenzumrichter mit PROFIBUS DP®-Koppelung

# D

## Dahlander circuit

The Dahlander circuit is used for pole-changing motors with two speeds in a ratio of 1:2.

The motor is better utilized when compared to pole changing using 2 separate windings as, for each speed, the complete winding is used. The winding comprises two coil groups for each phase.

Pole changeover is achieved by changing-over and reversing the current of the appropriate coil groups. There are various Dahlander circuits to allow the motor to be better adapted to the load torque.

The most usual are:

D/YY for drives with a constant torque
Power ratio, P1 / P2  1 : 1,4

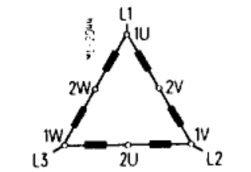
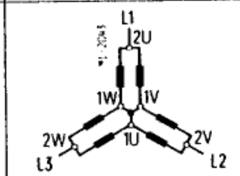
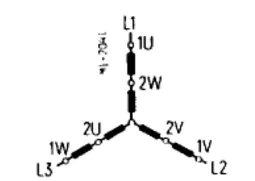
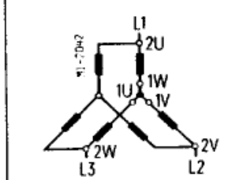
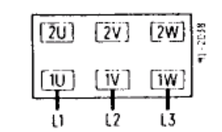
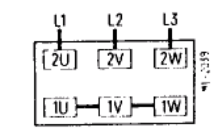
YY/D for drives with a constant power
Power ratio, P1 / P2  1 : 1

Y / YY for drives with a square-law torque characteristic (e.g. fan drives)
Power ratio, P1 / P2  1 : 4 to 8

Additional advantages:

Only 6 terminals are required. The speed is changed by changing-over and creating a star-point connection.

With the D circuit, Y-D starting is possible; for the YY circuit, starting is possible with a single star point and a current and torque ratio of 1 : 4. A larger terminal box with the necessary number of terminals is required.

| **Connection for two speeds with one winding** (Dahlander or PAM connection) | For motor with low speed | high speed |
|---|---|---|
| Winding for standard output ratings |  |  |
| Winding for output ratings of fan motors |  |  |
| Terminal arrangement |  |  |

(also refer to Pole changing, PAM winding, Star-double star starting, Heavy-duty starting)

## Dimension drawings

A CAD generator is used to generate dimension drawings for the 1LA5/6/7/9, 1MA, 1MJ and 1LG series. For 1LA8 motors, presently there are only dimension sheets available for IMB3 and IMV1. The CAD generator generates a dimension sheet taking into account the MRPD (Machine Readable Product Designation - Order No.) and the option codes. This means codes which can modify the frame, such as e.g. terminal box position are also shown.

## Deckwater-proof motors

Motors which are suitable for marine applications where there is a danger of flooding (they do not have an external fan).

IP 56 degree of protection.

## Deflection amplitude

(for more detailed information, refer to DIN ISO 2373 and VDI 2056)

For pure sinusoidal vibration and for a known vibration frequency of f, the deflection amplitude s can be calculated as follows using its measured RMS vibration velocity vRMS:

$$\hat{s} = \frac{\sqrt{2} \times v_{eff}}{2 \times \pi \times f}$$

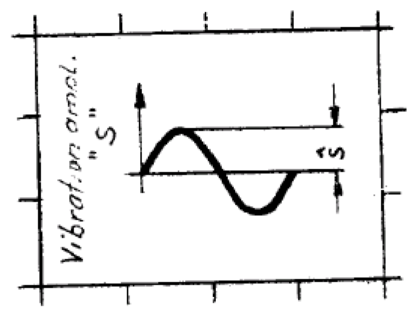
$$\hat{s} = 9{,}55 \times \frac{v_{eff}}{n} \times \sqrt{2}$$

instead of "f" in this formula, $f = \frac{n}{60}$ can be used, whereby "n" means the synchronous speed of the motor

The max. values of the vibration severity "$v_{eff}$" are indicated in the catalogue M1.

The deflection amplitude (related to 50 Hz = n = 3000 rpm) belonging to the correspondent max. value of the vibration severity is shown by the following table:

| $v_{eff}$ mm/s | $\hat{s}$ µm 2 pole | 4 pole | 6 pole |
|---|---|---|---|
| 0.28 | 1.25 | 2.5 | 3.75 |
| 0.45 | 2.0 | 4.0 | 6.0 |
| 0.71 | 3.15 | 6.3 | 9.45 |
| 1.12 | 5.0 | 10.0 | 15.0 |
| 1.8 | 8.0 | 16.0 | 24.0 |
| 2.8 | 12.5 | 25.0 | 37.5 |
| 4.5 | 20.0 | 40.0 | 60.0 |




(also refer to Vibration severity)

## Degree of protection - according to DIN VDE 0530, Part 5

Depending on the operating and ambient conditions, the following should be avoided by selecting a suitable degree of protection

The damaging effect of water, foreign bodies and dust; coming into contact with rotating parts inside a motor or live parts.

The degree of protection for electrical machinery is specified using a code which comprises two letters and two digits. It can also include an additional code letter.

| | | | |
|---|---|---|---|
| IP | | | (International Protection) code letter for the degree of protection against coming into contact with and the ingress of foreign bodies and water |
| | 0 to 6 | | 1st code number for the degree of protection against coming into contact with and the ingress of foreign bodies |
| | 0 to 8 | | 2nd code number for the degree of protection against the ingress of water (this does not represent protection against the ingress of oil) |
| | | W / S / M | Additional code letters for special protection types |

Special protection types

W for weather-protected electrical machinery: The letter W is located between the IP code letter and the degree of protection code, e.g. IPW23.

This is valid for electrical machinery "to be used under specific ambient weather conditions and with additional protective measures or equipment".

S and M for water protection: For special applications, (for example, open, open-circuit ventilated motors on the deck of a ship, where the motor air entry and air discharge openings are closed when the motor is stationary) then a code letter can be specified after the number which specifies whether protection was proven against damaging water entry with the motor stationary (the letter S) or with the motor running (the letter M).

In this particular case, the degree of protection must be specified for both motor operating states, e.g. IP55S / IP23M.

If the additional letters are omitted, then the degree of protection is maintained in both operating conditions – which means when it is running and when it is at a standstill.

The supplementary letter R for electrical machinery with pipe connection, defined in the old Standard, is no longer included as a result of the international agreements reflected in DIN IEC 34, Part 5. A combination of degree of protection/cooling type should be used for electrical machinery with pipe connection. For example, what was previously IPR44 is now IP23/IC37 or IP23/IC31.

The motors are mainly supplied with the following degrees of protection:

| Motor | Degree of protection | 1st numeral Protection against contact | foreign bodies | 2nd numeral Protection aigainst water |
|---|---|---|---|---|
| Internally ventilated | **IP 21** | with the fingers | medium-size bodies with diameters greater than 12 mm | dripping water falling vertically |
| | **IP 22** | | | dripping water falling at an angle up to 15° from the vertical |
| | **IP 23** | | | water sprayed at an angle up to 60° from the vertical |
| surface-ventilated | **IP 44** | by tools or similar objects | small bodies with diameters greater than 1 mm | water splashed from any direction |
| | **IP 54** | complete protection | Protection against harmful deposits of dust | water splashed from any direction |
| | **IP 55** | | | water projected by a nozzle from any direction |
| | **IP 56** | | | water from temporary flooding [1] heavy stream |
| | **IP 65** | complete protection | protection against ingress of dust | water projected by a nozzle from any direction |
| | **IP 67** | | | motor submerged under fixed pressure and time conditions |

1) In the case of heavy seas (temporary flooding) only the non-ventilated motor type 1PB can be used.

## Differences between CEMEP - EPACT

**Differences:**
**Efficiency acc. to EPACT / CEMEP**

| | EPACT - USA | CEMEP - Europe |
|---|---|---|
| *Status* | Legally prescribed minimum efficiency | Voluntary undertaking to<br>– classify efficiency<br>– drastically reduce EFF3 motors |
| *Motors covered* | 2-, 4- and 6-pole 60 Hz squirrel-cage motors<br>1 to 200HP (0.75 to150kW) | 2- and 4-pole 50 Hz squirrel-cage motors<br>1.1 to 90 kW |
| *Efficiency determined acc. to* | IEEE 112 B | Individual-loss procedure in acc. with IEC 60034-2 |
| *Efficiency* | Nominal value ηN acc. to NEMA MG1 | Tolerance in acc. with IEC 60034-1 |
| *Marking required* | Efficiency (ηN) on rating plate | – Efficiency class on rating plate of motor<br>– ηN, η3/4 load and efficiency class in documentation |

## Direction of rotation

The motors can be operated in both directions of rotation – clockwise and counter-clockwise (exception: 1LA8, 1MA8 and 1MJ8 motors, 2 pole). When U1, V1, W1 are connected to L1, L2, L3, the motor rotates clockwise when viewing the drive shaft end. The motor has a counter-clockwise direction of rotation when two phases are interchanged.

2-pole 1LA8 and 1MA8 motors have, in the normal version, an axial fan for a clockwise direction of rotation (exception: 1LA831). The fan can be subsequently changed for counter-clockwise operation.

## DURIGNIT 2000

DURIGNIT 2000 is a Siemens registered trademark for a high quality insulating system which has been proven millions of times over in our standard motors.

The DURIGNIT 2000 insulating system comprises, e.g. for standard motors with insulation Class B, the following components: The insulating coating of the enameled wire (varnish-insulated wire) can withstand limit temperatures of more than 180 °C (F = 155 °C). The impregnating resin which is applied using a highly developed technique (full impregnation with rotating hardening) corresponds to Class F. The insulating sheet material used for the slot liners is manufactured out of high quality materials with temperature rise Class B which is further refined as a result of the impregnation.
DURIGNIT 2000 guarantees the highest electrical and dynamic strength, e.g. when the motor is powered-up against 100 % residual field, security against thermal peak loads and a high lifetime.

DURIGNIT 2000 is the consequential further development of the world-known "Durignit insulation".

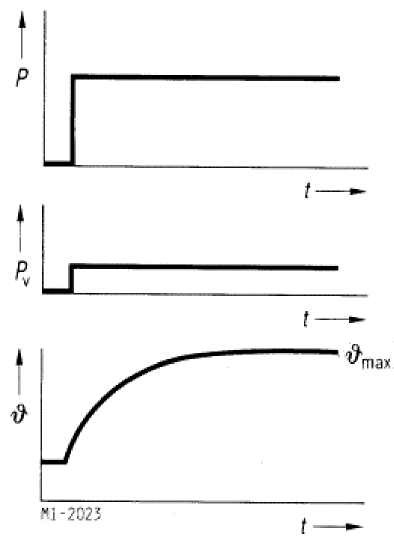
As far as the lifetime of the insulating materials is concerned, Montsinger drew up the following interrelationship on a statistical basis: For a permanent temperature increase of approximately 10 K, the insulation lifetime is reduced by about 50 %.

(also refer to Insulation Class)

# Duty types

Continuous duty (S 1)

Operation at a constant load long enough for a thermal steady-state condition to be reached.



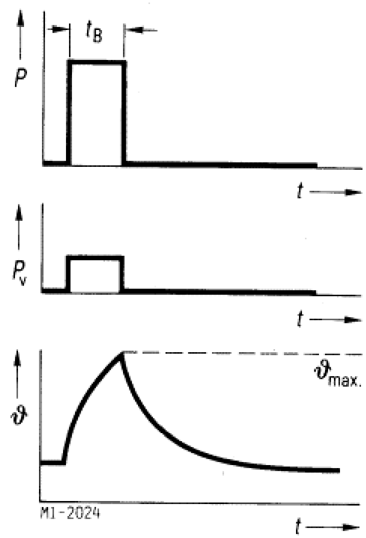

Duty Type S1: Continous duty

Short-time duty (S 2)

Operation at a constant load, which is not long enough that a thermal steady-state condition is reached and a subsequent no-load interval which is long enough so that the motor temperature does not deviate by more than 2 K from the cooling medium temperature.

10, 30, 60 and 90 minutes are recommended values for the duration of short-time duty. The time required to cool-down can be 30 minutes for extremely small motors and several hours for larger motors.

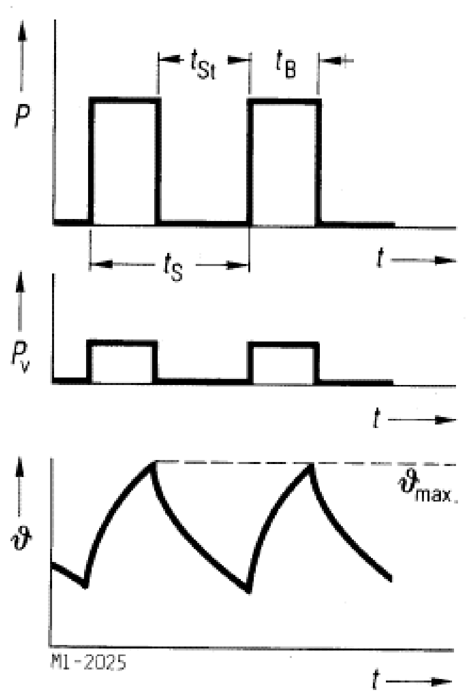
When motors are ordered, they can be adapted to the specific operating conditions which is the case, for example, for motors which are used for crane applications.



Duty Type S2: Short-time duty

Intermittent duty without influencing starting (S 3)

This type of operation comprises a sequence of similar duty cycles, each of which involves a constant load time and a no-load interval, whereby the starting current does not significantly influence the temperature rise.

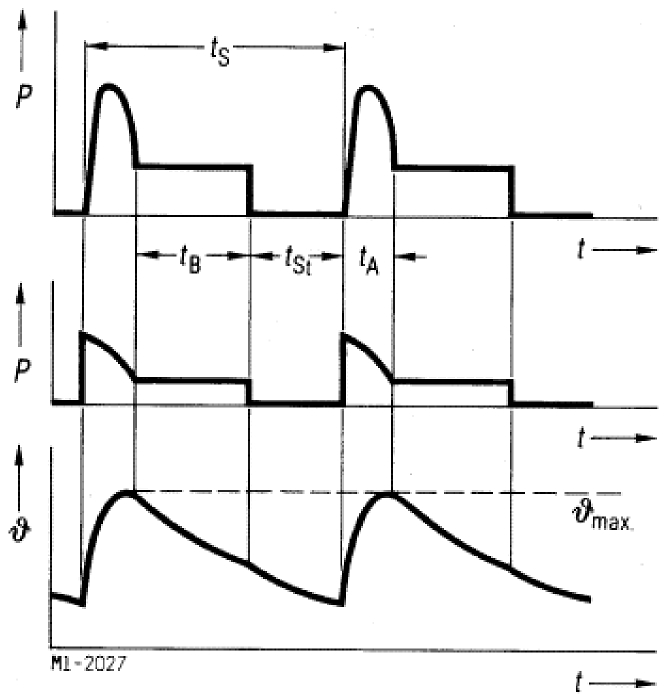


Duty type S3: Intermittent duty without influencing starting

$$t_t = \frac{t_B}{t_B + t_{St}}$$

Intermittent duty where starting is influenced (S 4)

This type of operation comprises a sequence of similar duty cycles, each of which involves a noticeable starting time, a constant load time and a no-load interval.

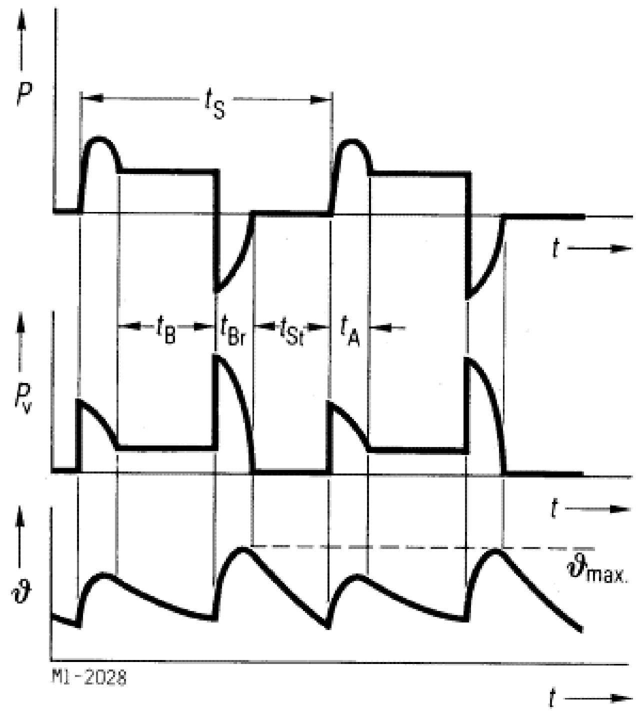



Duty type S4: Intermittent duty where starting is influenced

$$t_r = \frac{t_A + t_B}{t_A + t_B + t_{St}}$$

Intermittent duty where starting is influenced and electrical braking (S 5)

This type of operation comprises a sequence of similar duty cycles, each of which involves a noticeable starting time, a constant load time and a no-load interval.




Duty type S5: Intermittent duty where starting is influenced and electrical braking

$$t_t = \frac{t_A + t_B + t_{Br}}{t_A + t_B + t_{Br} + t_{St}}$$

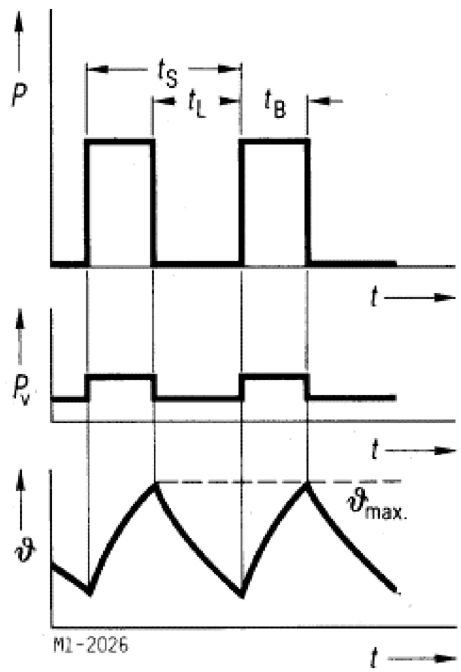
Continuous duty with intermittent load (S 6)

This type of operation comprises a sequence of similar duty cycles, each with a constant load time and a runtime.

There are no no-load intervals.

When specifying the increased output (power) on the rating plate, duty type S 3 and S 6 must still be supplemented by the on time or duty cycle duration. If the duty cycle duration is not specified, then VDE is applied which is 10 min.

Operation, with alternating load times of 5 min and no-current intervals of 10 min which consecutively follow each other is, e.g. designated with S 3 : 5 min/15 min. However, this can also be replaced by the relative on time and the duty cycle: Duty S 3 : 33%, 15 min. 15, 25, 40 and 60% are recommended values for the relative on period.



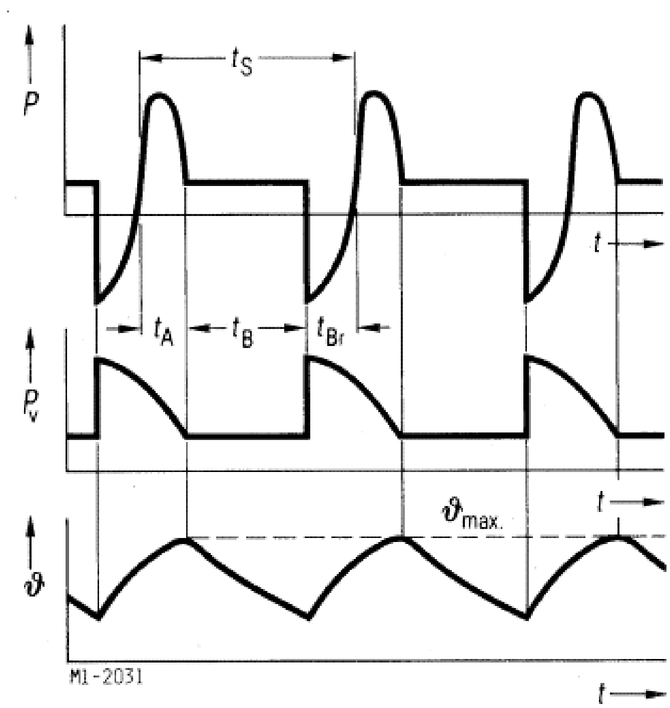

Duty type S6: Continous duty with intermittent load

$$t_r = \frac{t_B}{t_B + t_L}$$

Uninterrupted duty with starting and electrical braking (S 7)

This type of operation comprises a sequence of similar duty cycles each with a noticeable starting time, a constant load time and a time with fast electrical braking.

There is no no-load interval.



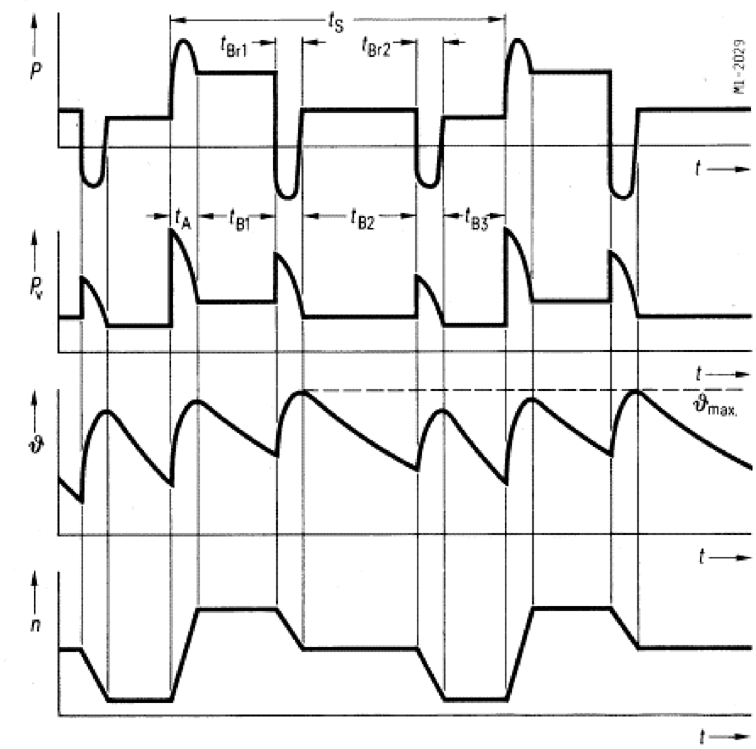

Duty type S7: Uninterrupted duty with starting and electrical braking

$t_r = 1$

Uninterrupted duty with periodic speed change (S 8)

This type of operation comprises a sequence of similar duty cycles; each of these duty cycles involves a constant load time and specific speed followed by one or several periods with another load which correspond to different speeds.

(for instance, this is achieved when changing-over the poles of induction motors). There is no no-load interval.




Duty type S8: Uninterrupted duty with periodic speed change

$$t_{r1} = \frac{t_A + t_{B1}}{t_A + t_{B1} + t_{Br1} + t_{B2} + t_{Br2} + t_{B3}}$$

$$t_{r2} = \frac{t_{Br1} + t_{B2}}{t_A + t_{B1} + t_{Br1} + t_{B2} + t_{Br2} + t_{B3}}$$

$$t_{r3} = \frac{t_{Br2} + t_{B3}}{t_A + t_{B1} + t_{Br1} + t_{B2} + t_{Br2} + t_{B3}}$$

| | | | | | |
|---|---|---|---|---|---|
| P | = | Power | tBr | = | Braking time |
| n | = | Speed | tL | = | No-load time |
| t | = | Time | tr | = | Relative power-on duration |
| tA | = | Starting time | tS | = | Duty cycle duration |
| tB | = | Load time | tSt | = | Standstill time |

(also refer to On time, Switched operation)

# E

## Effective output at the motor shaft

The motors have temperature rise Class F and are utilized in accordance with temperature rise Class B. If this utilization is to be kept, and if the conditions change, the permissible output must be reduced (de-rated) corresponding to the adjacent table. The reduced output, taking into account the particular ambient temperature reduction factor, is the effective output at the motor shaft. This output is specified in the data sheet as rated output if a value is not specified in the field "Stamped values / output".

Examples for de-rating: Cooling medium temperature > 40 °C, installation altitude above sea level > 1000 m

## Efficiency

Efficiency is the ratio between the power output and the power drawn

The efficiency is the ratio of the output to the input:

$$\eta = \frac{P_2}{P_1} = \frac{P_1 - V}{P_1} = \frac{P_2}{P_2 + V} = 1 - \frac{V}{P_1}$$

whereby

$\eta$ = efficiency (< 1, indication also in %)
$P_1$ = input in kW
$P_2$ = output in kW
$V$ = losses in kW

If several units are connected one after the other, then the overall efficiency is obtained by multiplying the individual efficiencies with one another.
hG = h1 x h2 x ....

The motor efficiencies are specified in the various Catalogs.

Examples of efficiencies (these are only approximate values):

| | |
|---|---|
| Gearbox | depending on the ratio, between approximately 99 % and 95 % |
| Worm gear | depending on the ratio, between approximately 90 % and 50 % |
| Centrifugal pumps and fans | approximately 70 % |
| Reciprocating machines | approximately 90 % |

(also refer to Power distribution)

## EPACT definition

EPACT Energy Policy and Conservation Act

Involves pole numbers 2, 4 and 6

Output range, 1 HP (0.75 kW) up to 200 HP (160 kW)

Minimum efficiencies which are specified by the appropriate legislation in the US

Efficiency is calculated according to IEEE 112b

The nominal efficiency and NEMA MG-1 are stamped on the rating plate.

## EPACT legislation

SIEMENS

EPACT-Gesetz:
Mindestwirkungsgrade für alle in die USA importierte Motoren

**Hindergründe zur Einführung des EPACT-Gesetzes**

- Zu Beginn der 70er Jahre leiteten die USA Maßnahmen zur Verringerung der Import-abhängigkeit bei der Energieversorgung und zur Reduzierung der $CO_2$ Emission ein. Daraus resultierten Vorschriften, die zwingend einen Mindestwirkungsgrad für Elektromotoren vorschreiben.
- Das EPACT- Gesetz, am 25.Oktober 1997 in Kraft getreten, fordert die Einhaltung von Mindestwirkungsgraden für den direkten und den indirekten Import von Motoren in die USA und ist Teil des EPCA (Energy Policy and Conservation Act). Gültigkeit für:
  - 2, 4, 6polige Standard-Drehstrom-Asynchronmotoren mit Kurzschlussläufer
  - im Leistungsbereich von 1 bis 200 HP (0,75 bis 150 kW)
  - ab dem 25.10.1997 gefertigte Motoren
  - Ermittlung der Wirkungsgrade nach IEEE 112 B
  - Labelling- und Zertifizierungsauflagen ab Ende 1999
  - Einteilung der Motoren in 5 Kategorien

## European Standards

### for firedamp and explosion-protected electrical equipment

From the 1st of May 1978, EN 50 014 to EN 50 020 apply in Germany as

DIN EN 50 014/VDE 0170/0171 Part 1 to

DIN EN 50 020/VDE 0170/0171 Part 7

in Great Britain, from the 30th of December 1977, as

BS 5501 Part 1 to

BS 5501 Part 7

in France, from the 27th of June 1977, as

NF C 23-514 to

NF C 23-520 .

These Standards include the following regulations for the construction of equipment:

| | |
|---|---|
| EN 50 014 | General regulations |
| EN 50 015 | Oil enclosure "o" |
| EN 50 016 | Pressurized enclosure "p" |
| EN 50 017 | Powder enclosure "q" |
| EN 50 018 | Flameproof enclosure "d" |
| EN 50 019 | Increased safety "e" |
| EN 50 020 | Intrinsic safety "i" |

Codes:

Firedamp protection: EEX I

Explosion protection: EEX II

Type of protection:

Increased safety: e

Flameproof (explosion-proof) enclosure: d

Pressurized enclosure: p

Powder enclosure: q

Oil enclosure: o

Special protection: s

Intrinsic safety: i.

Explosion group: II A, II B + H2, IIB + CS2, IIB + C2H2, II C

Temperature Class: T1, T2, T3, T4, T5, T6

Examples of the two codes:

EEx dI

EEx deIIC T4

EEx eII T3

(also refer to Types of protection "e", "d" and "p")

## Explosion protection

Special regulations and rules, e.g. DIN 57 165, apply when motors are installed in hazardous areas where an explosive atmosphere can occur in a potentially dangerous quantity. These areas are then further sub-divided into zones. Gases and vapors are classified corresponding to their ignition temperatures in temperature classes and corresponding to the spark ignition properties when explosions occur, into explosion groups.

The operating company is responsible in specifying which type of protection is necessary and which regulations have to be observed. In special cases, this is specified by the relevant regulatory bodies.

The hazardous zones are as follows:

Motors for Zone 1

Increased safety type of protection Eex e II temperature Classes T1 – T3
Flameproof enclosure type of protection Eex de II C temperature Classes T1 – T4

Motors for Zone 2

| | |
|---|---|
| Version for Zone 2 | T3 according to DIN VDE 0165 |
| Version for Zone 2 | Ex nA II T3 according to IEC 79-15 |
| Version for Zone 2 | ExN T3 according to BS 5000, Part 16 |
| Version for Zone 21 | Dust explosion protection |
| Version for Zone 22 | Dust explosion protection |

(also refer to European Standards)

# F

## Fail-safe brake

Brakes which operate according to the fail-safe principle, the brake is actuated using a spring. The brake is released using magnetic force, i.e. a solenoid.

The magnitude of the braking force is determined by appropriately selecting the springs.

When the power fails, the brake is automatically applied (safety or fail-safe brake).

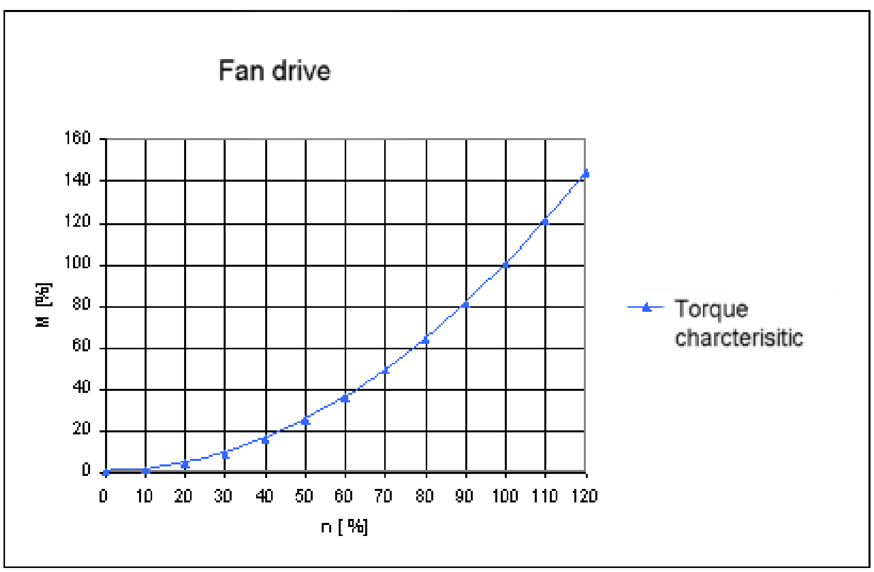
## Fans and blowers

These are sub-classified as follows:

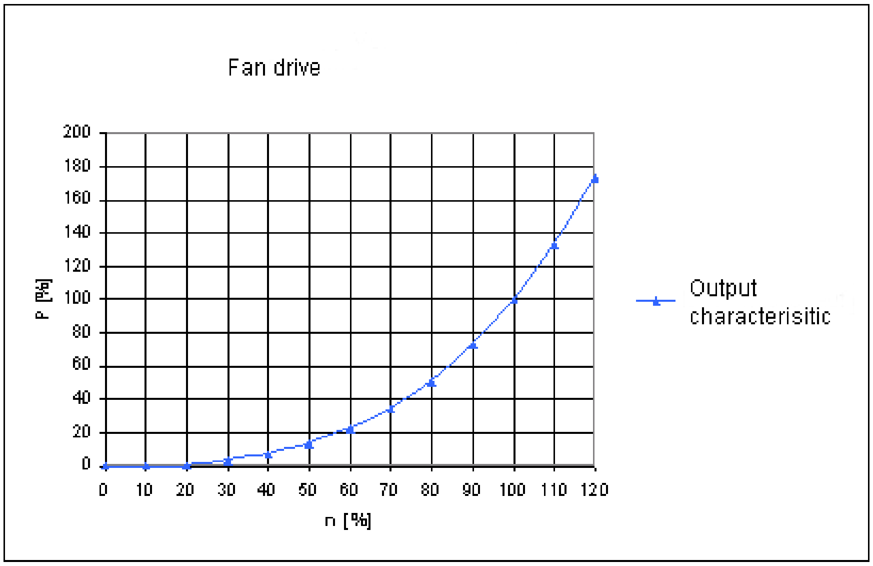
- Axial fans
- Radial fans
- Special fans

When evaluating starting, it must be taken into account that the fan torque increases to the square of the speed. This means that at 50 % speed, the fan load torque is only 1/4 of its nominal torque. This means that the power which the fan requires increases to the power of 3 with respect to the speed.

In the diagram, the speed is referred to 100% at 50Hz and 120% at 60Hz !!




This means, that a motor which was designed for a fan drive with an output at 50Hz cannot be simply operated at 60Hz !!!




Generally, radial fans have high moments of inertia; for applications such as these, the starting time must be carefully calculated.

(also refer to Starting time, Heavy-duty starting)

## Fan drives

Today, three-phase asynchronous motors of all outputs are predominantly used.

The following can be realized as variable-speed drives:

- Three-phase motors fed from AC drives with a square-law torque characteristic.
- Single-phase motors with square-law torque characteristic.
- Pole-changing three-phase motors with a square-law torque characteristic.
- For special applications, three-phase short-circuit motors with a belt drive.
- A special version would involve changing the speed by reducing the voltage; for example, this could be realized using tapped transformers or phase control up to approximately 1.5 kW. However, in this case, the standard power is not possible or the power must be reduced. Furthermore, generally a high-resistance squirrel-cage rotor must be used.

## Firedamp protection

The regulations in VDE 0118 apply if motors are to be used in areas with firedamp, i.e. in underground mining where methane could be present.

Firedamp-protected motors, with type of protection EExdI and EexeI, are certified by the BVS, Dortmund Derne.

(also refer to European Standards)

## Flexible coupling

The motor shaft is coupled to the shaft of the driven load coaxially through a flexible shaft coupling. When the two shafts move relatively to one another, the coupling must be able to absorb the resulting additional stressing on the bearings and shafts.

Flexible couplings can either be torsionally stiff or torsionally elastic.

Flexible, torsionally stiff coupling are, e.g. jointed shafts and toothed couplings.

For elastic couplings, any movement is equalized by the elastic deformation of intermediate elements, e.g. rubber blocks, rubber sleeves/bushings, steel springs.

## Flywheel effect

$GD^2$ in $kpm^2$; this is an out-of-date unit

New SI units and their conversion, refer to Moment of inertia.

## Frequency

The frequency is the number of periods (of the AC current) per second. A full period comprises a positive and a negative halfwave. The dimensions are Hertz (Hz).

In Europe, the standard line supply frequency is 50 Hz. In other continents (overseas), line supplies with a frequency of 60 Hz are being more frequently used. The line supply network of the German National Railways (DB) for traction applications has a frequency of 16 2/3 Hz.

The motor speed is proportional to the frequency.

(also refer to Frequency change)

## Frequency change

The torque of a motor changes inversely proportional to the square of the frequency; when the frequency is increased by 20 %, the stalling (breakdown) torque is only 69 % of the original absolute value.

The current of a motor changes inversely proportional to the frequency; e.g. when the frequency is increased by 20 % the starting current is only 83 % of the original absolute value.

The speed of a motor changes linearly with the frequency. Rated output is possible at a constant voltage up to a frequency deviation of ± 5 %.

A voltage change influences the motor magnetization in the opposite way to a frequency change. This means that a frequency change can be partially compensated by a voltage change which is applied with the same sense. (The following cannot be compensated: Iron losses when the frequency is increased, lower cooling effect when the frequency decreases).

It is most frequently used when operating motors with a 380 V, 50 Hz winding on a 460 V, 60 Hz line supply. In this case, the output can be increased by approx. 15 %.

(also refer to Speed, Voltage change)

## Forced ventilation

With forced ventilation, the motor or generator is cooled by a fan which is not driven by its shaft.

This is used, for example, for variable-speed motors, for constant torque of the driven load if this is operated at lower speeds.

(also refer to Cooling types)

## Foundation vibration

Foundation vibration generate a continuous surge-type stressing which can prematurely destroy ball or roller bearings.

The following counter-measures can be used if foundation vibration occurs:

1. Use pre-loaded bearings
2. Mount the motor/generator on matched and coordinated vibration damping elements
3. Use sleeve bearings for larger machines
4. Use a donkey motor. These are small mounted geared motors which continually spin the rotor at a low speed, e.g. on ships.
5. Change the natural frequency of the foundation by using reinforcements (under-critical) or additional elasticity (over-critical).

(also refer to Rotor support device, Vibration severity)

## Frame material

Standard low-voltage asynchronous motors, shaft heights 56 to 225 and EExe motors, shaft heights 63 to 160, have aluminum frames.

Furthermore, gray cast iron motors from shaft heights 100 to 315 are available as standard asynchronous motors and as EExe motors

EEx de motors always have gray cast iron frames

# Frame sizes

Frame sizes etc. and the associated important mounting dimensions for motors are defined in IEC Publication 72 (1971).

| | |
|---|---|
| Foot mounting: | Shaft height<br>Distance between the holes in the mounting feet<br>Distance between the shaft shoulder and the center of the holes in the mounting feet |
| Flanged types of construction: | Flange dimensions<br><br>Dimensions of shaft ends |

Output series in kW and PS

Frame sizes, rated outputs and cylindrical shaft ends from IEC 72 are assigned in DIN 42673 to, for example, totally-enclosed fan-cooled three-phase motors with squirrel-cage rotor, type of construction IM B3 with roller bearings.

The dimension for the motor shaft height, type of construction IM B3, coincides with the numerical quantity specified in the type of construction; e.g. h = 63mm for frame size 63 or h = 225mm for frame sizes 225 S and 225 M.

The frame size is also included in the type designation of the new series of standard Siemens motors. For example, type 1LA5 130 corresponds to frame size 132 S and type 1LA6 207, frame size 200L. In this case, the frame size is coded in the first and second digits and the length in the last digit:

0, 1, 2 for S (narrow)

3, 4, 5 for M (medium=average)

6, 7, 8 for L (long)

(also refer to Standards, MRPD)

# G

## Geared motor

A geared motor comprises a standard motor with type of construction B5 and a mounted gearbox.

The drive speed (n2) is a speed which deviates from the rated motor speed.

The output torque changes inversely proportional to the speed.

The operating ratio (operating coefficient) takes into account the dynamic load of the gearbox as a result of surges and vibration. It is dependent on the degree of unevenness (surge level), the operating time per day, as well as the switching frequency and the moment of inertia of the driven load. The rough order of magnitude is: 0.8 to 1.75. Siemens standard motors can also be assembled using gearboxes from various manufacturers.

## Grease

Lithium-soap greases are preferably used for motors. The bearings of low-voltage three-phase motors, frame sizes 56 to 400 are normally lubricated with non-aging lithium-soap multigrade grease - "Unirex N3". The temperature range of this grease lies between -30 °C to +130 °C.

High and low temperature greases are used for special requirements.

(also refer to Lubricating plate)

## Grease lifetime

The grease lifetime is limited so that the bearings must be re-lubricated at the specified intervals in order to achieve the nominal lifetime of 40.000 h.

The re-greasing/re-lubricating intervals for motors essentially depends on the type of bearing, the grease itself, the speed, temperature of the grease and also the degree of protection.

Siemens motors achieve optimal values by providing a grease reservoir on the outside of the bearing (i.e. the colder side) and the IP 54 degree of protection.

The bearings have permanent lubrication up to shaft height 250. If the grease lifetime has expired, the bearings should be removed from these motors, cleaned and re-greased or the complete bearing should be replaced.

Standard motors from shaft height 280 are equipped, in the standard version, with re-lubricating devices.

The grease lifetime of a motor is specified in the Operating Instructions. Motors which are equipped with a re-lubricating device also have a lubrication instruction plate.

also refer to Re-lubrication device ; Lubrication instruction plate

## Grease valve grease slinger

The grease slinger automatically pushes the excess grease to the outside through centrifugal force.

## Grounding (earthing) stud

There is always a protective conductor connection provided in the terminal boxes of Siemens motors. For motors above 100 kW, VDE 0530 specifies an additional, external grounding (earthing) stud.

From frame size 180, Siemens motors already have this additional, external grounding (earthing) stud. Explosion-protected motors (1MA and 1MJ) and motors in the VIK version also always have an additional external grounding (earthing) stud.

# H

## Harmonics

The magnetic field of electric motors is not purely sinusoidal, even if the line supply voltage is sinusoidal. Using Fourier analysis, every periodic function can be broken down into a sinusoidal fundamental having the same frequency and a series of sinusoidal harmonics (higher harmonics) having a higher frequency.

## Heavy-duty starting

Heavy-duty starting is involved if the load torque while starting is extremely high. In this case, a motor must have an appropriately high starting torque or a high torque class.

Heavy-duty starting especially involves high moments of inertia, for example, centrifuges, large fans etc. where the starting time would be too long for a normally dimensioned motor. The motor temperature would increase to an excessive level.

Starting times of up to 10 seconds from the warm condition are permissible for standard Siemens motors.
Exception: 1RA6 motors, 6 sec.

For heavy-duty starting:

1. Check (possibly in the factory), as to whether the motor can handle these heavy-duty starting conditions, e.g. as a result of its reserve.
2. A larger motor with higher thermal capacity and higher accelerating torque: This can be advantageous.
3. Pole-changing motor. The starting losses are halved when starting in 2 stages, 1 : 2.
4. Slipring rotor motor. The power loss when starting is dissipated in the starting resistor.
5. Starting coupling. Thermal power loss when starting is dissipated in the more rugged coupling.

   For starters, heavy-duty starting is involved if the ratio between the average starting current, which is obtained from the switching stages, and the rated motor current, is greater than 2.

   (also refer to Starting time)

## Height above sea level

The motors have temperature rise Class F and are utilized in accordance with temperature rise Class B. If this utilization is to be kept, if the conditions change, the permissible output must be reduced (de-rated) corresponding to the adjacent table. SD01 automatically takes into consideration these factors and displays the reduced (de-rated) motor output.

| Aufstellungshöhe über NN in m | Reduktionsfaktor |
|---|---|
| 1000 | 1,00 |
| 1500 | 0,97 |
| 2000 | 0,94 |
| 2500 | 0,90 |
| 3000 | 0,86 |
| 3500 | 0,82 |
| 4000 | 0,77 |

## Heyland circuit

or also called the Ossanna circle, is the locus diagram of the currents of a three-phase induction motor.

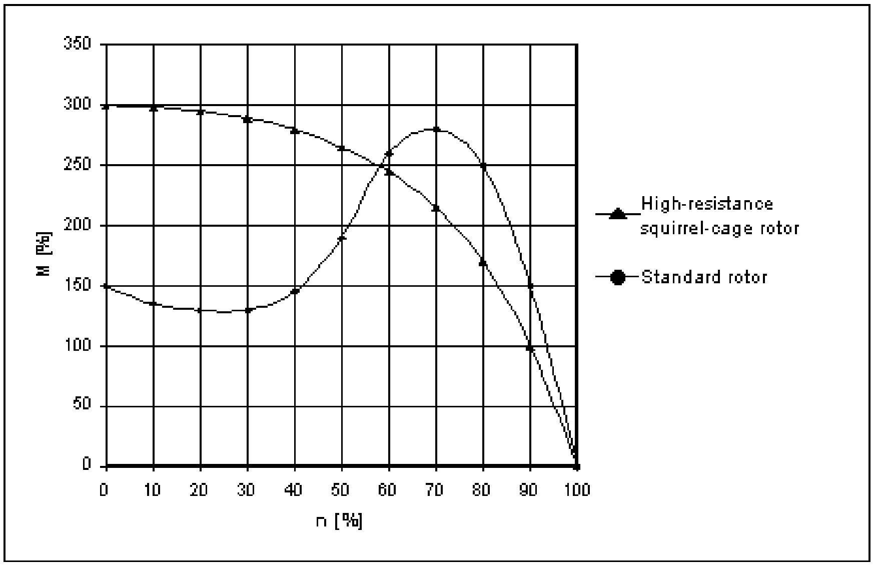
Extremely simplified and assumed as prerequisite is that the ohmic (resistance) and inductive resistance as well as the line voltage are constant in the particular operating range of the motor. This is essentially only true for squirrel-cage rotors, which have no skin effect, and slipring rotors.

The vector of the current as a function of the load and all possible operating statuses moves in a circle in the circle diagram. The associated technical data can be taken, for a theoretical situation, from the special operating points and the appropriate connecting lines, e.g. torque and power characteristic, and that for various operating states.

## High-resistance squirrel-cage rotor

These are rotors, where the resistance of the rotor bars and short-circuit rings have a higher resistance due to the material being used. These materials include, for example, Silumin, brass or bronze.

In the rated operating range, these types of motors have a higher slip and an appropriately poorer efficiency. The torque characteristic is softer, the rated slip higher. Motors with high-resistance rotors must be de-rated (the power output reduced).




These types of rotors are used for flywheel-type drives, e.g. press drives, compressor drives or for motors which are frequently powered-up.

## High-voltage motors

These are motors 1.1 to 11 kV, 50 Hz and 60 Hz and with outputs of approx. 200 to 16.000 kW and higher

# IJ

## IEC regulations

International Electrotechnical Commission

IEC Publication 72 contains, for foot-mounting and flange-mounting types of constructions, mounting dimensions for electrical machinery from shaft height 56 to 315 mm (there are no assigned powers).

IEC 72A contains, for foot-mounting types of construction, mounting dimensions for electrical machinery with shaft heights from 355 to 1000 mm.

IEC Publication 34 contains regulations and specifications for engineering and dimensioning electrical machinery.

IEC Publication 79 contains explosion protection types.

These regulations have already been taken into account in the appropriate German Standards (DIN) and VDE regulations.

## Impregnation

The winding, inserted in the slots, is treated with insulating enamel/varnish or impregnating resin.

Siemens places special significance on the quality of the impregnation medium and the impregnation technique and technology. This plays an important role in the electrical, mechanical, thermal and chemical properties and features of the insulation and represents a significant component in the "DURIGNIT 2000" and "MICALASTIC" insulating systems used for Siemens motors.

A solvent-free impregnating resin is used for "DURIGNIT 2000":

It penetrates the insulating sheet material and improves its electrical properties

It binds the complete winding to form a compact unit

It protects against external effects.

The following technique is applied for "DURIGNIT 2000":

Full impregnation with rotating hardening.

Using this special impregnation technique, the winding is continually rotated until the impregnation agent hardens. This ensures that not only that the liquid impregnation agent completely penetrates all parts of the winding, but also prevents the impregnation agent flowing out during the drying process. This avoids resin loss during the gel and hardening phases.

(also refer to Durignit, Residual voltage)

## Information and certificates

When ordering "Without safety and commissioning information/instructions", the appropriate declaration is required stating that the customer does not need these. The appropriate form is available in the Intranet.

## Inline pumps

are circulating pumps, which are installed directly in the piping (generally for oil) using two mounting flanges.

Motors, with a special shaft are used. There are directly coupled to the pump impeller. It is important to pay special attention to any possible axial force.

Recently, standard motors are being increasingly used to drive inline pumps.

## Inrush current

This is caused by electromagnetic transients (inrush effect) when establishing a magnetic field after powering-up or reversing a motor. The peak value can assume the following values:

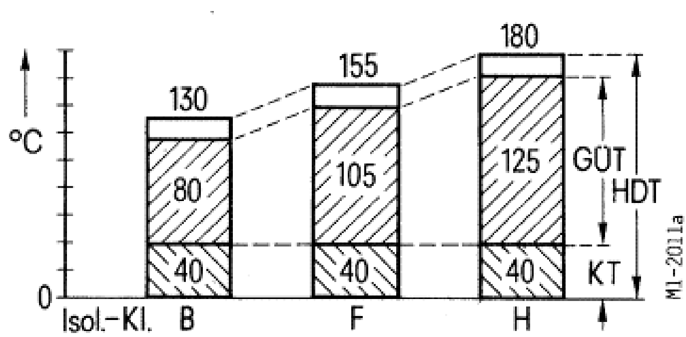
| | |
|---|---|
| Starting: | $i_{max} = \sqrt{2} \times I_A \times (1{,}8 \;....\; 2{,}0)$ |
| Y / Δ Switch over: | $i_{max} = \sqrt{2} \times I_A \times (2{,}1 \;....\; 3{,}7)$ |
| Reverse: | $i_{max} = \sqrt{2} \times I_A \times (2{,}7 \;....\; 5{,}0)$ |

It decays in just a few periods and is significantly lower after 20 ms.

(also refer to Residual voltage)

## Insulation Class

Insulating materials including the impregnating medium are classified into various insulation Classes in VDE 0530. Precisely defined temperature values are assigned to these Classes.




GÜT Temperature rise limit in K (average value)
KT Cooling medium temperature in °C
HDT Highest permissible continuous temperature in °C (for the hottest point in the winding).

Temperature rise limit in K

| For insulation Class | B | F | H |
|---|---|---|---|
| Insulated winding | 80 | 105 | 125 |
| Sliprings | 80 | 80 | 80 |

The highest permissible continuous temperature of the individual insulating materials comprises, as shown in the diagram, the cooling medium temperature and the temperature rise limit of the winding. Furthermore, beyond this, a temperature rise tolerance as safety margin should be taken into account as the measurement of the winding temperature using the ohmic resistance doesn't detect the hottest point of the winding, but instead, only an average value of the temperature increase. The specified motor outputs for all insulation Classes are based on a cooling-medium temperature of 40 °C.

**Caution:**

Since VDE 0530 was published in July 1991, insulation Class was re-named temperature Class.

# L

## Lifetime

The lifetime of electrical machinery is mainly defined by the lifetime of the insulating system and the roller bearings.

Insulation

According to VDE 0304, a time period of 25.000 hours is used as reference time to evaluate the components of the insulating system of an electric motor or generator. For organic insulating materials, Montsinger found a mathematical interrelationship, based on statistics, which today is still essentially applied for inorganic insulating materials: "If the permissible temperature is continuously approx. 10 K higher, then the lifetime is halved." For the "DURIGNIT 2000" insulating system materials used for Siemens standard motors, the permissible limit temperature lies significantly above the continuous temperature which occurs under normal load conditions. Corresponding to the mathematical interrelationship which Montsinger determined, then the lifetime must also be increased by a multiple. In practice, the lifetime of the insulating system for Siemens standard motors can be neglected.

Roller bearings

The nominal (calculated) lifetime of a roller bearing also depends on the particular load and the speed. For standard Siemens motors, this lifetime is 40.000 operating hours under the assumption that there is a coupling out-drive. The larger the bearing, then the higher the churning work and grease consumption. However, consistent lubrication properties are a prerequisite for a high bearing lifetime.

Relationship between load and lifetime:

The lifetime of a bearing always depends on the load. The interrelationship is as follows:

a ) for ball bearing $$L = \left(\frac{C}{P}\right)^3 \quad \text{or} \quad L_h = \frac{1000000}{60n}\left(\frac{C}{P}\right)^3$$

b) for roller bearing $$L = \left(\frac{C}{P}\right)^{10/3} \quad \text{or} \quad L_h = \frac{1000000}{60n}\left(\frac{C}{P}\right)^{10/3}$$

whereby P is the equivalent load of the bearing in kg.

The expression P is known as "Loading ratio".

In order to simplify the calculation, generally, the required loading ratio for any lifetime (L) in millions of revolutions for ball bearings and roller bearings can be taken from tables. Furthermore, bearing catalogs generally include tables listing the associated values of lifetime (Lh) and the loading ratio for various speeds (n) for ball bearings and roller bearings.

# Line supply (UK: Mains)

Electric power is transmitted from the power station to the loads through the line supply (UK: Mains).

A differentiation is made between tree-type and radial line structures which transfers the power to the load and the ring-type line supply where the load can obtain power through two routes. For ring-type line supplies and for further sub-divided meshed line supplies, when a fault develops, the power feed is not interrupted.

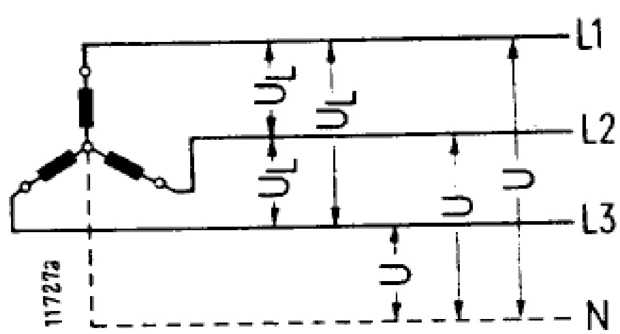
Three-phase low-voltage line supplies (up to 690 V) comprise 3 main phases (conductors) and are either with or without neutral point conductor N. Neutral conductors are connected at the neutral point of the generator or transformer on the low-voltage side.

When the 3 phases are evenly loaded, current does not flow through the neutral conductor.

If the load is not even, a current flows through the neutral conductor which is the geometrical sum of the 3 phase currents.

2 main phases alone or one main phase with neutral conductor form a single-phase AC line supply.

The voltage between 2 main phases (L1, L2, L3) is the phase-to-phase voltage.




The voltage between a phase conductor and the neutral conductor (N) is the neutral to phase voltage.

230 V, 400 V and 690 V are specified in DIN IEC 38 as preferred values for the line supply voltage.

The frequency in the public line supply and in industrial line supplies in Germany is 50 Hz.

(also refer to Operating circuit)

# Load torque

A differentiation is made between

**a) Load torque as a function of the time.**

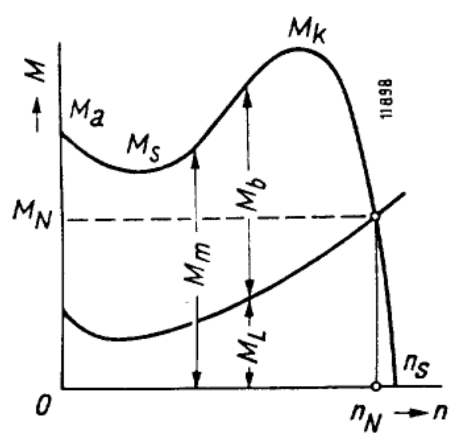
This is important when determining rated operation or the rated power of the motor (also refer to Duty types)

**b) Load torque as a function of the speed.**

This is important when evaluating motor starting.

**1. The torque is practically constant, the output is proportional to the speed.**

This applies to, for example, cranes, reciprocating pumps and compressors when transporting or pumping medium against a constant pressure, positive-displacement blowers, rolling mills, conveyor belts, crushers without fanning action, machine tools with constant cutting force, machines to overcome the force of gravity: Shears, punches, wood grinding machine can also approximately have this torque characteristic.

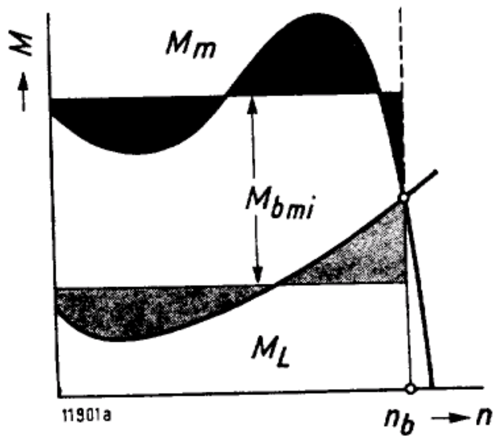



$M_N$ = rated torque
$M_m$ = motor torque (mean value)
$M_L$ = load torque (mean value)
$M_b$ = acceleration torque
$M_a$ = locked rotor torque
$M_k$ = break down torque
$M_s$ = pull-up torque
$n_N$ = rated speed
$n_s$ = synchronous speed

Fig. 1 shows the typical torque characteris three-phase asynchronous motor. The loa torque of the driven machine counteracts motor. The motor torque must be larger t the load torque over the whole range of t speed because the drive can only run up t

**2. The torque increases in proportion to the speed - the power proportional to the square of the speed.**

Machines to smooth material webs and paper, also hot presses, calenders.




$M_m$ = motor torque (mean value)
$M_L$ = load torque (mean value)
$M_{bmi}$ = average of acceleration torque
$n_b$ = operation speed

In general it is sufficient to know the averag the acceleration torque for the calculation c the starting time, which is done as follows (s also fig. 2).

A horizontal line is drawn through the torq characteristic of the motor as well as of the in that way that the upper and the lower cu area of each curve has exactly the same size average of the acceleration torque than is t difference of the average of the motor torq and the load torque $M_{bmi} = M_m - M_L$.

**3. The torque increases to the square of the speed - the power is proportional to speed to the power of three.**

This torque characteristic applies for centrifugal pumps, fans, reciprocating machines which pump a medium in an open pipe. (Against a closed valve, the final value is approx. 50 % of the final value when the valve is open.) Machines with a centrifugal effect; also ships drives, mixers, centrifuges and for straight-line motion against air resistance.

**4. The torque decreases inversely proportional to the speed - the power remains constant.**

This only applies for closed-loop controlled operation. It applies to lathes and similar machine tools, winders and rotary peeling machines.

In the above mentioned cases, the average torque (Mm) is calculated from the torque after ramp-up has been completed (Me) as follows:

1) Mm = Me
2) Mm = Me/2
3) Mm = Me/3

(also refer to Duty types, Torque)

## Locating bearings

1LA7,1LA6, 1LA9 and 1MA7 motors up to frame size 132 M do not have locating bearings. The bearings on the drive side are pre-loaded. For frame sizes 160 M to 315 L and for all 1MJ6 motors, a locating bearing is installed at the non-drive end (NDE) and a floating bearing at the drive end (DE). This is a pre-loaded deep-groove ball bearing. Versions with cylindrical roller bearings are the exception.

When required, for various motors, it is possible to provide a bearing design where the bearing cover presses against the locating bearing where the outer bearing race at the non-drive end (code L04) or a locating bearing at the drive end (code K94).

# M

## Magnetically operated brake

When braking according to the working current principle, the brake is only actuated using magnetic force when the motor is powered-down. The magnitude of the braking torque is defined by the magnitude of the voltage which is applied. Braking is not possible when the power fails. This type of braking is not suitable for cranes and emergency braking operations when the power fails.

(also refer to Fail-safe brake)

## Moment of inertia

The moment of inertia for rotary motion corresponds to the mass for linear motion. It indicates the inertia with which the moved body opposes a change in the rotary motion. For example, the higher this moment of inertia, then the longer it takes to reach a specific speed with the same accelerating torque.

The moment of inertia is the sum (integral) of all parts which make up the body, each multiplied by the square of its distance to the axis of revolution.

If a total mass m is considered in a ring, which cannot expand, with the ideal distance ri from the axis of rotation, then the following is obtained

$J = m \times ri^2$ (kgm²)

As the mass m (kg) has the same numerical value as the previous force due to weight G (kp) and because
r = D/2, then the following also applies

$$J = \frac{GD^2}{4}$$

J = moment of inertia in kgm²

GD² = flywheel effect in kpm²

(also refer to Starting time, Switched operation)

## Modular mounted components

The motors can be used in a significantly wider range of applications by mounting the following modules (e.g. as brake motor):

rotary pulse encoder

or separately-driven fan

or brake

or a combination.

For 1LG motors, options G17 (mounted separately-driven fan), G26 (mounted brake) can be combined with all of the tachometer/encoder options (H57,H58,H70-H80).

For safety-related reasons, the brake may only be mounted in the plant. The rotary pulse encoder and/or the separately-driven fan can also be subsequently mounted (retrofitted). When modular components are mounted, the motors have an IP55 degree of protection.

## Motor protection

Protective equipment and devices which provide protection against thermal motor overload:

1. Current-dependent protective devices, which directly monitor the motor winding temperature using the current flowing in the feeder cable. In this case, a current-dependent image of the motor temperature rise is generated. Overcurrent relays (bimetallic) are used with contactor and series fuse or overcurrent release in a motor protection circuit-breaker.

2. Temperature-dependent protective devices as thermistor motor protection. PTC temperature sensors, integrated in the motor winding, directly monitor the motor winding temperature. At the nominal response temperature for each integrated PTC thermistor, the resistance rises significantly and results in the motor being tripped.

The 3UN6, 3UN8 and 3UN9 tripping units are suitable for all PTC temperature sensors used. They operate according to the closed-circuit current principle.

For more detailed information, refer to Catalogs M 11 and NS 2.

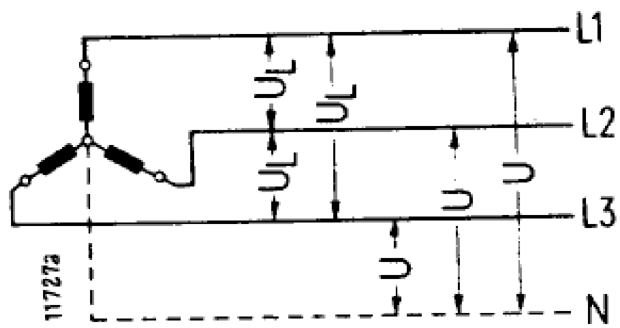
For PTC temperature sensors (these are predominately used for special-purpose machines), the response temperature can be subsequently adjusted at the tripping unit.

In some cases, other temperature monitors are used for motor protection which operate using the bimetallic principle.

Motor range according to CEMEP and EPACT

## Motor running connection

The line frequency in Germany is 50 Hz. The voltage between two main (phase) conductors (L1L2L3) is the phase-to-phase voltage VL (phase-to-phase voltage, line supply voltage). The voltage between a main (phase) conductor and the neutral conductor is the phase-to-neutral voltage VPh (also called the line-to-neutral voltage). The following interrelationship exists VL = 1.73 x VPh

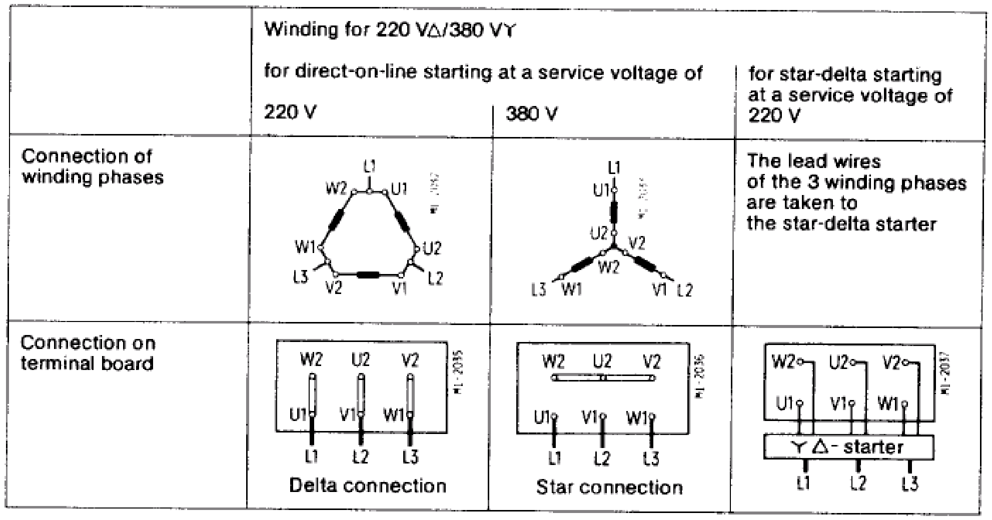



(Fig. 1)

The three starting points of the winding (U1, V1, W1) and the three end points (U2, V2, W2) are fed to the six terminals in the terminal box. There, the three main conductors (L1, L2, L3) are always connected with the starting points of the phases.

If the ends of the phases (U2, V2, W2) are connected together, then the motor is in a star (Y) connection. The sum of the voltages and currents is zero at the neutral point (star point), the phase voltage is connected across the phase resistance. The motor current is the current in the winding phase.

If the end of one phase is connected with the start of the next phase, then the motor is in a delta (D) circuit configuration. The line supply voltage is connected across the phase resistance. The motor current is obtained from the geometrical sum of two phase currents (Fig. 2).




(Fig. 2)

These interrelationships clearly show that a motor in a Y connection can be connected to a 400 V line supply and in a D circuit configuration, can be connected to a 230 V line supply. Approximately the same current flows in the winding phase in both cases. The same is essentially true for the new preferred voltages 690 V (Y) and 400 V (D). If the alphabetical sequence of the terminal designations (U1, V1, W1, U2, V2, W2) coincides with the sequence of the phases over time, then the motor should rotate in the clockwise direction of rotation. Two outer cables must be interchanged if the motor is to rotate counter-clockwise.

In accordance with VDE 0530, the terminal box must have a terminal to connect the protective conductor. Motors with rated outputs above 100 kW must additionally have a grounding (earthing) stud at the frame.

## Motors with thermally critical rotor

A thermally critical rotor means that the rotor reaches the permissible limit temperature earlier than the stator. PTC temperature sensors, integrated in the stator winding, respond too late to protect the rotor. This means that the rotor temperature can be significantly higher than that of the stator which can result in a noticeable reduction in the motor lifetime. This is especially the case if the motor is powered-up from the cold condition with the rotor locked.

(also refer to Motor protection, Motors with thermally critical rotor)

## Motors with thermally critical stator

If the stator of a motor reaches its maximum temperature faster than the rotor, then this involves a motor with a thermally critical stator.

(also refer to Motors with thermally critical rotor, Motor protection)

# Mounting the coupling halves

## and other machine elements in the motor plant

It is fairly straightforward to mount the coupling halves to the shafts of motors with deep-groove ball bearings. The additional price depends on the amount of labor and the number of units involved. For motors with cylindrical roller bearings on the drive end, it is not possible to mount coupling halves on the motor shaft end in the plant. This is because the motor has to be equipped with special rotor support elements in order to avoid damage to the bearings (scoring).

The following must be observed for couplings, belt pulleys or other machine elements:

1) The fit must be according to that specified in the dimension drawings/sheets

2) Balancing

When mounting and removing coupling halves and bearings at the customer's site, suitable equipment must be used; hammers should not be used!

All of the motors have a centering thread (DIN  332) in the shaft face to facilitate mounting machine elements.

## MRPD
### Machine Readable Product Designation

Type designation and Order No. for quotation and contract administration, or communications involving ordering and invoicing, for work scheduling, for warehouse planning, as well as for reporting based on serial numbers.

The meaning of the individual code numbers is only valid in conjunction with the previous code numbers.

Example:
1st block:

| | |
|---|---|
| 1st position, e.g. | 1 = electrical machinery |
| 2nd position, e.g. | L = totally enclosed fan cooled motors |
| 3rd position, e.g. | A = basic version, squirrel-cage induction motor |
| | P = basic version, squirrel-cage induction motor, non-ventilated without fan |
| 4th position, e.g. | 7 = series 7 |
| 5th and 6th position, e.g. | 16 = shaft height 160 |
| 7th position, e.g. | 0 - 2= length S of the particular frame size |
| | 3 - 5 = length M of the particular frame size |
| | 6 - 8= length L of the particular frame size |

The second block can only be taken, for a specific motor version, from the price list or from a quotation. Under no circumstances can it be generated, e.g. based on other versions.

In order to be able to electronically administer customer requirements which frequently occur, for many special versions, so-called normalized ordering data are defined. In this case, a -Z is added to the 13th position of the Order No. (K17 = radial sealing ring).

Example: 1LA7 166-8AB40-Z
K17

## Multi-voltage motors

If the line supply voltage is not known when the motors are ordered, then versions for two voltage can be ordered. It is then possible to change between the two voltage levels (also refer to Catalog M1).

The simplest voltage changeover is for a motor with a 230V Δ / 400V wound motor which can be operated in a delta circuit configuration on a 230V line supply as well as in a star circuit configuration on a 400V line supply. The same is true for 400/690V.

A multi-voltage 220/440V version is often required for 60 Hz line supplies.
In this case, the motor can be provided with a non-standard 220/440V YY/Y winding and requires one terminal box with 9 terminals.

If a Y/Δ starting is required for both voltages, the motor must have a terminal box with 12 terminals and is Y/Δ started for 220V with YY/ΔΔ and for 440V with Y/Δ.

(also refer to Running connection, Frequency changes, Voltage changes)

# N

## National and international regulations

Significance of frequently used abbreviations and the most important testing bodies for certification.

| Abbreviation | Significance and brief explanation |
|---|---|
| ABS | American Bureau of Shipping: Ships Classification Society with US as the country of origin. |
| ABNT | Brazilian Standards, e.g. frame size 71 with an output of frame size 80.<br>We cannot acknowledge this Standard |
| ANSI | **A**merican **N**ational **S**tandards **I**nstitute: This publishes regulations and Standards for almost all subject areas (not only for electrical and electronic engineering).<br>For motors, ANSI essentially uses the American NEMA and UL regulations.<br>ANSI C 52.1-.... corresponds to NEMA-MG 1 |
| API | **A**merican **P**etroleum **I**nstitute: American Institute for Oil<br>API 670 (or another). We cannot acknowledge these regulations |
| AS | **A**ustralian **S**tandard: In some instances this has been harmonized with IEC |
| ASTM | **A**merican **S**ociety for **T**esting and **M**aterials<br>We cannot offer any ASTM certificates |
| BASEEFA | **B**ritish **A**pprovals **S**ervice for **E**lectrical **E**quipment<br>British Certification Society (just the same as the PTB in the Federal Republic of Germany)<br>We cannot offer any BASEEFA certificates |
| BKI | Hungarian Certification Society, Hungary<br>We cannot offer any BKI certificates |
| BS | **B**ritish **S**tandard: In some instances this has been harmonized with IEC |
| BV | Bureau Veritas: Ships Classification Society, country of origin, France |
| BVS | Berggewerkschaftliche Versuchsstrecke, Dortmund-Derne [Experimental facilities for mining equipment] |
| CEB | Corresponds to BEC, Comite' Electrotechnique Belge, Brussels: Electrical and Electronic Engineering Committee Belgium |
| CEI | Comitato Elettrotecnico Italiano: Italian Electrical and Engineering Association |
| CEI | Corresponds to IEC, Commission Electrotechnique Internationale, Genf [Geneva] |
| CEMEP | **C**ommittee **E**uropean of **M**anufacturers of **E**lectrical Machines and **P**ower Electronics / **C**omite **E**uropeen Constructeurs de **M**achine **E**lectriques et d'Electronique de **P**uissance<br>EFF1 and EFF2 motors according to the CEMEP agreement, minimum efficiencies for 2 and 4-pole motors from 1.1 to 90kW<br>Efficiency is determined according to EN 60034-2 |
| CENELEC | European Committee for Electrical Standards (General Secretary is headquartered in Brussels) |
| CSA | Canadian Standards Association: This issues regulations and Standards and also issues certificates |
| DEMKO | Danmarks Elektriske Materielkontrol: Danish Regulatory Body for electrical |

| | |
|---|---|
| | equipment, which publishes regulations and issues certificates |
| DIN | Deutsche Industrienormen [German Industrial Standards] |
| EEMAC | **E**lectrical and **E**lectronic **M**anufacturers **A**ssociations of **C**anada: (previously CEMA) and comparable with NEMA |
| EEMUA 132 | This regulation includes three-phase motors, general<br>(also refer to: OCMA = EEMUA)<br>We cannot acknowledge EEMUA, our motors are in compliance with<br>EN 60 034, IEC 60 034, previously VDE 0530 |
| EN | **E**uropäische **N**orm [European Standard] |
| EPACT | **E**nergy **P**olicy **Act** of 1992<br>This US Act specifies minimum efficiencies<br>for motors, type of construction IM B3 up to 160kW<br>We can also acknowledge this regulation (for 60Hz) for our motors<br>in compliance with EPACT |
| EVPU | Slovakian Certification Society (Slovakia)<br>We cannot offer any EVPU certificates |
| FTZU | Czech Certification Society (Czech Republic)<br>(the same as the PTB in the Federal Republic of Germany)<br>We cannot offer any FTZU certificates |
| GL | Germanischer Lloyd: Ships Classification Society, country of origin, Federal Republic of Germany |
| GOST - R | Certification according to GOST -R - Standards in Russia<br>We have the necessary GOST certificates, refer to the INTRANET |
| IEC | International Electrotechnical Commission: All of the large industrial nations participate in the International Electrotechnical Commission. The IEC recommendations, which are drawn-up there, are, to some extend, directly used in the national regulations, or, in some cases, the national regulations are essentially harmonized to the IEC Recommendations |
| IS | Indian Standard: In some instances this has been harmonized with IEC |
| IEEE | Institute of Electrical and Electronical Engineers<br>The IEEE also issues regulations and rules.<br>We can acknowledge the measurement of efficiency for EPACT motors<br>in compliance with IEEE 112b |
| IPS | Iran Petroleum Standards<br>We cannot acknowledge these Standards |
| ISO | International Organization for Standards |
| JIS | Japanese Industrial Standard |
| KEMA | Keuring van Elektrotechnische Materialien: Testing body in The Netherlands for electrical equipment, among others, CSA certification for European manufacturers<br>The abbreviation KEMA S 17 means a special motor version (on request) |
| LRS | Lloyd’s Register of Shipping: Ships Classification Society, country of origin, Great Britain |
| NBN | Belgium Standards: Issued by the Institute of Belgium Standards (this has to some extent been harmonized with IEC) |
| Abbreviation | Significance and brief explanation |
| NEC | National Electrical Code = ANSI C1 |
| NEMA | National Electrical Manufacturers Association |
| NEMA-MG1 | NEMA Standards Publication-Motors and Generators: = ANSI C 52.1.... |

| | |
|---|---|
| NEMKO | Norges Elektriske Materiellkontroll: Norwegian testing body for electrical equipment, publishes regulations and issues certificates |
| NEN | The Netherlands Standard: Standards in The Netherlands |
| NF | Norme Francaise: French Standards |
| NFPA | National Fire Protection Association |
| NK | Nippon Kaiji Japan Marine Association |
| NPT | USA Standard Taper Pipe Threads: This corresponds to USAS B 2.1... |
| NV | Det Norske Veritas: Ships Classification Society, country of origin, Norway |
| NEC | National Electrical Code = ANSI, C1 |
| OCMA | Oil Companies Materials Association |
| ÖVE | Österreichischer Verband für Elektrotechnik: ÖVE regulations essentially coincide with VDE and IEC |
| PRS | Polski Rejestre Statkow: Ships Classification Society, country of origin, Poland |
| PTB | Physikalisch-Technische Bundesanstalt, Braunschweig [Physical Technical Office, Braunschweig] |
| REGO | Richtlijnen voor de samenstelling en de beproeving van Elektrisch materieel in verband met Gasontploffingsgevaar, Nederland: Directives for the manufacture and testing of electrical equipment for use in hazardous zones, The Netherlands |
| RINa | Registro Italiano Navale: Ships Classification Society, country of origin, Italy |
| SABS | South African Bureau of Standards |
| SASO | Saudi Arabian Standard Organization |
| SASOL | South African Standards for Oil companies<br>We cannot acknowledge these Standards |
| SEMKO | Svenska Elektriska Materielkontrollanstalten: Swedish testing body for electrical equipment, publishes regulations and issues certificates |
| SEN | Svensk Standard: Swedish Standards |
| SEV | Schweizerischer Elektrotechnischer Verein [Swiss Electrotechnical Committee] |
| UBC | Uniform Building Code<br>(regulations for seismic requirements for buildings)<br>We cannot acknowledge UBC |
| UL | Underwriters^ Laboratories, Inc.: Testing body for the domestic fire insurance in the US, which also tests all types of electrical equipment and publishes the appropriate regulations.<br>We can only offer the UL marking for 1LA / 1LG motors.<br>This is possible using Option D31 |
| UNI | Ente Nazionale Italiano die Unificazione: Italian Standards Office |
| UTE | Union Technique de l^Electricite: French Electrotechnical Committee |
| VDE | Verband Deutscher Elektrotechniker [Association of German Electrical Engineers] |

## NEMA regulations

NEMA = "National Electrical Manufacturers Association"

This Regulation (NEMA-MG1) which simultaneously applies for versions in accordance with ANSI C52.1, was published by the "Motor and Generator Section (MG1)" of the "National Electrical Manufacturers Association (NEMA)" which is made up of manufacturers of electrical machinery in the US.

The NEMA regulation was accepted as (domestic) regulation of the "American National Standards Institute (ANSI)" taking into account the requirements of a wide group of interested parties (users/consumers, power utility companies etc.).

This regulation was also accepted by the Canadian EEMAC (Electrical and Electronic Manufacturer of Canada).

NEMA or EEMAC Regulations forms the basis for the CSA Regulations. As far as motors are concerned, there is no difference between NEMA MG1 and the CSA Regulations.

Standard Siemens motors can be realized electrically in accordance with NEMA; this is not possible mechanically, as the dimensions for an IM B3 type of construction deviate significantly from the NEMA dimensions (imperial dimensions).

The required, permissible voltage deviation is ± 10 %. When the tolerance is fully utilized, NEMA takes into account that the lifetime will be shorter, it is still possible to order motors with the full 60 Hz power. The required "Service Factor" is

for IP44 motors (TEFC) 1.0

for IP23 motors (ODP) 1.15.

Frequently, for special requirements, a Service Factor of >1 is requested also for IP44 motors. Special measures are required in these cases (e.g. a higher insulation Class).

(also refer to CSA)

## Nominal values

In compliance with the new VDE 0530, Part 1 from July 1991, all nominal values are re-named as rated values. The rated values are motor data under rated operating conditions, i.e. operating at rated power and maintaining the external operating conditions, for example

- Rated speed
- Rated frequency
- Rated output
- Rated power factor
- Rated voltage
- Rated current
- Rated torque

etc.

## Non-sparking version

### Zone 2 in compliance with IEC 60 079-15 for motors connected directly to the line supply

Also designated as type "N" in BS 5000 Point 16 and which is distinguished by 4 essential requirements:

1. Terminal boxes must have degree of protection IP 54.

2. Terminals must be secured so that they cannot release themselves, specified air and creepage distances must be maintained.

3. Air gaps and clearances between rotating parts must be maintained. Components used in the cooling/ventilation system must be of a heavy-duty design.

4. The maximum permissible temperature limits may not be exceeded, e.g. for temperature Class T3 200 °C.

Our 1LA standard motors, in the standard version, fulfill these requirements.

Regarding 3) Fan and fan cowl with special material combinations are only required in the US, in some customer specifications and in some instances, in France and Italy. Thermoplastic fans fulfill this requirement. Special measures are required for other fans.

Type of protection Ex nA II T3 is specified in IEC 60079-15. The same measures apply as for DIN VDE 0165. This is not possible for 1LA5 motors and 1LA6 motors are supplied instead. The motors have an external grounding (earthing) terminal.

A PTB certificate is available. Ambient temperatures, -20 °C to +50 °C. The rating plate and the supplementary label have the following text: Ex nA II T3 acc. to IEC 60 079-15.

## Noise

Limit values for the sound power level of electrical machinery are specified in DIN VDE 0530, Part 9.

The noise level measuring techniques for rotating electrical machinery are defined in DIN 45 635, Sheets 1 and 10.

In order to define the motor noise level, the A-weighted sound pressure level (LA) is measured at several points on the measuring plane (1 m from the motor surface). The measurements are made in low-reflection rooms. The sound level can be increased by up to 3 dB(A) as a result of noise reflection, depending on the acoustic properties of the surroundings.

The measuring units are decibels and today, the sound power level is, due to international definition, exclusively evaluated with the evaluation characteristic A according to DIN 45 633 (dB(A)).

The A sound power level is normally used when engineering a drive system if it is necessary to determine the noise radiated from a group of machines whose envelope dimensions differ significantly. The sound power cannot be measured but is calculated from

LWA = LpA + LS (dB(A)).

| | | |
|---|---|---|
| LWA | = | A sound power level |
| LpA | = | sound pressure level |
| LS | = | measuring surface dimensions |

The measuring surface dimension is the logarithmic ratio between the measuring surface and the 1 $m^2$ reference surface.

There is generally a + 3 dB(A) tolerance for the sound pressure level values due to uncertainty in the measurement and production tolerances.

The human ear perceives an increase of approx. 8 to 10 dB(A) as double the noise level,

and a reduction of approx. 8 to 10 dB(A) as half the noise level.

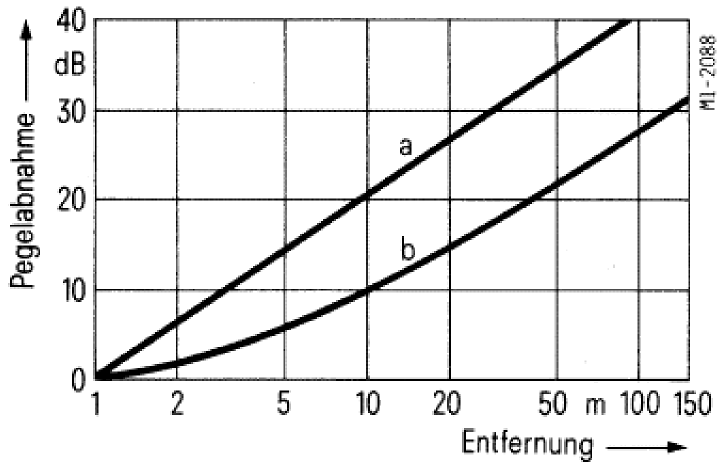
The motor noise comprises:

Magnetic noise

Bearing noise

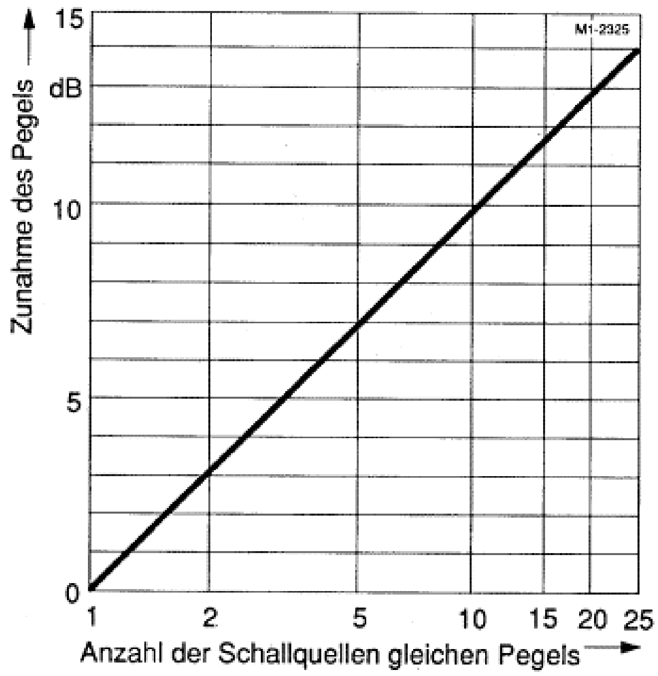
Fan noise

The fan noise dominates for 2-pole motors. For higher-pole and pole-changing motors, the magnetic noise can be dominant.

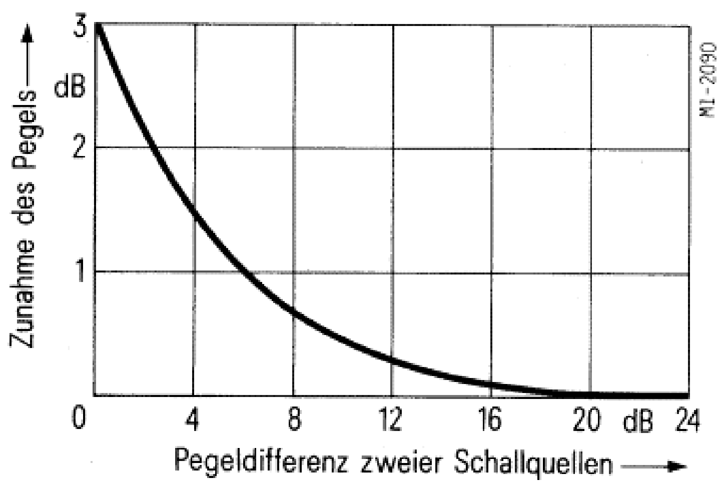



a ohne Reflexion
b mit teilweiser Reflexion

Abnahme des Schalldruckpegels $\overline{L}_{pA}$ mit der Entfernung




Zunahme des Pegels




Zunahme des Schalldruckpegels $\overline{L}_{pA}$ bei 2 Schallquellen unterschiedlichen Pegels

# No-load starting time

The no-load starting time of electric motors has only limited significance. It can be calculated using the following equation.

$$t_A = \frac{J \times n}{9{,}55 \times M_{mot}}$$

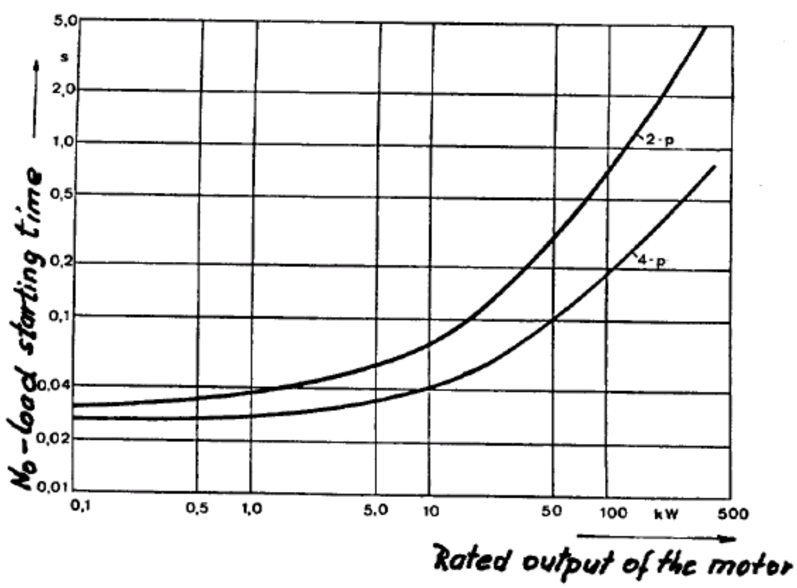
tA = starting time in seconds

J = moment of inertia in kgm2

n = operating speed in RPM

Mmot = average starting torque in Nm

Typical values from the following diagram.




(also refer to Starting performance)

## No-load current

If an electric motor is connected to a line supply without load, then the no-load current flows. It mainly comprises the magnetizing current and a low load current to overcome friction. It is approximately proportional to the voltage change to the power of three. For small motors, the no-load current is relatively high up to approx. 90% of the rated current.
For large motors, it is approximately 30-40% of the rated current.

# O

## On time

The relative On time (operating time, running time) is the percentage of the time with constant load compared to the complete duration of a duty cycle.

$$t_r = \frac{\text{time with constant load}}{\text{time with constant load} + \text{time without current}} \times 100\ \%$$

VDE 0530 recommends the following values for the On time: 15, 25, 40 and 60 %.

If not otherwise specified, the duty cycle time is 10 minutes.

The relative On time as a percentage is specified between the code for the rated duty type and the duty cycle time in minutes, e.g. S 3 : 25 %, 12 min.

The lower the relative On time, then the rated output can be increased that much more with respect to continuous duty, whereby for standard designs, the stall torque must be observed (according to VDE, 160 % of the rated torque). Motors for crane operation have a special design.

(also refer to Duty types)

## Open-circuit cooling

For motors with open-circuit cooling, the heat is dissipated to the flow of cooling air, which is continually renewed. The degrees of protection which can attained are either IP 23 or IPR 44 (pipe connection).

Advantage: rated output — The cooling airflow directly reaches the heat sources. This means a higher with respect to enclosed motors having the same frame size.

Disadvantage: Lower degree of protection (IP23); lower possible loads when starting and at lowerspeeds (drive operation).

## Overload capability

The permissible continuous load of a motor should correspond to its rated output. Motors up to 315 kW can briefly have 150 % current at the rated voltage for 2 minutes according to VDE 0530.

The 5 % voltage reduction, permissible according to VDE 0530, corresponds to a continuous overload condition of 5 %.

According to Montsinger, a permanent winding temperature increase of approx. 10 K reduces the lifetime by 50 % (statistical values).

(also refer to Service factor)

# P

## Paint finish

1) Durability

A  Standard paint finish

Suitable for the "Moderate" climate group in compliance with IEC Publication 721-2-1 (Edition 1982). Thermal endurance:100 °C continuous, 120 °C briefly.

B  Special paint finish

This is suitable for the "Worldwide" climate group in compliance with IEC Publication 721-2-1 (Edition 1982). It is essentially resistant to aggressive chemicals. According to the test certificate of the Gesellschaft für Kernforschung mbH, it can also be de-contaminated (the test is not available for 1MJ2). Thermal endurance:120 °C continuous, 140 °C briefly.

Suitable for climate groups according to IEC Publication 721-2-1.

"Moderate"

for indoors and outdoors use

Briefly:
Up to 100 % relative air humidity at temperatures up to + 30 °C

Continuous:
Up to 85 % relative air humidity at temperatures up to + 25 °C

"Worldwide"

for outdoors installation

Briefly:
Up to 100 % relative air humidity at temperatures up to +35 °C

Continuous:
Up to 98 % relative air humidity at temperatures up to +30 °C

2) Toxicity

The paints used do not contain hazardous substances such as cadmium, lead and their compounds or chromates.

3) Treatment of unpainted materials

Gray cast iron and steel parts are sand-blasted (0.9 to 1.2 mm grain size).
Steel surfaces correspond to degree of purity Sa 3 (bare metal)
Gray cast iron, degree of purity Sa 2 1/2 (pure metal) in compliance with SIS 055 900.
Aluminum parts are de-burred using sandblasting, de-greased and passivated.

4) Basic primer

a)  For silumin frames, no primer is applied.

b)  For gray cast iron frames, alkyd resin with active and paint pigments.

c) For steel components of 1MJ2 motors, single-component primer on a polyvinyl-butural basis.
Coat thickness when dry, 30 µm (1MJ2 motors 25 µm)

5) Standard paint finish

a) 1LA5, 1LA61, 1LA7, 1LA9 up to shaft height 225: Special paint finish, standard version

b) 1LA6 shaft height 225 and 1LG shaft height 180-315: On an alkyd-resin basis

c) MJ2 motors, 2 component paint on an acryl-resin basis.
Total coat thickness when dry:

a: 30 µm
b: 60 µm
c: 70 µm

## 6) Special paint finish

a) Motors up to 1LA5, 1LA6, 1LA7, 1LA9 to shaft height 225
have a final paint finish using a 2-component epoxy-resin basis paint

b) Motors from 1LA6, shaft height 225 and 1LG, shaft heights 180-315
have an intermediate paint coat on a polyurethane basis
color, RAL 7001 and a final paint finish on a polyurethane basis

c) 1MJ2 motors have a 2-component paint finish on an epoxy-resin basis.
Total coat thickness when dry:

a: 60 µm
b: 90 µm
c: 70 µm

## 7) Testing and incoming check

### A Testing

The usability and durability of paint finishes are proven in laboratory investigations and tests under outdoor conditions in marine and in industrial climates (chemical industry) on test metal sheets and workpieces with the specified coating thicknesses. These tests have been confirmed with excellent experience with these paints in the field over many years.

### B Incoming check

The following incoming checks are continually carried-out:

a) Pigments, identification and quantitative evaluation (wet-chemical),

b) Binding agent, identification (IR - spectroscopically),

c) Drying and hardening characteristics, determining the drying time and the degree of hardening (differential thermo analysis).

## 8) Ability to be painted

### A Basic primer

If motors are only ordered with primer, customers can apply the following paint types:

a) Epoxy resin/polyamide two-component paints (also for 1MJ2 motors)

b) PUR paints (also for 1MJ2 motors)

c) Chlorinated rubber paints

d) Paints, based on vinyl-copolymerization

e) Synthetic resin paints

f) Paints with a combination of synthetic resins

g) Paints based on cyclo-rubber/oil combinations.

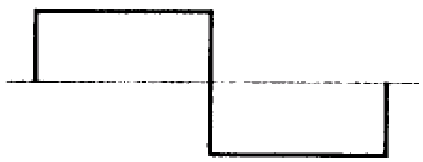
### B Standard paint and special paint finishes

After the surface has been sanded and cleaned, it can be painted with a standard paint or the special paint using the paints specified under 8.1.

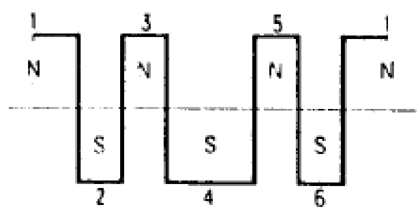
## PAM winding

PAM = Pole Amplitude Modulation

Only 1 winding as for a Dahlander circuit. For pole-changing motors, whose speeds are not in the ratio 1 : 2.



2 pole wave resulting from inversing of the current




With the PAM circuit (Rawcliff winding), the change in the pole number can be considered as a modulation of the original field excitation characteristic, caused by current reversal in the individual coil groups.

For example, if the current reverses in half of the winding in an 8-pole spatial field distribution (this corresponds to a modulating 2-pole wave), a 6-pole field distribution is obtained.

The irregularity (diagram) is compensated by a sophisticated winding design (irregular arrangement of the coil groups, coil groups with different numbers of individual coils, intermediate layer winding etc.). However, the harmonic content is still relatively high.

Excluding the actual manufacture, a PAM winding should be treated similar to a Dahlander winding. There is no difference when selecting the switching devices and applying it.

For individual frame sizes and speeds, a PAM winding allows the output to be increased by up to 60 %. This generally means a smaller frame size than for pole-changing motors with separate winding.

(also refer to Dahlander circuit, Pole changeover)

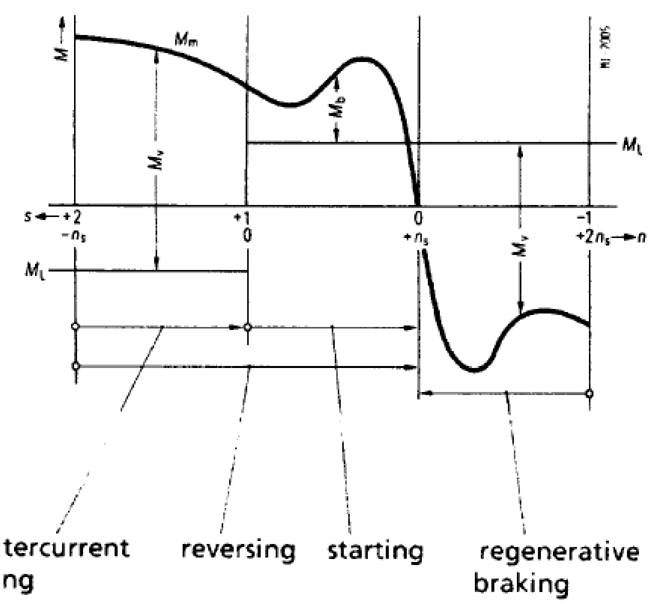
## Performance value (efficiency/power factor)

Efficiency and power factor can be improved by changing the motor magnetization. However, this also impacts other values. This is the reason that a statement regarding the performance value of a motor is only possible by specifying the product of efficiency and power factor.

| | | |
|---|---|---|
| $g = \eta \cos \varphi$ | g: | Performance value |
| | $\eta$: | Efficiency |
| | $\cos \varphi$: | Power factor |

## Plug-type braking

When two phases of a three-phase motor are interchanged, the motor direction of rotation reverses. If the phases are interchanged or switched-over while the motor is still spinning, then the motor rotor is braked by the torque of the rotating field which opposes the direction of rotation of the rotor. The motor must be shutdown at zero speed as otherwise the motor would accelerate in the opposite direction. This is realized using a speed monitor. The approximate torque characteristic with the rotor spinning in the opposite direction of rotation, i.e. for a slip of 2, is shown in the diagram.




Starting, braking, and reversing with squirrel-cage motors

$M_m$ - Motor torque
$M_L$ - Load torque
$M_b$ - Acceleration torque
$M_v$ - Retardation torque

For switched duty with plug-type braking each duty cycle has an accelerating phase and plug-type braking. Both of these phases are fairly close together. The switched operation can be calculated as S5 duty using the Z0 number.

$$Z = \frac{K1}{FI} \times Z_0$$

(also refer to Duty types, Braking)

## Pole changeover

If the stator of an asynchronous squirrel-cage induction motor is provided with windings for several pole numbers, then this motor can be operated in several, appropriate speed ranges.

If 2 windings are combined or a Dahlander circuit is used, 3 or 4 speeds are obtained.

(also refer to Dahlander circuit, PAM winding)

## Pole number

The synchronous speed of a three-phase motor is inversely proportional to the pole number 2p

$$n_s = \frac{120 \times f}{2 \times p}$$

E.g. a 2 pole (2p = 2; pole pair number p = 1) motor has a synchronous speed of 3000 RPM for a 50 Hz line frequency.

The most usual pole numbers are: 2, 4, 6, 8

Pole numbers 10 and 12 represent non-standard motors and must be inquired!

The most usual pole number is 4. The torque is approximately constant for the same motor frame size which means that the output is lower for higher pole numbers. The efficiency and cos phi are slightly poorer.

(also refer to Speed)

## Power

Power is the work done in a unit of time, measured in W (Watt).

For continuing motion, power (P) at a specific instant, it is the product of the effective force (F) and velocity (v)
P = F x v.

For rotary motion the following applies

$$P = Fr\varpi = M\varpi = 2\pi Mn$$

For constant force and constant velocity, the work done over distance (s) in the required time (t) is given by W = F x s. The constant power Pc = W/t is calculated from this.

Dimensions:

| | | |
|---|---|---|
| 1 W | = 1 J/s | (1 joule per second) |
| | = 1 Nm/s | (1 Newton meter per second) |
| | = 1 kgm²/s² | |
| | = 0.102 kpm/s | |

1 kW = 1.36 PS

The following applies for three-phase motors:

$$PN = \sqrt{3} \times U_{supply} \times I_{supply} \times \cos phi \times \eta$$

| | |
|---|---|
| PN | = rated output/power in W |
| U | = line suppy voltage in V |
| I | = line current in A |
| cos phi | = power factor |
| h (Eta) | = efficiency |

The rated output is one of the most important motor parameters. Certain powers are assigned to individual motor frame sizes for continuous duty S1 in accordance with DIN 42 673 - maintaining the regulations in compliance with VDE 0530. Deviating operating conditions or duty types generally result in a change in the rated output.

(also refer to Duty types, Switched operation)

## Power split

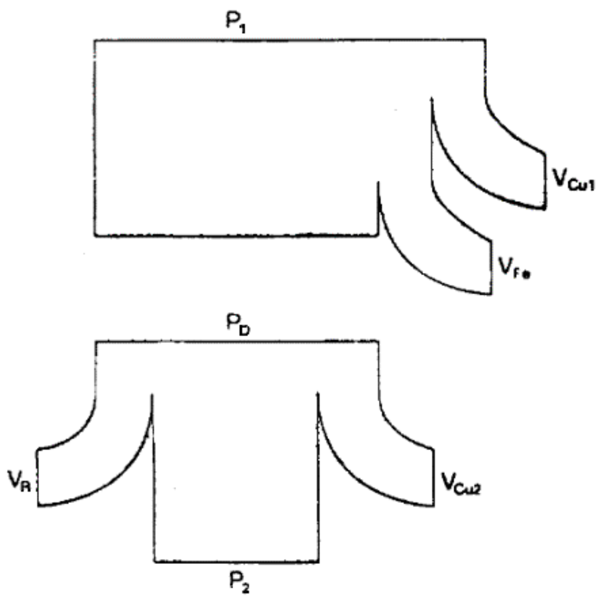
The power, for an asynchronous motor is split-up as follows:
The primary power P1 is drawn from the line supply by the stator. After the copper and iron losses in the stator have been subtracted (VCu1, VFe) the rotor power input PD remains.

$$P_D = P_1 - \left(V_{Cu1} + V_{Fe}\right)$$

The rotor power input is transferred into the rotor where it is split-up into the rotor losses (VCu2), the friction and fan losses (VR) and power P2 output at the shaft.

$$P_2 = P_D - \left(V_{Cu2} + V_R\right) \text{ mit } V_{Cu2} = s\,P_D$$

Further, P2 = h  P1.




$$P_1 = U\,I\cos\varphi$$
$$P_D = P_1 - (V_{Cu} + V_{Fe})$$
$$P_2 = P_D - (V_{Cu} + V_R)$$
$$\eta = \frac{P_2}{P_1}$$

$V_{Cu1} = 3\,I^2 R$ $\quad V_{Fe} = V_H + V_W$

$V_{Cu2} = s\,P_D$ $\quad V_R = V_{La} + V_{Lu}$

$V_H \sim f\,B^2$ $\quad V_W \sim f^2 B^2$

$V_{La} \sim n\,F_A$ $\quad V_{Lu} \sim n^2$

(also refer to Efficiency)

## Pre-loaded bearings

Every ball bearing has a small axial play. Often, only a low level of excitation is required to get the rotor in a motor to axially vibrate. This additional vibration is often associated with noise. A defined axial pressure is exerted on the motor rotor by pre-loading the bearings. This retains the rotor in a specific position. This therefore achieves a clearly defined steady-state bearing arrangement. The ball bearings are pre-loaded

using a spring and end float washer on the drive end of 1LA7/9, 1LA6, 1LG motors up to frame size 250 (normal version)

using end ring with spiral springs on the drive end of 1LA6, 1LG motors, frame sizes 280-315 (normal version)

(also refer to Bearings, Roller bearings)

## Protective canopy

Motors with a vertical type of construction and where the shaft end faces downwards (V1, V5, V8, V18) are often supplied with a protective canopy. This prevents small objects and tools falling into the various openings and fan.

For explosion-protected electrical machinery and the specified types of construction, a protective canopy is specified.

The effectiveness of the protective canopy to protect against the ingress of rain is only conditional. A special roof assembly is the preferred solution.

## Protective class

For example, protective Class 1 and 2 according to VDE 0730 "Regulations for electrical drives for household equipment".

The following applies:

Protective Class 1: Protected by a protective conductor

Protective Class 2: Protected by protective insulation
For example, the electrical part of the equipment is covered by a plastic housing or an enclosure so that it is not possible to come into contact with metallic parts.

(also refer to Grounding (earthing) stud)

## PTC thermistor (PTC)

PTC temperature sensors are mainly used for thermistor motor protection devices (alarm or trip). These PTC sensors are generally fixed to the winding overhang. This means that the stator winding is directly protected but the rotor winding only indirectly.

The temperature difference between alarm and trip is 10 K .
For example, option A12 means a 145°C PTC thermistor ( alarm ) and 155°C ( trip ).
At the particular response temperature, the nominal resistance of the sensor increases as a step function (jump). The tripping unit responds.

## Pull-in method

This is a method of winding coils. The coils, pre-wound at the same work location are drawn into the slots of the laminated core using a mandrel. This is realized in one operation and is an extremely modern cost-effective procedure for high unit quantities.

## Pumps

The motor power required to drive liquid pumps is calculated from the quantity to be pumped (delivery rate) and the delivery heights.

When reciprocating pumps start against a constant pressure, they have a high load torque. Reciprocating pumps are equipped with a flywheel due to the dead points in the motion cycle. It is important to check the pump starting characteristic together with the starting time.

When starting, centrifugal pumps have a torque characteristic which is proportional to the square of the speed. The moment of inertia is generally small in comparison to that of the motor so that starting times are even short when starting against a load.

# R

## Radial eccentricity

Tolerance N (normal) and tolerance R (reduced) are defined in DIN 42 955:

1. Radial eccentricity tolerance of the shaft end
2. Concentricity tolerance of the shaft end and the flange centering
3. Axial eccentricity tolerance of the shaft end and the flange surface

Regarding 1) Radial eccentricity tolerance of the shaft end:

| Diameter of the cylindrical shaft end according to DIN 748 Sheet 3 d (mm) | Radial eccentricity of machines with Tolerance N (mm) (normal) | Tolerance R (mm) (reduced) |
|---|---|---|
| up to and including 10 | 0.03 | 0.015 |
| above 10 to 18 | 0.035 | 0.018 |
| above 18 to 30 | 0.04 | 0.021 |
| above 30 to 50 | 0.05 | 0.025 |
| above 50 to 80 | 0.06 | 0.030 |
| above 80 to 120 | 0.07 | 0.035 |

IEC letter D

(also refer to Concentricity, Axial eccentricity)

## Radio interference suppression

VDE 0875 Part 3 "Radio interference suppression of electrical equipment and plants" applies for the radio interference suppression of electrical machinery.

Comment:
As a result of the laws regarding the operation of high-frequency equipment, the company operating a machine is responsible in ensuring that this machine does not disturb radio reception. If radio interference suppression is required, this must be discussed when the electrical machine (motor or generator) is ordered.

The following radio interference suppression levels are defined in VDE 0875:

Radio interference suppression level G is for coarse radio interference suppression
Radio interference suppression level N is for normal suppression
Radio interference suppression level K is for low suppression
Radio interference suppression level O designates equipment which does not cause radio interference (e.g. heating elements)

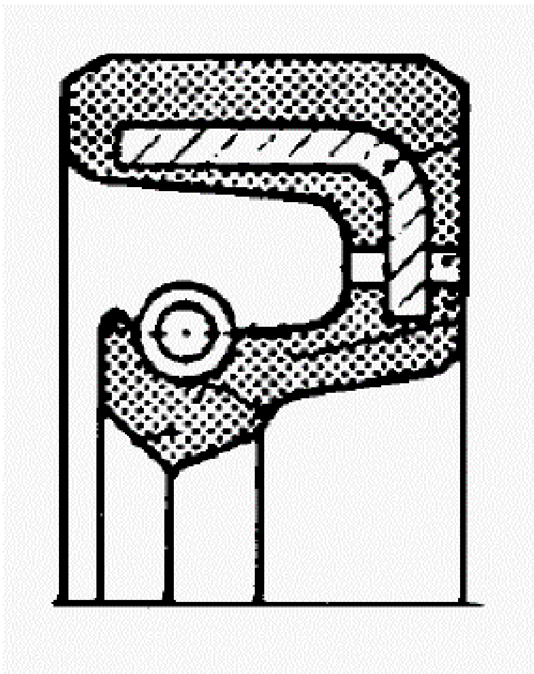
Machinery and equipment, which is installed in residential areas, must have radio interference suppression level N.

No specific radio interference suppression level is specified for industrial environments. If the electrical machines maintain suppression level G, then from experience, the level N for residential areas is also fulfilled.

Three-phase squirrel-cage induction motors are generally included in equipment which does not cause any radio interference. Squirrel-cage induction motors have radio interference suppression level K.

Three-phase motors with slipring rotor, supplied from Siemens have, in the normal version, a minimum radio interference suppression level of G.

## Radial sealing ring or Ina sealing ring



The radial sealing ring seals the bearing against the ingress of liquids, lubricating mediums, gases and vapors whereby its sealing lip is pressed against the shaft either using the pre-tensioned material or additionally by a small spiral spring. It is manufactured out of an elastic material. The radial sealing ring is inserted in the bearing endshield or the outer bearing cover of the drive end bearing.

The shaft surface must be finely polished to ensure that the sealing ring functions perfectly. Furthermore, during operation, cooling medium or lubricating medium (water, oil, grease etc.) must be permanently in contact with the ring.

## Rating plate

According to IEC 34-1 from 1969 and VDE 0530, the rating plate contains:

- Name of the manufacturer
- Production number
- Type of electrical machinery: Mot = abbreviation for motor
- Nominal duty type (there is no comment for continuous duty)
- Rated output in kW
- Rated voltage
- Rated current
- Current type (3± = abbreviation for three-phase current)
- Rated frequency
- Rated speed
- Insulation Class or limit temperature rise
- VDE regulations
- Type of circuit configuration (e.g. Y or D )
- Power factor
- For slipring rotors, secondary open-circuit voltage [wound-rotor motor: open-circuit voltage, secondary voltage] and rotor current
- Ambient temperature (no comment is made for KT 40)
- Installation altitude (no comment up to 1000 m)
- Weight of motors above 1000 kg (for VIK, the weight is stamped for motors above 100 kg)

Deviating from IEC, VDE 0530 also requires:

- Degree of protection
- Limit voltages with the associated data if the voltage range exceeds + 5 %
- For motors for several duty-type ratings, the rating plate data for every rated operation
- Special greases are specified for roller bearings which require special grease

For explosion-proof motors, the rating plate also specifies:

- No. of the PTB certification
- Temperature Class and for 1MJ motors, the explosion group
- For 1MA motors, the tE time and IA/IN

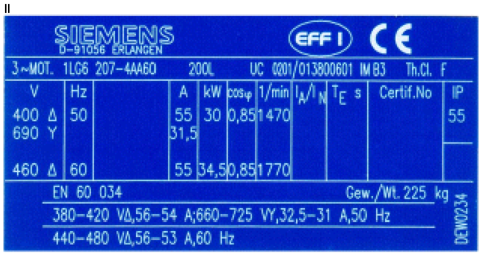
Stock motors have a rating plate for 50 and 60 Hz.

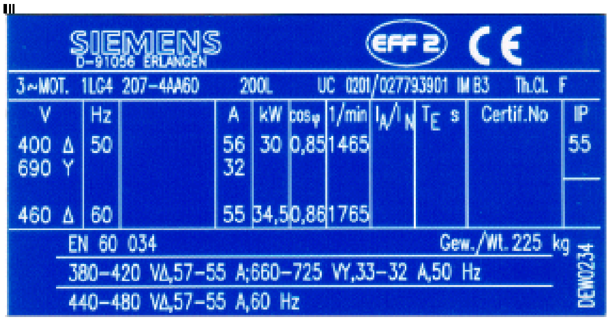
Rating plate materials:

EWN/MOH: Titanium-stabilized austenitic steel (X 10 CrNiTi 18 9) 0.5 mm thick

NMA/FRE: Chrome-nickel steel (X 5 CrNi 18 9) 0.8 mm thick.

Examples :




## Ratio

For gearboxes, the ratio i is the ratio between the driving (incoming) speed of shaft 1 and the outdrive speed of shaft 2.

i = n1 / n2

As far as the number of gearbox teeth the following applies:

i = z2 / z1

For diameters for belt drives the following applies:

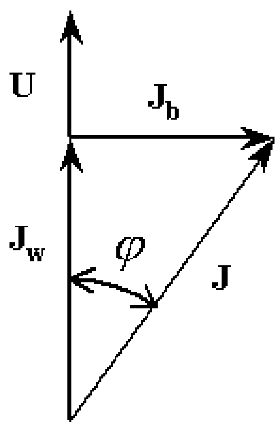
i = d2 / d1

The torque is increased in the same ratio in which the speed is reduced, i.e. with a ratio of i. For example, if a gearbox is used to reduce the motor rated speed from 1450 RPM to 500 RPM, then the rated motor torque at the gearbox shaft is increased to MN x i = MN 1450/500 = 2.9 MN.
At the same time, for decreasing speeds (outdrive speed), the moment of inertia, referred to the end of the motor shaft decreases to the square of the ratio.

(also refer to Starting time)

## Reactive current

The reactive current is that component of the motor current which is required to generate the magnetic field. This is also the reason that it is called the magnetizing current. It is phase-shifted by 90° with respect to the voltage (lagging, inductive). It is very dependent on the voltage due to the non-linear permeability. The reactive current (Jb) is obtained from the vector diagram as follows.




| | | |
|---|---|---|
| Jb | = | J x sin phi |
| Jb | = | J x square root of (1 - cos² phi) |
| Jb | = | reactive current in A |
| Jw | = | active current in A |
| cos phi | = | power factor |

## Reactive power

The reactive power is that component of the apparent power, drawn from the line supply, which is necessary to maintain the magnetic field in the motor.

$$Q = \sqrt{3} \times U \times I \times \sin phi$$

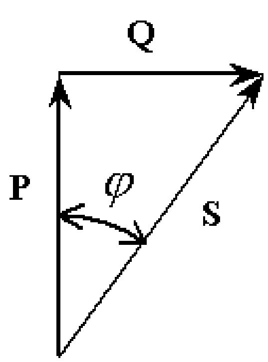
$$Q = \frac{P_N \times \sqrt{1 - \cos^2 phi}}{\eta \times \cos phi}$$

whereby:

| | |
|---|---|
| Q | = reactive power (kVar) |
| $P_N$ | = rated output of the motor (kW) |
| cos phi | = power factor of the motor (< 1) |
| $\eta$ | = efficiency of the motor (< 1) |

With partial load corresponding values for P and cos phi are to be applied).

The reactive power is created as a result of the phase shift of current J with respect to the voltage V. The interrelationship between the apparent power (S), drawn active power (P) (=rated output / efficiency) and reactive power (Q) is obtained from the diagram.




The reactive power means an additional load for all of the machinery, equipment and cables involved in transferring the electrical power, as the full current (apparent current) flows.

Companies must pay for the reactive power depending on the particular power tariff of the power utility company. This is the reason that for many line supplies, the power factor is improved by using the appropriate power factor compensation equipment (e.g. capacitors) (cos phi approximately 1).

(also refer to cos phi , Power)

## Reduction factor

The connection space in the terminal boxes and the terminals of standard motors are dimensioned for connecting cables which can conduct twice the rated current, referred to 380V.

This means that they fulfill the requirements according to "reduction factor 0.5".

Reason for requiring a reduction factor of 0.5:

The connecting cable cross-section must be dimensioned corresponding to the load tables listed in VDE 0271a for the maximum rated current which occurs at the rated voltage of the selected motor; furthermore, the voltage drop along a 100m long cable may not be more than 3% at the rated current; this cable must also be dimensioned for continuous load (reduction factor referred to the power utility load: 0.75) and when routed underground, it must be assumed that several cables will be routed together (reduction factor: approx. 0.67). When these are multiplied together, the product results in an overall reduction factor of 0.5.

## Reinforced bearings

When required, motors can be equipped with modified bearings on the drive end to handle increased cantilever forces, e.g. belt drives. This option involves an additional price. Please inquire for 1MJ6 motors, frame sizes 280 to 315 and for 1MJ8 motors; this is not possible for 1MJ6 motors up to frame size 160 L.

## Required motor output in kW

Minimum motor rated output (50 Hz) so that the required "50 Hz output at the shaft" is available at the motor shaft taking into consideration the ambient conditions.

For 60Hz, the 60Hz output applies as listed in Catalog M11. However, this does not apply to EExe motors.

## Residual voltage

When an asynchronous motor is powered-down, energy remains in the rotor (residual field). This induces a voltage in the stator winding. Depending on the motor size, it can take up to several seconds for this residual field to decay. The residual voltage which can be measured decays with the decreasing residual field.

When powering-up the motor again after a brief power failure, the induced residual voltage can act against the line supply voltage which has returned. This means that a current spike of

$$i_{max} = \sqrt{2} \times I_A \times (2{,}7 \ldots 5{,}0)$$

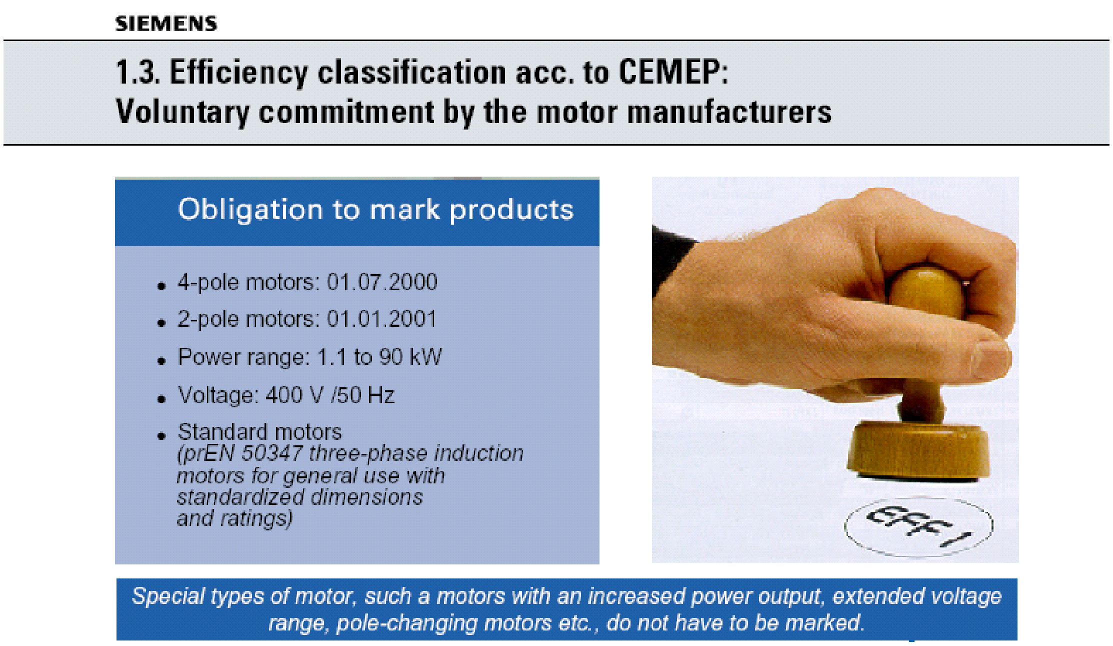
can occur during a half wave.

The current forces which occur, especially at the winding overhangs, are absorbed by suitable mechanical retaining measures, such as bindings, lashings as well as suitable winding impregnation.

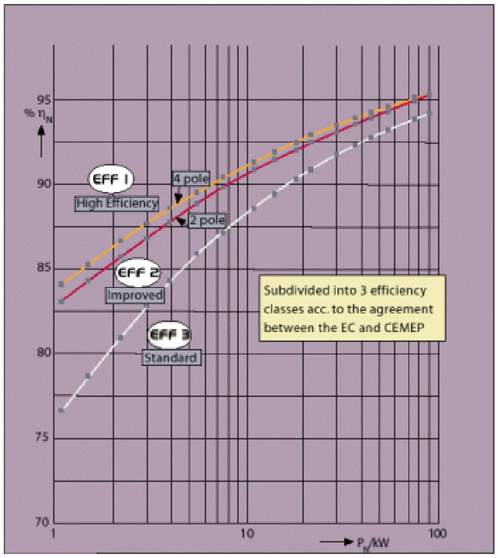
The impregnating resins which are used today allow low-voltage motors to be powered-up again against 100% residual field. When 2-pole motors above frame size 180M are continually powered-up and down or reversed on a repetitive basis, then the motor factory must be contacted for further clarification.

(also refer to Inrush current)

## Responsibility in appropriately marking their motors (CEMEP)



# 1.4. Efficiency markings according to CEMEP

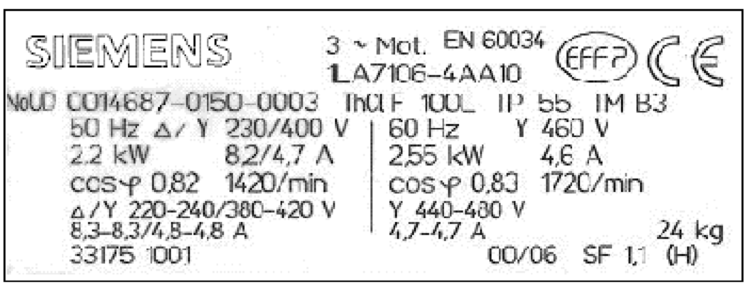


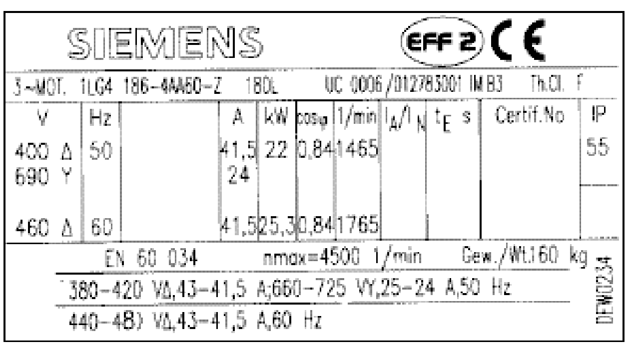

## Where do eff. classes appear?

- Documentation:
  Catalogs / Advertising leaflets

  - Efficiency- class (EFF1/ EFF2)
  - Efficiency at 3/4 load and full load
- Rating plate
  - Efficiency class

*More details in the Internet*
*Article on energy-saving motors:*
*"Classified acc. to efficiency"*
*http://sd.nes.siemens.de/sales_2000/marketing/press/Articles/html_00/index.html*



## Re-lubrication device

Re-lubrication devices for motors with roller bearings are necessary if, for example, for large bearings or high speed bearings, the relative velocity in the bearing is too high and as a result, the lubricating intervals in comparison to the theoretical bearing lifetime becomes too small. For motors with re-lubrication device, new grease can be introduced into the bearing through the lubricating nipple while the motor is operational. Spent grease is removed by the grease slinger and accumulated in a spent grease space.

The spent grease space in the bearing cover is large enough so that it can hold practically all of the grease required for the complete lifetime of the bearing of approximately 40.000 operating hours for all re-greasing intervals (approx. 10).

The re-lubrication device has the following lubricating nipple:

Up to shaft height 160, tapered lubricating nipples, M 8x1, type A according to DIN 71412
From shaft height 180 onwards, flat lubricating nipples, AM 10x1 according to DIN 3404

Refer to Catalog M11 for more detailed information.

(also refer to Grease lifetime, Grease slinger. Lubricating plate

## Roller-table motors

Roller-table motors are mainly used in steel mills where the slabs of metal are fed or transported to the roller stands using roller tables.

There are two basic types of roller tables:

Transport roller tables generally run in one direction and at a constant speed. Standard three-phase squirrel-cage induction motors with the usual speed-torque characteristic can be used for these drives. This means that the motor size is essentially selected depending on the power required to transport the material.

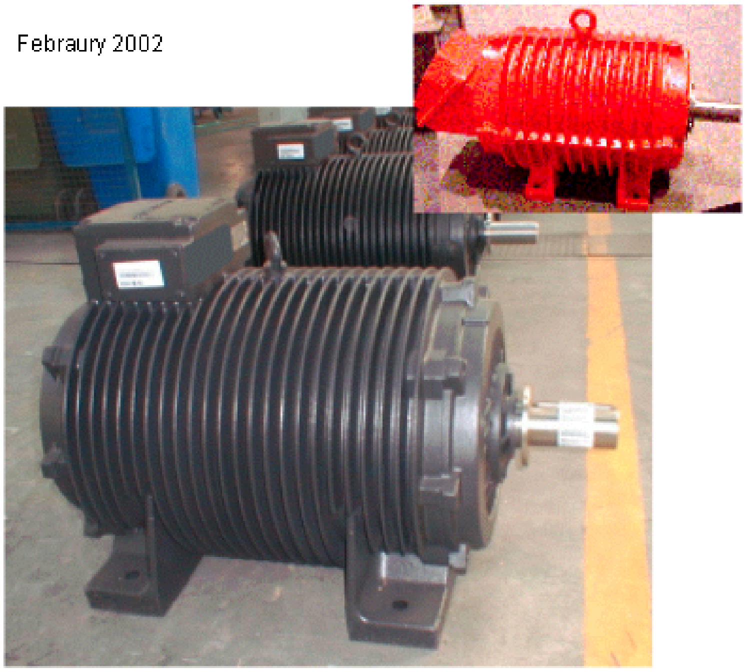
Working roller tables, whose rolls change their direction of rotation with every rolling pass. This means that high moments of inertia must be accelerated and braked in an extremely short time. These motors have to handle high electrical and mechanical stressing due to the frequent starting and direction of rotation change when fully loaded - and when they are occasionally blocked as a result of the rolling material. This is the reason that these motors are appropriately rugged and have a special electrical design. High-resistance squirrel-cage rotor motors are used with the smallest possible rotor diameter for a low intrinsic moment of inertia. PTC thermistor temperature sensors are used. The motor frames have ring-shaped ribs to increase their external surface area in order to better dissipate the power losses. These motors do not have an external fan. Special versions are available in the market with a rotor in the form of a drum.

In addition to three-phase motors, DC series-wound motors with the appropriate design are used.

**AC Roller-table drive motor in frame sizes 132 to 400**

**for invert supply on SIMOVERT MASTERDRIVE**

Febraury 2002



## Rotating the terminal box

For 1LA7, 1MA7 and 1LA9 motors, the terminal box is cast to the frame and has 4 knock-out openings (2 to the left, 2 to the right), which are closed by a thin membrane. An intermediate adapter with tapped holes is used when the terminal box is to be rotated.

The terminal box is bolted-on for 1LA6 and 1LG motors. The terminal box can be rotated through 4x90 degrees by releasing the four retaining bolts.

## Rotor class

The slot shape of a motor rotor doesn't clearly define the torque characteristic of a motor. This is the reason that in 1960, Siemens introduced its own rotor classification. This designates the motor characteristic according to the highest permissible load torque when starting.

For example, a motor with rotor class KL 16 can reliably accelerate a load torque of 160 % of the rated motor torque - even under unfavorable conditions, e.g. for a voltage reduced by 5 %,. However, if the load torque is as high as the rated torque, then in this case a minimum torque class of KL 10 is required and is suitable.

(also refer to Torque)

## Rotor locking device

Motors with cylindrical roller bearings or with angular-contact ball bearings have a rotor locking device in order to protect the bearings when the motor is transported (this prevents the bearings from being scored). The rotor locking device must be removed before the motor is commissioned.

The bearings can be scored if the motor rotor is not rotating but the motor is subject to vibration. Bearings can be scored when the motor is being transported or when the motor is not operational (e.g. in marine applications).

(also refer to Foundation vibration)

## Roller bearings

Only roller bearings are used for standard motors. Deep-groove ball bearings are used for standard and roller bearings for reinforced bearing designs from frame size 180L and above.

For the bearing designation it should be observed that the last two digits (from 04) multiplied by 5 result in the bearing bore. This means that a deep-groove ball bearing 6205 has a 25 mm diameter bore. The third from last digit designates the diameter series of the bearings. Bearings of different diameter series for the same bore, cannot be replaced.

2-type series roller bearings are predominantly used for our motors. This results in lower velocities, lower bearing temperatures, longer lubrication intervals, longer lifetime, quieter and lower noise operation.

Bearing clearance (radial and axial):

This is the dimension by which one bearing ring can move with respect to the other.

Additional designations:

C2 Rad. – bearing clearance is less than standard

C3 Rad. – bearing clearance is greater than standard

C4 Rad. – bearing clearance is greater than C3

Caution: Replacement bearings must have the same bearing clearance as the bearings which were first used.

(also refer to Bearings, Shaft seals)

## Rush torque

The rush torque is the maximum torque amplitude of a torque oscillation which briefly occurs when a motor is powered-up or is reversed.

Under worst case conditions, the rush torque can be between 500 and 600 percent of the rated torque – which is approximately twice the starting torque.

The rush torque decays again after a few periods.

Generally, this rush torque is absorbed within the elastic coupling and isn't completely transmitted to the driven load.

# S

## Safety couplings

Safety couplings are essentially designed as friction couplings, which slip when a specific torque is reached (slip coupling).

The slip torque can be set by adjusting the appropriate spring force. It can also be made dependent on the centrifugal force.

For the function as safety coupling, it is important that the selected friction torque remains constant.

## Second standard shaft end

A second standard shaft end is not possible when either rotary pulse encoders and/ or separately-driven fans are mounted. Please inquire if a brake is to be mounted.

## Selecting a motor type - overview

### Low-voltage squirrel-cage induction motors for three-phase line supplies

Basic version ( 1LA / 1LG )

Energy-saving motors according to the CEMEP definition with aluminum and gray cast iron frames

Improved Efficiency "eff2"

High Efficiency "eff1"

Energy-saving motors according to the EPACT definition with aluminum and gray cast iron frames

Motors with increased output

Motors with increased safety: Type of protection EExe II T1-T3 ( 1MA )

Motors with flameproof enclosure: Type of protection EEx de IIC T1-T4 ( 1MJ )

## Selected motor output

If the conditions change and the F/B utilization is to be kept, the permissible output must be reduced corresponding to the applicable reduction factors. This can mean that a motor with the next highest output must be selected. The output of the selected motor is displayed in the "Rated output" field.

## Service factor - overload factor

If a "service factor" is specified on a motor rating plate, then this means that the motor can be continually operated with an overload condition.

The maximum continuous power is calculated as follows:

Ppermissible = service factor x PN

PN in this case is the rated power specified on the rating plate.

When a motor is operated with the maximum permissible continuous output, the normal operating conditions, including required tolerances, must be used as basis. The limit temperature rise may be exceeded by 10 K. Several foreign regulations specify a service factor; NEMA and EEMAC specify, e.g. for

IP44 motors, a service factor of 1.0
IP23 motors, a service factor of 1.15.

In practice, customers can also specify other service factors. In cases such as these, special measures will be required.

## Shaft seals

The degree of protection of an enclosed motor/generator essentially depends on the bearing sealing system and therefore the shaft at the drive and non-drive ends.

The shaft seal protects the motor and bearings against the ingress of liquids, lubricating mediums, dust, gases and vapors. Depending on the degree of protection required, various techniques are used to achieve the appropriate shaft sealing (shaft sealing ring). For degrees of protection which are higher than IP 55, please refer to Motor Catalog M 1.

In their normal version, Siemens 1LA, 1LG, 1MA and 1MJ motors have degree of protection IP 55 and have the following bearing and shaft seals:

| | | | | |
|---|---|---|---|---|
| Frame size | 56 | to | 100L | using Z bearings |
| Frame size | 112M | to | 160L | using a fine labyrinth seal |
| Frame size | 180M | to | 450 | using a V ring (axial sealing ring) |

Motors can be supplied with a radial seal for mounting to gearboxes.

Other sealing measures are required if degrees of protection higher than IP 55 are required.

Flameproof motors have, as standard, an IP 55 degree of protection.

(also refer to Degree of protection, V ring)

## Shaft-mounted fans

are used for self-ventilated motors. They are mounted on the shaft outside the motor frame and are covered with a fan cowl which is simultaneously used to guide the air.

All Siemens motors, in the standard version, have a radial fan as outer fan, which cools independently of the motor direction of rotation; only motors, shaft height 56 are supplied without fan (non-ventilated).

2-pole motors are the exception. They have axial fans which are dependent on the direction of rotation for noise reasons.

In order to reduce the noise, 2-pole motors from frame size 132, can be equipped with a low-noise axial fan; this is only suitable for one direction of rotation.

The following table indicates the cooling airflow rates for standard 1LA and 1LA6 motors.

| | **2 pole** | | **4 pole** | | **6 pole** | | **8 pole** | |
|---|---|---|---|---|---|---|---|---|
| | **V** | **dp** | **V** | **dp** | **V** | **dp** | **V** | **dp** |
| **Shaft height** | **($m^3$/s)** | **(N/$m^2$)** | **($m^3$/s)** | **(N/$m^2$)** | **($m^3$/s)** | **(N/$m^2$)** | **($m^3$/s)** | **(N/$m^2$)** |
| 63 | 0.014 | 60 | 0.007 | 15 | 0.005 | 10 | - | - |
| 71 | 0.024 | 80 | 0.012 | 20 | 0.008 | 10 | 0.006 | 5 |
| 80 | 0.029 | 80 | 0.015 | 20 | 0.010 | 10 | 0.007 | 5 |
| 90 | 0.052 | 140 | 0.026 | 35 | 0.018 | 15 | 0.013 | 10 |
| 100 | 0.066 | 160 | 0.031 | 35 | 0.021 | 15 | 0.016 | 10 |
| 112 | 0.083 | 150 | 0.050 | 50 | 0.033 | 25 | 0.025 | 15 |
| 132 | 0.134 | 200 | 0.084 | 75 | 0.056 | 35 | 0.042 | 20 |
| 160 | 0.215 | 180 | 0.159 | 100 | 0.106 | 45 | 0.080 | 25 |
| 180 | 0.19 | 108 | 0.18 | 96 | 0.13 | 51 | 0.09 | 24 |
| 200 | 0.26 | 155 | 0.20 | 92 | 0.15 | 52 | 0.11 | 28 |
| 225 | 0.28 | 137 | 0.27 | 128 | 0.21 | 77 | 0.15 | 39 |
| 250 | 0.37 | 185 | 0.32 | 138 | 0.24 | 78 | 0.18 | 44 |
| 280 | 0.39 | 152 | 0.39 | 152 | 0.31 | 96 | 0.23 | 53 |
| 315 | 0.73 | 426 | 0.58 | 270 | 0.45 | 162 | 0.34 | 92 |
| 355 | 1.75 | 320 | 0.78 | 347 | 0.64 | 233 | 0.49 | 132 |
| 400 | 1.00 | 450 | 0.93 | 389 | 0.75 | 253 | 0.57 | 146 |
| 450 | 2.05 | 1470 | 1.80 | 1130 | 1.50 | 780 | 1.13 | 446 |

(also refer to Cooling types)

## Shaft output at 50Hz

This is the mechanical output, which the motor can provide at the shaft under rated operating conditions. Under non-standard ambient conditions (e.g. an ambient temperature of 50 °C), this output must be reduced in accordance with defined factors in order to guarantee utilization to temperature rise Class F/B. When required, the program automatically determines and applies the particular reduction factors.

## Siemosyn motor

### Permanent-magnet synchronous motor

Externally, this looks just like a three-phase asynchronous motor (IP 54) with squirrel-cage rotor. The stator has a standard three-phase winding. The rotor has permanent-magnet poles.

As a result of the permanent-magnet excitation, it has significantly lower currents (50%) and a better power factor in comparison to reluctance motors. The drive which feeds the motor can be significantly smaller.

The AC drive specifies the synchronous speed which can lie between 500 and 5.000 RPM. Absolute synchronous operation is achieved.

Large numbers of Siemosyn motors are used to drive spinning pumps, godets and friction rolls.

## Single-phase motors

The pure single-phase motor does not have any starting torque. It must be aided when starting and is therefore of little importance. The motor has a second winding to generate a starting torque. This second winding is fed phase-shifted to the first winding through a series resistor.

The following versions are available:

1. Design with an auxiliary starting winding (type AC).
   The auxiliary starting winding is disconnected after running up
   $M_A$ = 1 to 1,3 x $M_N$ $I_A$ = 4 to 8 x $I_N$

2. Design with starting capacitor and auxiliary starting winding (type AD).
   The capacitor and the auxiliary winding are disconnected after running up.
   $M_A$ = 2,6 to 3 x $M_N$ $I_A$ = 3 to 7 x $I_N$

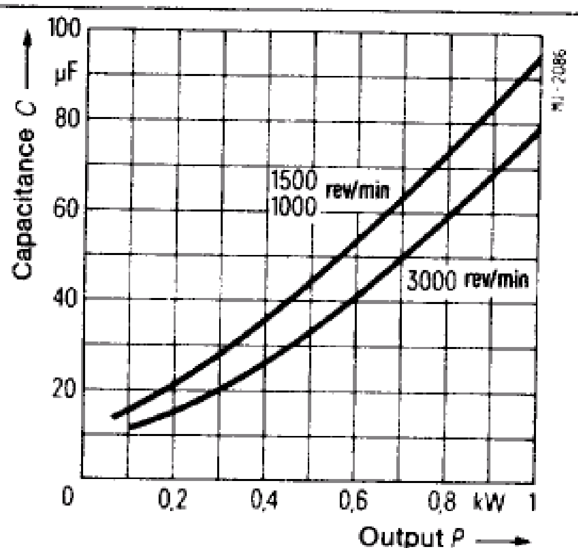
3. Design with running capacitor (type AB).
   There is no centrifugal switch necessary.
   $M_A$ = 0,25 to 0,6 $M_N$ $I_A$ = 2,5 to 5 x $I_N$

4. Design with running capacitor and high-resistance squirrel-cage rotor (type AJ).
   A centrifugal switch is not necessary.
   Especially suitable for intermittend periodic duty.
   $M_A$ = 0,5 to 1,2 x $M_N$ $I_A$ = 2 to 4,5 $I_N$

5. Design with running and starting capacitor (type AE).
   Best design for starting and running.
   The starting capacitor is disconnected after running up of the motor.
   $M_A$ = 1,5 to 1,8 x $M_N$ $I_A$ = 3,5 to 5,5 x $I_N$

All versions with starting capacitor are not suitable for jog operation and switched operation (Z >30).
Versions AC and AD, for the same frame size, are two power stages weaker than versions AB, AE and AJ corresponding as far as the output is concerned, to a standard three-phase motor.

## Single-phase operation




*Power output P in operation as single-phase motor (− 70 to 80 % of the three-phase output)*

For circuit 3, the required capacitor size, for the same rated motor power and same line supply voltage, is only half the size as for circuits 1 and 2. The capacitor must be designed for a continuous operating voltage of 1.35 x line supply voltage. For 220 V line supplies, i.e. it must be designed for 320 V AC.

The use of three-phase motors with continuous running capacitor for single-phase operation is only practical for single-phase operation up to 2 kW due to the costs for the capacitor.

For other line voltages, the capacitor size changes inversely to the square of the line supply voltage.

These motors are only suitable for fan drives and drives with reduced starting requirements as a result of the low starting torque and the poor accelerating characteristics.

## Slide rails

Slide rails are used to easily adjust a belt drive, especially if a belt tensioning roll is not used.

They are retained to the foundation using rag bolts or foundation blocks.

The motor can be simply shifted along the slide rails using the tensioning screws, which tension the belt. The motor is mounted onto the slide rails using the motor foot mounting bolts.

## Soft starting

A driven load must be started softly if a torque surge can potentially damage the driven load or the product itself; for example, a conveyor belt or the thread in a spinning machine.

The surge stressing is that much higher, the higher the motor starting torque, the higher the existing load on the driven machine and the higher the additional moment of inertia is in comparison to the motor moment of inertia.

Soft starting types:

- **Electrical:**
  Star/delta starting
  Multiple star-delta starting
  Kusa circuit
  Starting resistor for slipring rotor motors [US: wound-rotor motors]
  Starting transformer
  Voltage reduction using phase control
- **Mechanical systems:**
  Starting couplings

## Speed

The synchronous speed ns (RPM) of a three-phase asynchronous motor is obtained from the line frequency and the number of poles ( 4-pole motors => 2p = 4 ).

$$ns = \frac{120 * f}{2p}$$

When connected to a 50 Hz line supply, a 2p = 4-pole motor has a synchronous speed of

$$ns = \frac{120 * 50}{4} = 1500 \text{ RPM}$$

Correspondingly, the synchronous speeds for the most commonly used

2, 4, 6, 8, 10 and 12-pole motors are

| | | | | | | |
|---|---|---|---|---|---|---|
| For a 50 Hz line frequency | 3000, | 1500, | 1000, | 750, | 600, | 500 RPM |
| For a 60 Hz line frequency | 3600, | 1800, | 1200, | 900, | 720, | 600 RPM |

The rotor of a three-phase asynchronous motor rotates with a lower speed (with slip) than the rotating field.

Slip s is calculated using the following formula:

$$s = \frac{ns - n}{ns} \times 100$$

| | | |
|---|---|---|
| s | = | slip in % |
| ns | = | synchronous speed in RPM |
| n | = | rotor speed in RPM |

The nominal (rated) slip sN is appropriately calculated.

The rotor losses of the motor are approximately proportional to the slip. The aim is to achieve a low rated (nominal) slip in order to achieve a good efficiency.

The rated (nominal) slip depends on the motor size. For instance, for small motors it is approximately 10 % and for large motors, it is approximately 1 %.

(also refer to Pole number)

## Speed monitor

This is a switching device which responds at a specific speed.

This can be used, for example:

- As centrifugal switch for single-phase motors with starting equipment and running capacitor

- to shutdown a motor after plug-type braking.
- to shutdown a conveyor belt when the belt speed is too low.

## Squirrel-cage rotor

For squirrel-cage rotors, the rotor winding comprises solid rotor bars. These are connected, at both ends to a solid short-circuiting ring, to form a so-called squirrel cage.

Generally, the rotor cage is manufactured out of die-cast aluminum, and in special cases (e.g.: Large 2-pole motors, out of copper).

Depending on the required torque characteristic, the slot shape and therefore the shape of the rotor bar can vary widely. The most usual slot shapes are shown in Fig. 1. Their different properties are shown in Fig. 2.

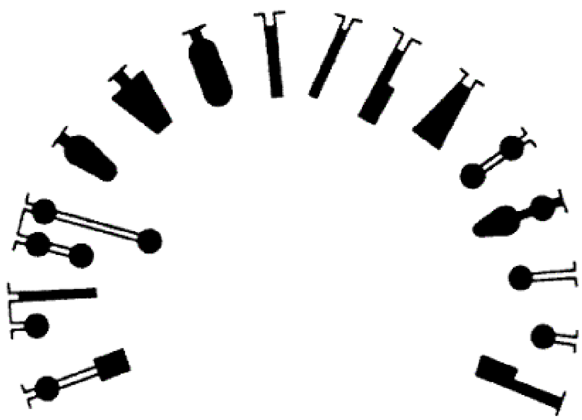
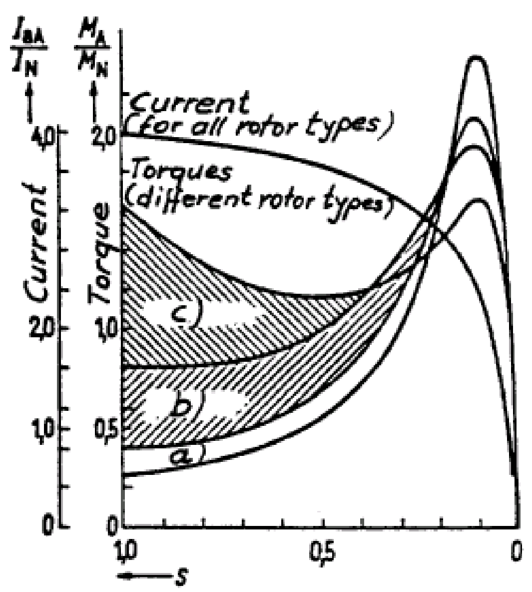


Bild 1



## Stamped values / output

When reducing the output (de-rating) – enter the output which is to be stamped on the rating plate. This output is then specified as rated output in the datasheet.

## Standards and regulations for low-voltage motors

The motors fulfill the relevant Standards and regulations, especially the following:

| Title | DIN | IEC | |
|---|---|---|---|
| General regulations for rotating electrical machinery | DIN VDE 0530, Part 1 | IEC 34, Part 1, IEC 85 | EN 60034 1 |
| As for Part 1, however (determination of the efficiency and losses) | DIN VDE 0530, Part 2 | IEC 34, Part 2, | EN 60034 2 |
| As for Part 1, however (synchronous machines, generator operation) **( not possible )** | | | EN 60034 3 |
| As for Part 1, however **General** requirements | | | EN 60034 4 |
| Converter-fed traction motors | VDE 0535 | IEC 60349 - 2 | |
| Flat lubricating nipple e.g. M10x1 | DIN 3404 | | |
| Tapered lubricating nipple e.g. A M10x1 | DIN 71412 | | |
| Mounting dimensions and assignment of powers for IM B3 | DIN 42673 | IEC 72 1) | |
| Mounting dimensions and assignment of powers for IM B5, IM B10 and IM B14 | DIN 42677 | IEC 72 1) | |
| Mounting flange | DIN 42950 | | |
| Dimension codes | DIN 42939 | | |
| Connection codes and direction of rotation for electrical machinery | DIN 57 530, Part 8/ VDE 0530, Part 8 | IEC 34, Part 8 | EN 60034 8 |
| Types of construction of rotating electrical machinery | DIN IEC 34, Part 7 | IEC 34, Part 7 | EN 60034 7 |
| Integrated thermal protection | - | IEC 34, Part 11 | EN 60034 11 |
| Cooling types of rotating electrical machinery | DIN IEC 34, Part 6 | IEC 34, Part 6 | EN 60034 6 |
| Degrees of protection of rotary electrical machinery | DIN IEC 34, Part 5 / VDE 0530, Part 5 | IEC 34, Part 5 | EN 60034 5 |
| Vibration severity of rotating electrical machinery | DIN ISO 2373<br>DIN VDE 0530 T14 (Draft) | IEC 34, Part 14 | EN 60034 14 |
| Cylindrical shaft ends of electrical machinery | DIN 748, Part 3 | IEC 72 | |
| Centering holes | DIN 332 | | |

| | | | |
|---|---|---|---|
| Keyways and keys | DIN 6885 | | |
| Fits of shaft ends | DIN 748, 7160, 7161 u. 42948 | | |
| Concentricity and axial eccentricity tolerances f. the shaft end | DIN 42955 | | |
| Noise, limit values | DIN VDE 0530, Part 9 | IEC 34, Part 9 | EN 60034 9 |
| Radio interference suppression | DIN VDE 875 | | |
| Resistance thermometer | DIN IEC 751 | IEC 751 | |
| Starting characteristics of squirrel-cage rotor motors at 50 Hz up to 660 V | DIN 57530, Part 12/ VDE 0530, Part 12 | IEC 34, Part 12 | EN 60034 12 |
| Standard voltages | DIN 60038 | IEC 38 | |
| **Ex Further, for EEx motors:** | **DIN** | **IEC** | **D** |
| General definitions | DIN EN 50014/ VDE 0171, Part 1 | IEC 79, Part 0 | EN 50014 |
| Pressurized enclosure "o"<br>Oil enclosure **( not possible )** | DIN 50015 | | EN 50015 |
| Pressurized enclosure "p"<br>Pressurized enclosure **( not possible )** | DIN 50016 | | EN 50016 |
| Pressurized enclosure "q"<br>Sand enclosure **( not possible )** | Din 50017 | | EN 50017 |
| Pressurized enclosure "d" | DIN EN 50018/ VDE 0171, Part 5 | IEC 79, Part 1 | EN 50018 |
| Increased safety "e" | DIN EN 50019 / VDE 0171, Part 6 | | EN 50019 |
| Increased safety "i"<br>Intrinsic safety **( not possible )** | DIN 50020 | | EN 50020 |
| Increased safety "n"<br>Intrinsic safety **( this must be inquired and a quotation made )** | DIN 50021 | | EN 50021 |

1) Only dimensions and frame sizes are defined in IEC 72; powers are not assigned to frame sizes.

## Standard voltages - according to DIN IEC 38 (European voltage)

Since 1987, IEC 38 from 1983 is also valid in Germany as DIN IEC 38. There are now only two standardized line supply voltages:

230 V / 400 V

400 V / 690 V

20 years were planned as the transition time. However, most line supplies have already been changed-over to the new Standard. During this time, in countries which previously had a 380 V line supply, a voltage tolerance of 400 V +6/-10 % applies and in countries which previously had 415 V line supplies, 400 V +10/-6 %. From the year 2000, then a ± 10 % applies everywhere. Siemens markets its motors worldwide so that today, they are already supplied with a voltage of 400 V ± 10 %.

VDE 0530, in tolerance range A (max 10K above the limit temperature of the temperature rise Class) defines an unchanged tolerance of ± 5 % for the motor. This means that the higher line supply voltage tolerance must be maintained by an appropriate voltage range for the motor.

This means that instead of 400 V ± 10 %, 380...420 V is now stamped on the motor rating plate. The required tolerance is obtained in conjunction with the ± 5 % in accordance with VDE 0530.

## Starting performance

The starting torque is a function of the square of the voltage applied (magnetization) and the starting current is proportional to the voltage applied. This means that the starting performance allows the starting characteristics of a three-phase motor to be evaluated independent of the magnetization.

$$g = \frac{\sqrt{M_A / M_N}}{J_A / J_N}$$

| | |
|---|---|
| g: | Starting performance |
| MA / MN: | Starting torque/rated torque |
| JA / JN: | Starting current/rated current |

This means a motor with a better starting performance has a lower starting (inrush) current than the second motor if it can provide the same starting torque by changing the magnetization than a second motor with a poorer starting performance.

## Starting time

The starting time is the time which a drive requires to accelerate from standstill up to the operating speed. The higher the external load of inertia coupled to the motor and the lower the accelerating torque when starting, then the higher the starting time.

$$t_A = \frac{J \cdot n}{9{,}55 M_b}$$

| | | |
|---|---|---|
| tA | = | starting time in seconds |
| J | = | total moment of inertia to be accelerated in kgm² |
| n | = | operating speed in RPM |
| Mb | = | accelerating torque Nm |

Only moments of inertia which are rotating at the same speed may be added.

If moments of inertia exist with different speeds, then the supplementary moment of inertias are calculated according to the following equation

$$J_2 \left( \frac{n_2}{n_M} \right)^2$$

| | | |
|---|---|---|
| $J_{ref}$ | = | moment of inertia referred to the motor speed |
| $J_2$ | = | moment of inertia of the machine |
| $n_M$ | = | motor speed |
| $n_2$ | = | machine speed |

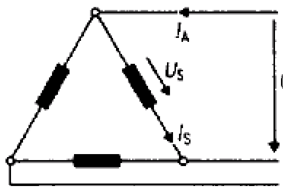
10 sec is permissible as starting time for 1LA and 1MJ motors (exception, 1MJ in T5 and T6 must be inquired),
for 1MA motors, the following applies: $t_A$ < 1.7 $t_E$.

These types of long starting times are only permissible for S1 duty.

(also refer to Torque, Load torque, Moment of inertia)

## Star-delta starting

Unfortunately, some line supplies and driven loads don't allow the motor to be directly connected to the line supply. The most well known starting circuit is the Y/D starter. The current and the starting torque are reduced to 1/3 of the values when connected directly to the line supply.

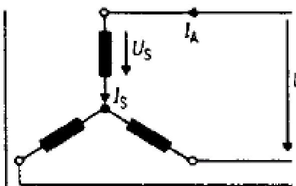



$U_{S\Delta} = U$

$I_{S\Delta} = \frac{U_{S\Delta}}{Z} = \frac{U}{Z}$

$I_{A\Delta} = I_{S\Delta}\cdot\sqrt{3} = \frac{U}{Z}\cdot\sqrt{3}$

$M_{A\Delta} = k\cdot U_{S\Delta}^2 = k\cdot U^2$




$U_{S\curlyvee} = \frac{U}{\sqrt{3}}$

$I_{S\curlyvee} = \frac{U_{S\curlyvee}}{Z} = \frac{U}{Z}\cdot\frac{1}{\sqrt{3}}$

$I_{A\curlyvee} = I_{S\curlyvee} = \frac{U}{Z}\cdot\frac{1}{\sqrt{3}}$

$M_{A\curlyvee} = k\cdot U_{S\curlyvee}^2 = k\cdot U^2\cdot\frac{1}{3}$

$$\frac{I_{A\curlyvee}}{I_{A\Delta}} = \frac{\frac{U}{Z}\cdot\frac{1}{\sqrt{3}}}{\frac{U}{Z}\cdot\sqrt{3}} \approx \frac{1}{3} \quad ^{*)}$$

$$\frac{M_{A\curlyvee}}{M_{A\Delta}} = \frac{k\cdot U^2\,\frac{1}{3}}{k\cdot U^2} \approx \frac{1}{3} \quad ^{*)}$$

$$\frac{I_{S\curlyvee}}{I_{S\Delta}} = \frac{\frac{U}{Z}\cdot\frac{1}{\sqrt{3}}}{\frac{U}{Z}} \approx \frac{1}{\sqrt{3}} \quad ^{*)}$$

$U$ Line to Line voltage
$U_S$ Phase voltage
$I_A$ Locked-rotor current in supply cable
$I_S$ Locked-rotor current per phase
$M_A$ Locked-rotor torque
$Z$ Impedance of one phase
$k$ Constant depending on motor data

*) These are approximate equations only. The torque developed by the motor is determine by the resultant flux and the rotor current; resistive and inductive voltage drops and magnetic saturation prevent these values from being strictly proportional to the terminal voltage applied.

*Fig. 1 Relationships between voltage, current and torque for star and delta connection*

It goes without saying, that also for the star circuit configuration, all basic prerequisites must be fulfilled (rotor class, load torque characteristic and moment of inertia).

For larger three-phase motors (1LA6 series) especially with deep bar squirrel cage rotors, only approximately 0.29x of the starting torque and the current can be expected.

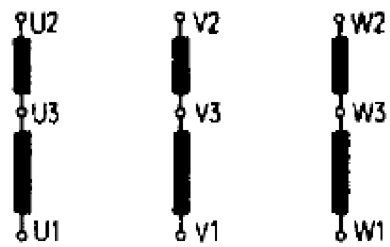
A check should always be made, because an incorrectly engineered Y/D starter has a significant financial impact and will not provide the reduced starting current required. The starting current is then only insignificantly lower than the current when connected directly to the line supply.

Multi-stage Y- D starting

1LA6 motors can, when required, be supplied for multi-stage Y-D starting and with terminal boxes with 9 terminals.

The following circuit schematic shows the winding configuration for 1LA6 three-phase motors in a special Y-D circuit, whereby the winding is switched in the motor itself.

*Fig. 3 Subdivision of windings for three-phase motors in special star-delta connection for multi-stage star-delta starting*



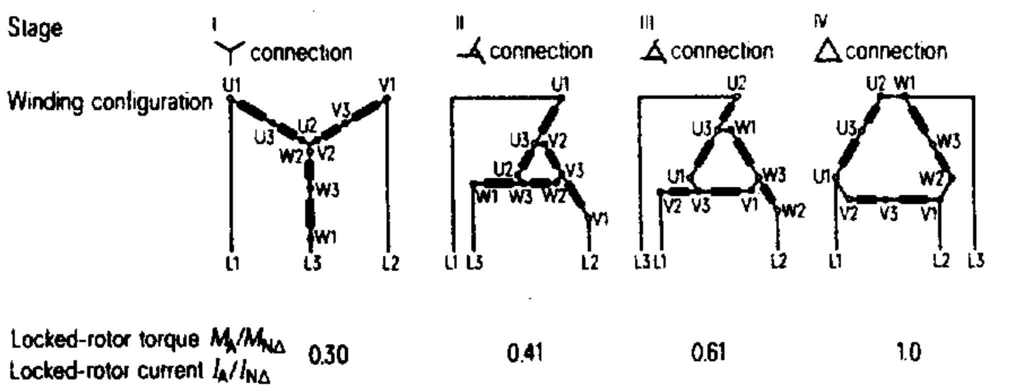




*Fig. 4 Changeover from star connection (stage I) to delta connection (stage IV) through intermediate stages II and III*

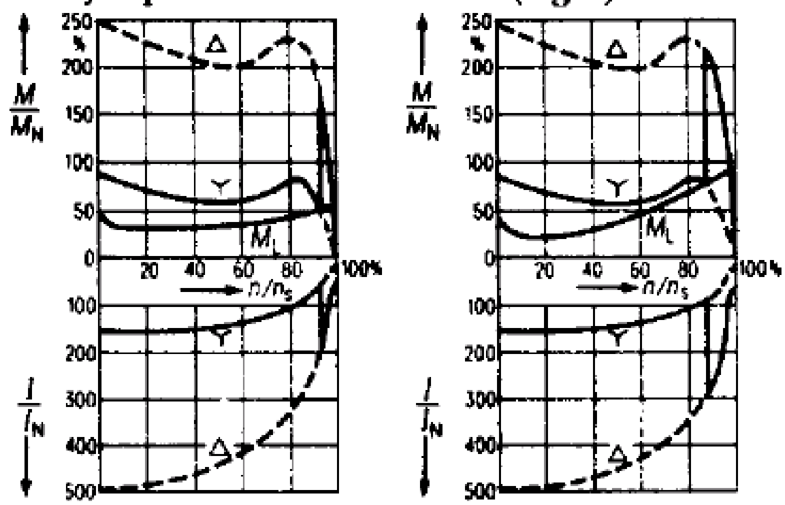



*Fig. 2 Torque and current over speed for correct star-delta switchover (left) and for premature switchover (right)*

## Star-double star starting

The Dahlander or PAM circuit is frequently used for pole-changing three-phase motors.

The Dahlander circuit is used for pole-changing three-phase motors with a speed ratio of 1:2. For example, 4/2 pole, 8/4 pole, 6/12 pole.

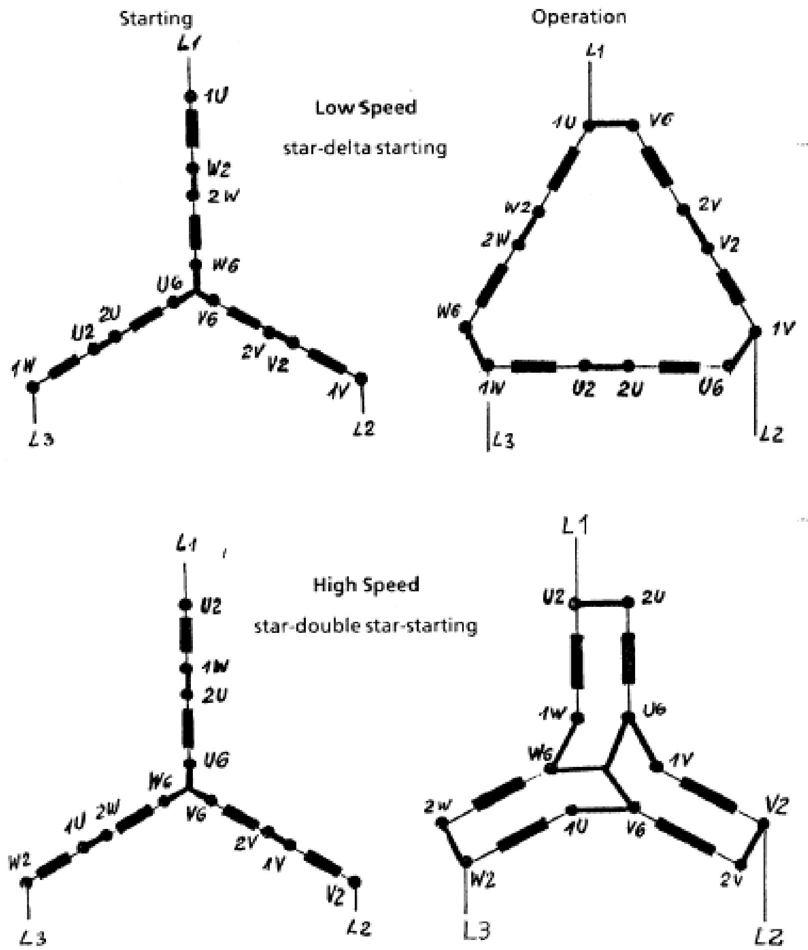
Constant torque drives have a D/YY connection and fan drives a Y/YY connection !

The PAM circuit is used for pole-changing three-phase motors with a speed ratio which is <u>not equal</u> to 1:2. For example, 6/4 pole, 8/6 pole.

Constant-torque drives have a D/YY connection and fan drives a Y/YY connection !

If a Y/D start is required for the low speed, a motor is required with a terminal box with 9 terminals and the winding for 9 cables.

If Y/D starting is required for both speeds ( this is not possible for fan drives ! ), a larger terminal box with 12 terminals is required.
In cases such as these, for the low speed Y/D starting is used and for the high speed, Y/YY or D/YY starting.




(also refer to Dahlander circuit, Star-delta starting)

## Surface cooling

The power loss, which is partially generated close to the air gap, should be transferred to the outer surface with the lowest possible thermal gradient. The heat is transferred either through conduction or convection. The largest possible surface area (ribs) should be provided with a high heat transfer coefficient.

Surface-cooled motors are available in the form of non-ventilated motors without their own shaft-mounted fan (type 1LP) with the appropriate de-rating and self-cooled motors with an external fan mounted on the shaft (1LA motors).

The surface temperature cannot be used to evaluate a motor. The objective is to transfer the heat quickly from the winding to the external surface through good thermal conduction. This heat is then dissipated through the air flow.

(also refer to Cooling types)

## Switched operation

If a motor is used in duty types other than continuous duty S 1, then this application must be more carefully engineered.

In order to be able to fully utilize a motor in the switched operation, we recommend that thermistor motor protection is used.

(also refer to Duty types)

## Synchronized asynchronous motor

The synchronized asynchronous motor is a motor which goes into synchronous operation after it has run-up. From the design, this motor corresponds to a slipring rotor motor [US: wound-rotor motor] with the possibility of additionally exciting the rotor with DC current. The motor starts asynchronously using a resistor starter. After the motor has run-up, a DC voltage is connected to the rotor winding and the rotor goes into synchronous operation.

Synchronized asynchronous motors are especially used for high rating drives where a synchronous speed is required, especially for applications where there are some difficult starting conditions which cannot be handled by the starting cage of a synchronous motor. A synchronized asynchronous motor is also used instead of a standard slipring rotor motor, if the reactive current drawn from the line supply is to be reduced.

## Synchronous motors

Synchronous motors are motors which operate at a synchronous speed, e.g. 3000, 1500, 1000, 750 RPM at a 50 Hz line frequency.

Synchronous motors are also available in the form of, e.g. reluctance motors and Siemosyn motors.

Synchronous generators with a constant voltage excitation device are also known as constant voltage generators.

# T

## Tachometer

Tachometers are small generators which are mounted and coupled to a main motor. They generate a voltage which is proportional to the speed.

## TEFC

Totally Enclosed Fan Cooled

IP 55 degree of protection in accordance with IEC and DIN with its own shaft-mounted fan, e.g. 1LA / 1LG

(also refer to Degree of protection)

## KTY 84-130 temperature sensors

This sensor is a PTC thermistor whose resistance changes as a function of the temperature according to a defined characteristic (refer to Catalog M11). Siemens drives determine the motor temperature using the resistance value of the temperature sensor. They can be set to a specific temperature for alarm and shutdown (trip). The temperature sensor is, just like a PTC thermistor, integrated in the winding overhang of the motor. The temperature signal is, for example, evaluated in the drive. For 1LA8 motors, when a temperature sensor is ordered, the PTC thermistors, included as standard, are omitted.

## Temperature Class

In order to make it simpler to engineer a drive system, the combustible gases and vapors are classified, according to their ignition temperature, in 6 temperature Classes - T 1 to T 6 and according to their internal ignition transmission characteristics in 3 explosion groups.

| Explosion group | Safe gap widths d for various types of protection in mm, dependent on the gap length, e.g. for 25 mm gap length |
|---|---|
| IIA | 0.5 |
| IIB | 0.3 |
| IIC | 0.2 |

| Temperature Class | Limiting temperature |
|---|---|
| T1 | 450 °C |
| T2 | 300 °C |
| T3 | 200 °C |
| T4 | 135 °C |
| T5 | 100 °C |
| T6 | 85 °C |

(refer to European Standards for firedamp and explosion-protected electrical equipment)

MA motors are certified, in type of protection EEx e II for temperature Classes T1 to T3. Please inquire for higher temperature classes. With the exception of 2-pole motors, from frame size 225 M onwards, all motors are standard, i.e. for T1/T2 or T3, motors can be operated with the particular rated output.

For special versions (different frequency, output, cooling-medium temperature, installation height etc.), it may be necessary to apply for a supplementary certificate or a new certificate. It is always necessary to specify the temperature Class, because if this data is not provided, the standard version for T1/T2 and T3 will be certified.

(double the certification costs)

## Temperature rise

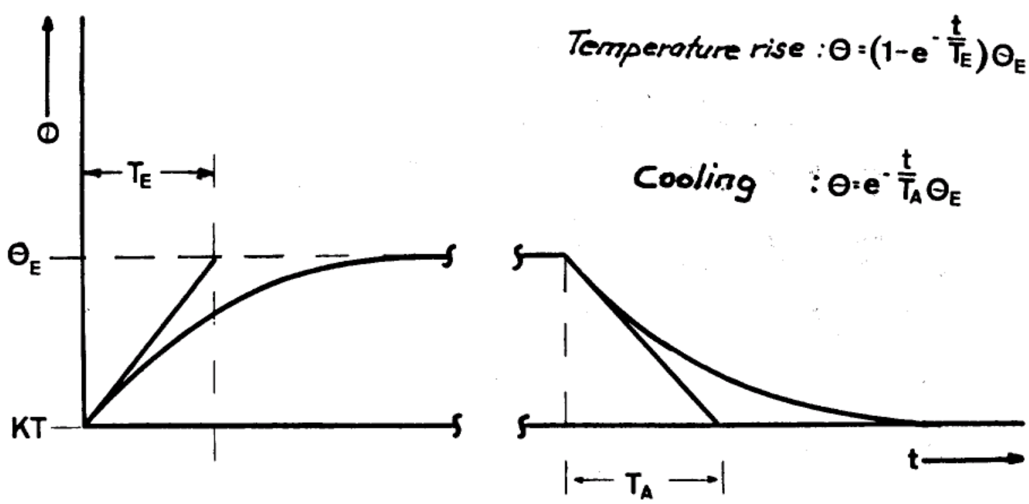
The losses which are incurred when a motor is operated increase the temperature of the motor. As the temperature increases, heat is transferred from the surface to the ambient air. Gradually, the thermal energy generated is the same as that dissipated to the ambient air which means that the rated operating temperature has been reached (steady-state condition).

When the motor is powered-down, its temperature decreases. When the motor is running under no-load conditions, it cools down faster as its cooling system still remains active. However, in this case the final temperature is not that of the cooling medium, but a steady-state temperature corresponding to the no-load losses (caution for small motors IO ± IN).

The temperature increases and decreases with an exponential function.

The tangent at the starting point of the exponential function intersects with the asymptote of the final temperature.

The time between this point of intersection and the starting point is called the time constant T. An exponential function approximately reaches its final value after 3 to 4 time constants.




(also refer to Insulation class, No-load current)

## Temperature rise

This is the difference between the temperature of a part of a motor or generator and the temperature of the cooling medium.

The limit temperature rise is the highest permissible overtemperature, i.e. the difference between the limit temperature and the specified highest cooling medium temperature.

In accordance with VDE 0530, the limit temperature rise for the winding of a three-phase motor, measured by resistance, is as follows:

For insulation Class E: 75 K
For insulation Class B: 80 K
For insulation Class F: 105 K
For insulation Class H: 125 K

Generally, standard induction motors have a winding with insulation Class F and are utilized in accordance with insulation Class B.

The limit temperature rise according to VDE 0530 is

for sleeve bearings and roller bearings: 50 K
for roller bearings with special grease: 60 K

Both of these temperatures apply for a cooling medium temperature of 40°C.

(also refer to Durignit, Temperature rise, Insulation Class)

## Temperature rise Class

refer to Insulation Class

## Temperature rise measurement

Montsinger has shown that the temperature has a high impact on the lifetime of the winding insulation. His investigations indicated that the winding lifetime is approximately halved when the permissible temperature is permanently exceeded by 10 Kelvin.

The winding temperature rise can be calculated from the increase in resistance for copper winding as follows:

$$\Theta = \frac{R_w - R_k}{R_k}\left(235 + \delta_K\right) + \delta_K - \delta_{K\ddot{u}}$$

$\Theta$ = Overtemperature

$\delta_K$ = Temperature of cold winding (before beginning of the measuring)

$\delta_{K\ddot{u}}$ = Coolant-temperature

$R_K$ = Winding resistance of cold motor at $_{-K}$ (before beginning of the measuring)

$R_W$ = Winding resistance of warm motor

Phase resistances below 1 Ohm must be measured using a Thomson measuring bridge. For higher values the resistance can be measured using a Wheatstone bridge.

## TENV

Totally Enclosed Non Ventilated

IP 55 without fan, e.g. 1LP

(also refer to Degree of protection)

## Terminal board

The terminals are mounted on the terminal board and the terminals are connected to the motor winding. The connecting terminals are designed so that up to frame size 225, the line supply can be connected without having to use cable lugs. From frame size 250 onwards, cable lugs are used as standard. If cable lugs are not to be used from frame size 250 onwards, then the appropriate clamping terminals should be ordered with option M47. Eexe and Eexde motors, from frame size 250 onwards, are always connected without using cable lugs. In this case, clamping terminals are provided in the scope of supply.

For all of the motors, the terminal board is permanently mounted to the frame so that when the terminal box is rotated, the connecting cables to the motor winding are not twisted.

(also refer to Terminal box, Reduction factor)

## Terminal boxes

The terminal box position is always viewed from the drive end. With the exception of 1LA8 and 1MA8 motors, for standard motor designs, the terminal box is always mounted at the top. For 1LA8 and 1MA8 motors, the terminal box is generally mounted on the righthand side.

Labeled connecting terminals are provided in the terminal box to connect the protective conductor. The external grounding (earthing) stud on the outside of the frame or motor foot is also labeled. For 1LA6 motors, from frame size 225 onwards and 1LG4/6, external grounding (earthing) is standard. For 1LA5, 1LA7, 1LA9, 1LA61 motors, this represents a special version.

The following applies for 1MJ motors:

The terminal boxes have type of protection EExe. A terminal box with EExd II B (Option K38) or EExd IIC (Option K53) is optionally available. For these two options, when supplied, the cable entry openings are closed. The customer must provide certified cable glands (e.g. from the Gothe company), as the cable gland must be selected depending on the connecting cable diameter.

Up to frame size 160, the winding ends of motors are fed into the terminal box through a common flameproof gland; from frame size 180 onwards, through individual glands.

# Tests

For low-voltage asynchronous motors, a differentiation is made between a routine test with a shortened test program and testing first versions (type test). The routine test is carried-out on every motor. The VDE regulation VDE 0530, 1972 is used as basis for all motors. Foreign regulations and specifications are essentially applied in the same way.

**a) Routine test**

A factory test 2.3 can be ordered for these measurements by order code B02.
(On SD-Configurator in Motor options 2, Certificate, Factory test 2.3)

About these measurings a work examining testimonial 2.3 can be ordered with the short detail B02.

1) Resistance measurement:
The DC resistance of phases U1 - U2, V1 - V2, and W1 - W2 of the stator winding in the running connection are measured and the DC resistance between terminals K - L, L - M and M - K of the rotor winding (for slipring motors [US: wound-rotor motors])

2) No-load test:
The no-load current and the no-load output at the test voltage and test frequency are measured

3) Short-circuit measurement:
The terminal voltage and the output when rated current is drawn, rated frequency and with the rotor locked are measured in the NMA as type test

4) The rotor standstill voltage (secondary open-circuit voltage) of slipring rotor motors is measured when the stator is fed with the rated voltage and rated frequency (the ratio is checked)

5) The mounted/integrated components are checked to ensure that they are functioning correctly (e.g. thermo sensor, anti-condensation heating etc.).

6) Winding test (high-voltage test) of the stator winding (and the rotor winding for slipring rotor motors)

7) The insulation resistance of the stator winding (and the rotor winding for slipring rotor motors) is checked using a DC voltage (Megger). Only when requested up to frame size 160L.

8) The vibration severity and motor/generator noise are evaluated.

**b) Type test**

If a customer requests a certificate for these tests, then the appropriate costs will be invoiced.

1) Resistance measurement as under Point 1.1

2) Temperature rise test at the rated load

3) The load characteristic is plotted

4) The locked-rotor impedance characteristic at partial voltages is plotted

5) The no-load characteristic is plotted and the no-load losses measured

6) Centrifugal test at 1.2 nN (rated speed) from frame size 180M

7) The efficiency is calculated from the individual losses

8) The torque and current characteristics are determined as a function of the speed (for squirrel-cage rotors)

**c) Additional tests**

1) The motor noise is measured

2) The vibration severity of the motors is measured

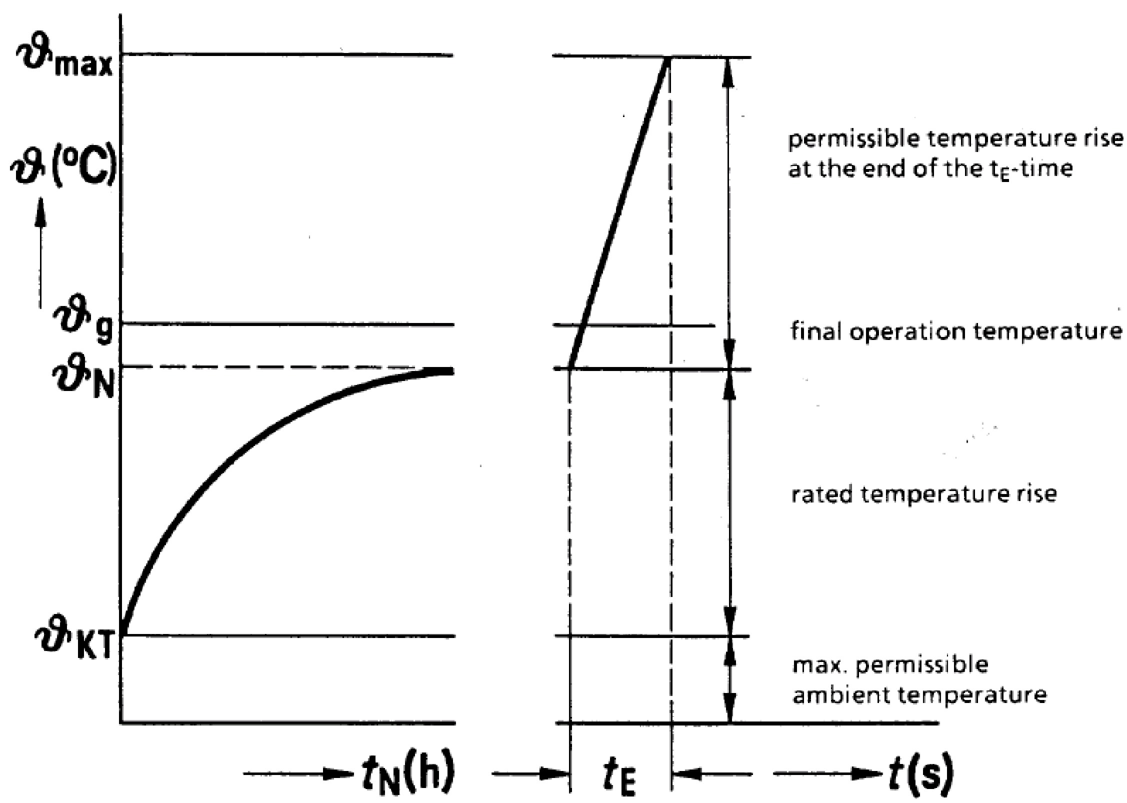
3) Measurements, which customers request for the motors which they have ordered, but which are not specified under Points 1 and 2.
After the technical possibilities have been clarified, all of the additional tests require an agreement in writing.

**d) Acceptance**

For acceptance testing, a selection should be made from the three specified points corresponding to the customer's requests. The acceptance costs are invoiced according to actual costs incurred.

## Te time

This is the time within which an AC winding temperature increases from its final temperature in rated operation up to its limit temperature at the highest permissible ambient temperature as a result of the starting current IA flowing through it.



# Torque

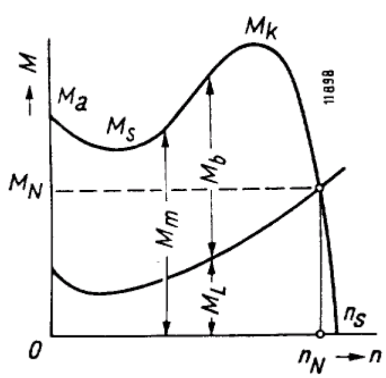
Torque is created by the effect of force applied to a lever arm. When theoretically calculated, it is the product of force multiplied by the vertical distance to the axis of rotation; for belt drives, e.g. the circumferential force multiplied by the radius of the belt pulley.

$$M = 9{,}55 \times P \frac{1000}{n}$$

M = Torque in Nm

P = Power in kW

n = Speed in RPM

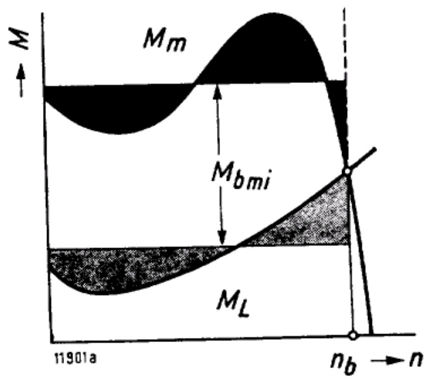



$M_N$ = rated torque
$M_m$ = motor torque (mean value)
$M_L$ = load torque (mean value)
$M_b$ = acceleration torque
$M_a$ = locked rotor torque
$M_k$ = break down torque
$M_s$ = pull-up torque
$n_N$ = rated speed
$n_s$ = synchronous speed

Fig. 1 shows the typical torque characteris
three-phase asynchronous motor. The loa
torque of the driven machine counteracts
motor. The motor torque must be larger t
the load torque over the whole range of t
speed because the drive can only run up t

Fig. 1

The typical torque characteristic of a three-phase asynchronous motor is shown in Fig. 1. The load torque of the driven machine opposes this. The motor torque must exceed the load torque over the complete speed range as the drive can only be brought up to its rated speed if there is sufficient accelerating torque.




$M_m$ = motor torque (mean value)
$M_L$ = load torque (mean value)
$M_{bmi}$ = average of acceleration torque
$n_b$ = operation speed

In general it is sufficient to know the averag
the acceleration torque for the calculation o
the starting time, which is done as follows (s
also fig. 2).

A horizontal line is drawn through the torq
characteristic of the motor as well as of the
in that way that the upper and the lower cu
area of each curve has exactly the same size
average of the acceleration torque than is t
difference of the average of the motor torq
and the load torque $M_{bmi} = M_m - M_L$.

Fig. 2

When calculating the starting time it is generally sufficient to use the average accelerating torque: A horizontal line is drawn through the characteristics of the motor torque and load so that the torque areas above and below this line are the same. The average accelerating torque is then the difference between the average motor torque and average load torque.

(also refer to Starting time, Rotor class, Load torque)

## Trans-standard motors

These are low-voltage motors larger than frame size 315M.

Three-phase motors, surface cooled and internally cooled are standardized up to and including frame size 315 M. This means that outputs and dimensions of the shaft ends are assigned to the various frame sizes.

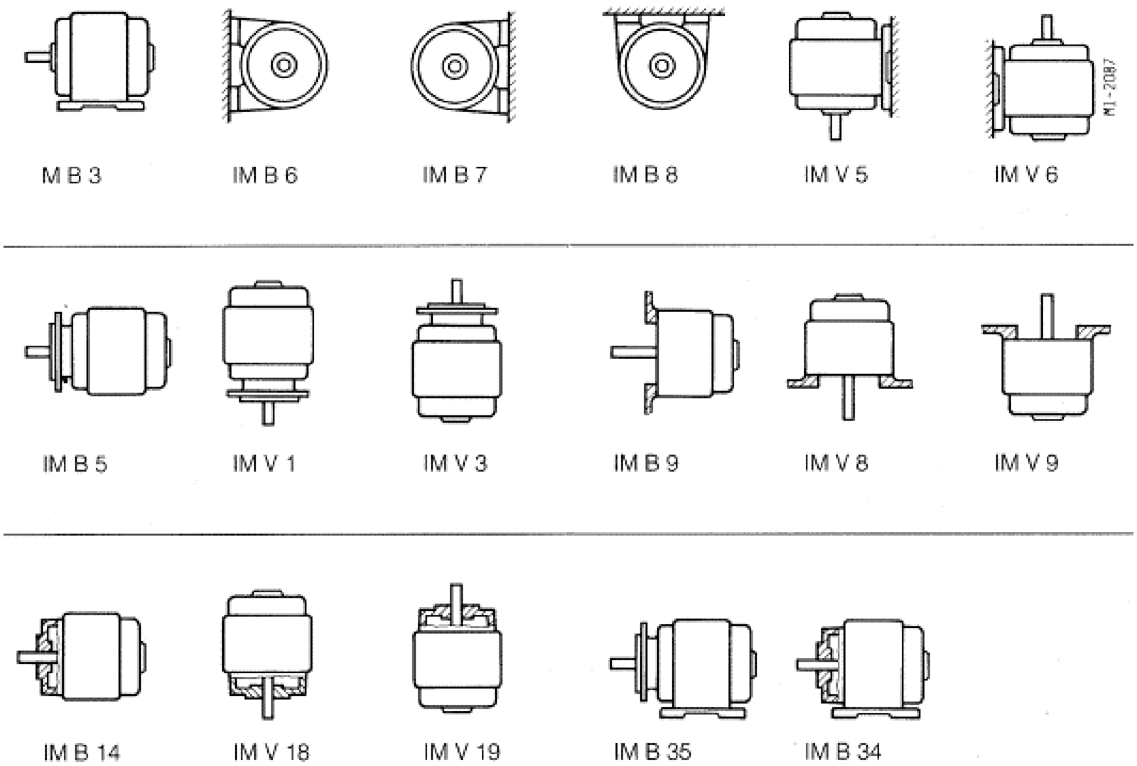
For larger motors (= trans-standard motors), up until now, only the mounting dimensions are standardized by IEC 72. However, these are not included in DIN 42 673 and DIN 42 677. The combination/assignment of size and power and shaft end can differ for individual manufacturers.

Standardized shaft heights for low-voltage motors:

355 mm
400 mm
450 mm

# Types of construction

## according to DIN IEC 34, Part 7




In addition to the basic IM B3 type of construction, motors are also available in other types of construction. The possible versions for a specific motor type are listed in the "Types of construction" selection tables in Catalog M1. Smaller motors up to frame size 160 have preferably type of construction IM B14 - with large or small flange - instead of type of construction IM B5. For IM B5, the motor mounting bolts are inserted through the holes in the flange. The IM B14 flange has tapped holes to retain the motor to the driven machine. Vertical types of construction also have a protective canopy - especially when they are installed outdoors. This is specified for all explosion-protected motors where the shaft faces downwards. For shafts which face upwards, solid objects must be prevented from falling into the fan cowl.

Standard 1LA5 and 1LA6 motors in the standard output range (up to frame size 315M) have the same Order No. supplement for the corresponding types of construction, e.g. 0 for IM B3, IM B6, IM B7, IM B8, IM V5, IM V6. They can be correspondingly used.

Below is a comparison of the most important codes for the various types of construction in accordance with DIN IEC 34, Part 1 with the old DIN  42950 and IEC 34-7, Code II.

| DIN IEC 34,Part 1<br>IEC 34-7 Code I | DIN 42950 | IEC 34-7 Code II |
|---|---|---|
| IM B3 | B3 | IM 1001 |
| IM V5 | V5 | IM 1011 |
| IM V6 | V6 | IM 1031 |
| IM B6 | B6 | IM 1051 |
| IM B7 | B7 | IM 1061 |
| IM B8 | B8 | IM 1071 |
| IM B15 | B15 | IM 1201 |
| IM B35 | B3 / B5 | IM 2001 |
| IM B34 | B3 / B14 | IM 2101 |
| IM B5 | B5 | IM 3001 |
| IM V1 | V1 | IM 3011 |
| IM V3 | V3 | IM 3031 |
| IM B14 | B14 | IM 3601 |
| IM V18 | V18 | IM 3611 |
| IM V19 | V19 | IM 3631 |
| IM B10 | B10 | IM 4001 |
| IM V10 | V10 | IM 4011 |
| IM V14 | V14 | IM 4031 |
| IM V16 | V16 | IM 4131 |
| IM B9 | B9 | IM 9101 |
| IM V8 | V8 | IM 9111 |
| IM V9 | V9 | IM 9131 |

## Types of protection

Increased safety "e"

This degree of protection is suitable for all electrical equipment, which, in operation, do not have an igniting effect (e.g. squirrel-cage motors, transformers, lamps, etc.). Special measures, with an increased degree of safety, prevent the possibility of inadmissibly high temperatures and sparking or arcing.

Flameproof (explosion-proof) enclosure "d"

All parts, which could ignite a firedamp or explosive atmosphere, are contained in an enclosure. This enclosure is able to withstand the explosion of an explosive mixture inside it and prevents the explosion from being transferred to the explosive ambient atmosphere surrounding the housing.

Pressurized enclosure "p"

The ambient atmosphere is prevented from entering the enclosure of the electrical equipment by using an inert gas, e.g. pure air which is used to pressurize the inside of the housing, and more precisely with or without continuous purging.

(also refer to European Standards)

# U

## UNEL-MEC

UNEL is an Italian regulation which corresponds to DIN.

MEC = Mercato - Europeo-Commune = EC

This means that motors which are in compliance with UNEL-MEC can be used in Europe and are in compliance with IEC

(also refer to European Standards, IEC regulations)

# V

## VDE regulations

VDE = Verband Deutscher Elektrotechniker e.V. [Association of German electrical engineers]

The general secretary of the VDE includes, among other things, the regulations department, which is responsible for regulations and the various commissions which have been set-up for this purpose.

VDE regulations involve themselves with defining specifications for the erection and operation of electrical plants and systems as well as the manufacture and operation of electrical equipment. They include technical data about the properties, features, dimensioning, testing, protection, maintenance and are intended to optimally protect human life and material objects in the generation, transmission, storage and use of electrical energy.

VDE 0530 "Regulations for electrical machinery" is mainly valid for low-voltage three-phase motors. These regulations apply independently of the output and voltage for all rotating electrical machinery and rotating transformers. Motors and generators for traction applications are excluded. They include the requirements which electrical machinery must fulfill.

Siemens standard motors not only maintain VDE regulations, but in some cases, considerably exceed them.

## Vibration severity

The vibration severity is the square of the average value (RMS value) of the vibration velocity. This RMS value of the vibration velocity should be directly measured using electrical equipment.

More detailed information is provided in DIN VDE 0530, Part 14 "Mechanical vibration of specific electrical machinery with a shaft height of 56 mm and higher; measurement, evaluation and limit values of the vibration severity".

The vibration measuring equipment must fulfill the requirements laid-down in DIN 45 666.

Table 1 Vibration severity limits according to DIN VDE 0530, Part 14

| | | Max. RMS values of the vibration velocity for shaft height SH in mm | | | | |
|---|---|---|---|---|---|---|
| Quality level | Rated speed | Electrical machinery which are measured when freely suspended | | | | Rigid mounting |
| | | SH 56 - 132 MM/S | SH 132 - 225 MM/S | SH 225 - 400 MM/S | SH > 400 MM/S | SH > 400 MM/S |

| | | | | | | |
|---|---|---|---|---|---|---|
| N (normal) | 600 - 3600 | 1.8 | 2.8 | 4.5 | 4.5 | 2.8 |
| 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 | | |

Comment 1:

For electrical machinery, which require lower values than are specified in Table 1, we recommend that values are selected from the preferred series 0.45; 0.72; 1.8 and 2.8 mm/s. As a result of their special features, the operation of machines with these vibration severity stages should first be discussed between the manufacturer and customer.

Comment 2:

Both mounting types can be applied for electrical machinery with H > 400 mm. However, the results are not comparable. Unless otherwise agreed, the manufacturer can select the mounting type.

Comment 3:

The evaluation of axial bearing vibration depends on the function and mechanical design of the bearing. For axial bearings, axial vibrations result in load fluctuations which means that sleeve bearings or parts of roller bearings could be damaged. Axial vibration in these bearings should be evaluated in the same way as lateral vibration. Lower requirements are permissible for bearings without axial guides. In this particular case, agreements must be made in advance between the manufacturer and the customer.

The limit values of IEC 34-14 deviate from the above mentioned values in Table 1 as follows:

Table 2 Vibration severity limits in accordance with IEC 34-14

| | Max. RMS values of the vibration velocity for shaft height SH in mm | | | |
|---|---|---|---|---|
| Rated speed | Electrical machinery which are measured when freely suspended | | | Rigid mounting |
| | SH 56 - 132 mm/s | SH 132 - 225 mm/s | SH > 225 mm/s | SH > 400 mm/s |
| 600 - 1800 | 1.8 | 1.8 | 2.8 | 2.8 |
| 1800 - 3600 | 1.8 | 2.8 | 4.5 | 2.8 |

## Vibration immunity

The new series of Siemens motors, with the high quality insulating materials and impregnating resins as well as the appropriate mechanical frame and feet designs are also immune to vibration in the normal version.

We recommend that a check is made for exceptional stressing, specifying the expected forces, e.g. as a multiple of the acceleration due to gravity. This is especially true for electrical machinery (motors and generators) for marine applications with vibration immunity specified according to BV 044/10.63.

## VIK

Vereinigung Industrielle Kraftwirtschaft, Essen. [German Federation of Industrial Energy Consumers and Energy Producers, Essen]

This is a Federation comprising over 400 German companies from all industry sectors such as mining, iron and steel, iron plants, metal processing, pulp, textile and chemical industries, machinery and vehicle construction. The purpose of this Federation is to generally promote industrial power management and secure the common energy-related interests of the member companies.

"Technical requirements" for three-phase asynchronous motors were drawn-up together with motor manufacturers. The latest status is May 1992. In addition to general data, mechanical design and electrical design data are defined in these requirements. They apply for Standard IP 54 motors as well as for the (Ex)e and (Ex)d versions.

Motors up to shaft height 355 are available in a VIK version. VIK is not possible for 1LA5 motors; 1LA6 motors should be used instead.

An additional low-noise version is required for 1LA6 and 1MA6 motors, frame sizes 315 S to 315 L, 2 pole and for all 2-pole 1MJ8 motors (code K37 or K38).

## Voltage selection

All standard voltages, which have no special codes and all non-standard voltages, for which codes are defined, can be selected using the "Voltage selection" combo box. Furthermore, all voltage which are technically possible, can have a non-standard winding. In this case, all 50Hz and 60Hz voltages can be selected. If a frequency is first selected, e.g. 50Hz, then only 50Hz voltages can be selected.

Voltage tolerance

According to DIN EN 60 034-1, motors have a voltage tolerance of ± 5 %. The tolerance of ± 5 % according to DIN EN 60 034 also applies to the rated voltage range. When this tolerance is utilized, the permissible limit temperature rise of the particular temperature rise Class may be exceeded by 10 K.

The rated voltage range is stamped for the following rated voltages:

| | |
|---|---|
| 1LA and 1MJ motors: | 230 VD/400 VY, 400 VD/690 VY, 415 VY, 415 VD, 460 V 60 Hz |
| 1MA motors (exception:1MA8) | 230 VD/400 VY, 400 VD/690 VY |

## Voltage changes

The torque of a motor changes as a function of the square of the voltage. This means, that when the voltage decreases by 10 %, the stall torque is only 81 % of the original absolute value.

The current of a motor changes linearly with the voltage. This means that when the voltage decreases by 10 %, the starting current is only 90 % of the original absolute value.

VDE 0530 specifies that a ± 5 % voltage deviation is possible for a motor. If the voltage is permanently reduced by more than 5 %, the output of a motor must be reduced by the same amount.

However, if the motor is loaded with its rated output, then the current correspondingly increases because the power is approximately proportional to the product of voltage and current. This would mean that for a voltage of 80 %, the current would be 125 % of the rated current.

Voltage increases greater than 10 % are normally not permissible for motors (please inquire). This results in a higher induction and the iron losses approximately increase to the square of the voltage drop. As soon as the motor is saturated, the magnetizing current increases rapidly.

The motor may be able to be supplied with a wide-range winding if significant voltage changes are expected. In many cases, this means that the winding is designed for the higher voltage and there is an appropriate de-rating (reduced power) for the lower voltage – or a higher insulation class is used. The S motor is also suitable for a wide voltage range.

(also refer to Frequency change)

## Voltage drop along the feeder cable

The voltage drop along the feeder cable can be determined using the total impedance (feeder cable and motor).

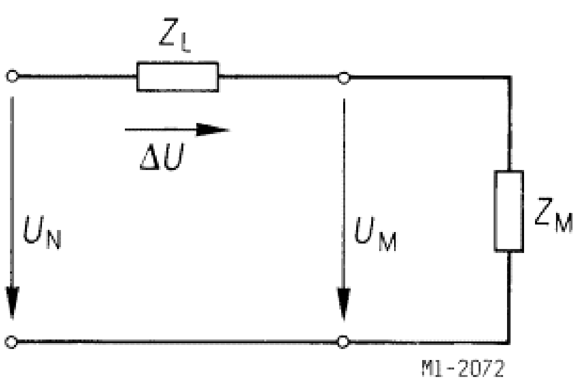
$$\Delta U = \sqrt{3} \times Z_L \times I; \qquad \text{whereby } I = U_N / (Z_{ges} \times \sqrt{3})$$

The total impedance is calculated as follows:

$$Z_{ges} = \sqrt{(R_L + R_M)^2 + \omega^2 \times (L_L + L_M)^2}, \text{ whereby}$$

$$R_M = Z_M \times \cos phi; \qquad L_M = Z_M \times \sin phi$$

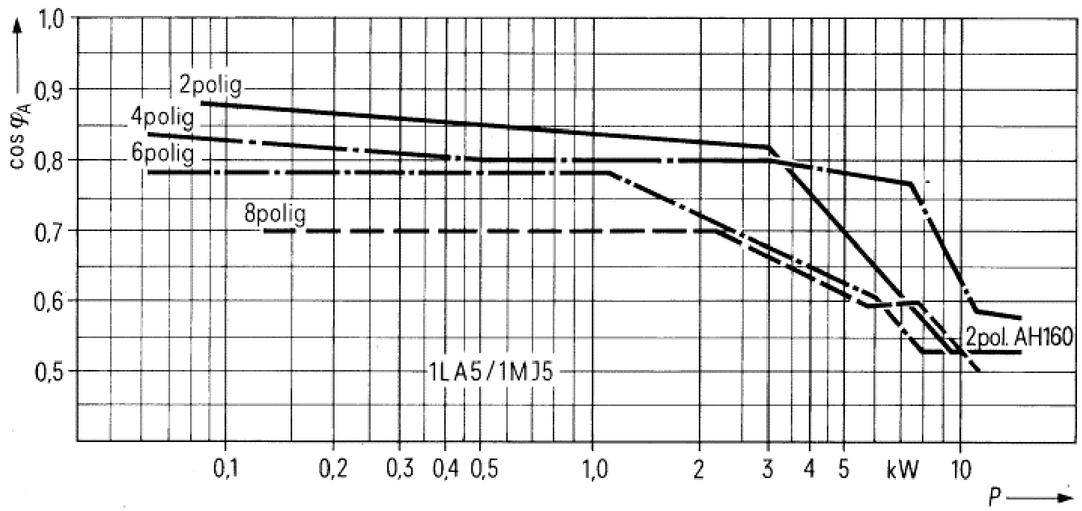
$$\sin phi = \sqrt{1 - \cos^2 phi}, \text{ and } \quad Z_M = U_{NM} / (I_{NM} \times \sqrt{3})$$

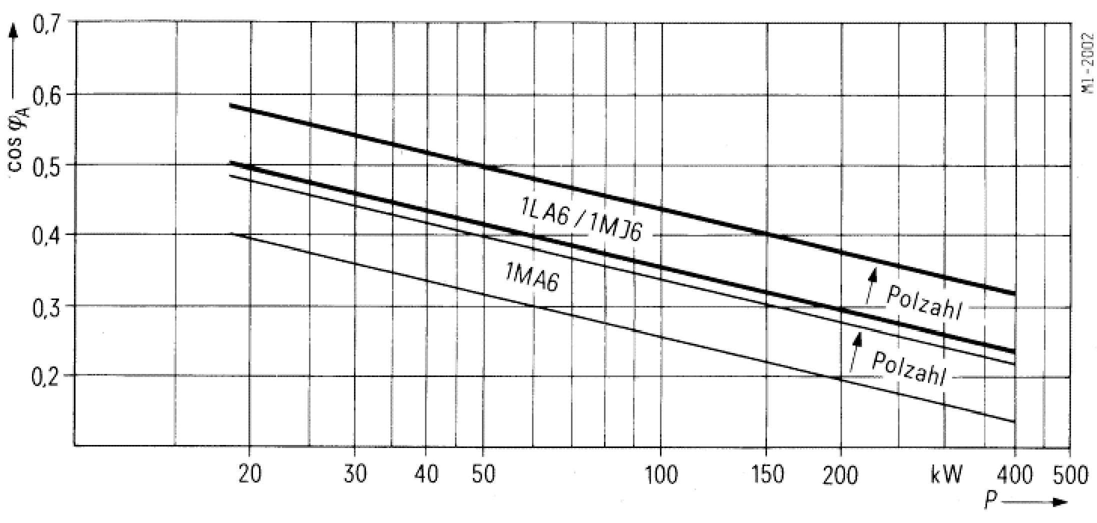



Delta V = voltage drop along the feeder cable
I = current in the feeder cable
VNM = rated motor voltage
INM = rated motor current
LL = inductance of the feeder cable (LL can be neglected under 25 mm²)
LM = motor inductance
RL = cable resistance
RM = motor resistance
Z = cable impedance (ZL = RL + j Omega LL)
ZM = motor impedance

Often, it is necessary to know the voltage drop when the motor is powered-up. In this case, the rated motor current is replaced by the motor starting current IA and the cos Phi by the starting cos PhiA. All of the required motor parameters are list values with the exception of cos PhiA.

Comment: It is assumed that the line supply is stiff for this calculation.



## V ring - axial sealing ring

The V ring is located on the shaft and rotates with this. Together with the mating surface it forms an axial seal.

The V ring is a shaft and bearing seal and is used to seal the bearings for Siemens standard 1LA6 motors. This means that the grease retains its lubricating properties for a longer period of time. The motor has an overall IP 55 degree of protection.

# WXY

## Water condensation drain hole

This is a water drain hole at the lowest point inside the motor so that any condensation water which forms can drain out of the motor.

1LA6225 – 315 and 1LG4/6 always have one water drain hole at the drive end and one at the non-drive end. The water drain holes have plastic plugs.

1LA5, 1LA61, 1LA7, 1LA9 do not have any water drain holes as standard . However, these can be optionally ordered.

For flameproof motors, water drain holes are not permitted. For the special case where condensation water does occur, recesses are cast inside the frames of 1MJ motors so that any condensation water is kept away from the winding.

## Winding

The winding is one of the most important components of any motor. Current flows through the winding conductors and for three-phase asynchronous motors, generates a rotating field in the stator. The single-layer winding of a 2-pole three-phase motor has 3 coils and that of a 4-pole motor, 6 coils. The conductors belonging to a particular coil group are distributed over several slots. The winding directly influences many of the motor data. The winding (design and implementation) and especially its insulation have an essential influence on the lifetime of any particular motor.

<u>A differentiation is made between various winding types:</u>

Fed-in winding (mush winding):
With this technique, the wires and conductors are manually or automatically fed into the slot.

Pull-through winding:
This technique is used if it is difficult to feed-in the conductors as a result of the small slot opening. The conductors are thread into the slot from one side and are then pulled through as the name suggests.

Machine winding:
With this technique, the winding coils are inserted using a machine.

Semi-automatic winding:
The winding coils are inserted in sections, one after the other, using a machine.

Manual winding:
With this technique, if the weight of copper is too high for machine winding, the winding is manually inserted in coil sections. This also means that a higher degree of filling of the stator slot is achieved.

<u>A differentiation is made between various winding types:</u>

Single-layer winding:
Every slot only contains conductors belonging to one coil side. This is the most usual winding, especially for stators of small motors. This can easily be done using a machine (pull-in technique).
A single-layer winding is only possible if an integer number is obtained as follows

[ stator slot number / ( phase number * pole number ) ]

Two-layer winding:
Every slot has two different coils, one for each coil side. This chorded winding (fractional-pitch winding) essentially avoids harmonics. However, it is extremely difficult to produce on a machine.

In this case [ stator slot number / ( phase number * pole number ) ] results in a fractional number

(also refer to Pull-in technique)

## Winding protection

The motors are generally protected using thermal, delayed overload protective functions (circuit-breaker for motor protection or overload relay). This protection depends on the current and is especially effective when the rotor is locked. Furthermore, it is possible to additionally protect motors using the semiconductor temperature sensor (PTC = PTC thermistor or PT 100), integrated in the winding, in conjunction with a tripping unit (thermistor motor protection). This type of protection is temperature-dependent and protects the motor against an inadmissible winding temperature rise. This can occur, for example, if the motor load fluctuates significantly or if the motor is being frequently powered up and down.

All 1LA8 and 1MA8 motors have, in the standard version, 6 PTC thermistors for alarm and trip.

For thermistor protection, three PTC temperature sensors, connected in series, are integrated in the motor stator winding. The 3RN1 tripping unit, which is part of the protective equipment, must be separately ordered.

If, in addition to the motor being shutdown, an alarm is also to be output, then two sets of three temperature sensors are integrated. Generally, the alarm is output 10 Kelvin below the shutdown temperature.

For the options for Zone 2, with drive operation (L87,L88,L89;M03,M04,M05), 1LA6225 – 315 and 1LG?18 – 315 motors always have 3 PTC thermistors to shutdown (trip) in the winding and 1 PTC thermistor for shutdown (trip) in the terminal box. The 4 PTC thermistors are connected in series.

The following applies for EExde motors:

If these motors are fed from a drive, PTC temperature sensors are an absolute necessity. In this case, for 1MJ6 motors, an additional PTC thermistor is installed in the terminal box.

# Requests and Requirements from specifications

A list with terms and abbreviations, which are used in specifications, is provided here.

This list neither claims to be complete nor correct

## Armored cables or screened cables

Cable glands for armored or screened cable are only
possible on request for frame sizes 180 - 315.
In this case, the outer cable diameter and the cross-section must be specified.

## Cable entry thread in NPT / thread hub size in NPT

NPT = **N**ational **P**ipe **T**aper

Overview:

| Metric | NPT | PG earlier |
|---|---|---|
| M16x1.5 | ½" | PG 7 or PG1061 |
| M20x1.5 | ½ - ¾" | PG13.5 to PG16 |
| M25x1.5 | ¾ - 1" | PG21 |
| M32x1.5 | 1 – 1¼" | PG29 |
| M40x1.5 | 1¼ - 1 ½" | PG36 |
| M50x1.5 | 2" | PG42 |
| M63x1.5 | 2 ½" | PG48 |
| M72/M75x1.5 | 3" | M72x2 |
| M80/M85x2 | 3" | M80x2 |
| M90x2 | 3 ½" | Not possible |
| M105x2 | | possible |

NPT (National Pipe Taper) cable entry threads should be ordered using the E line, specifying the thread size.

When supplied, the thread opening is closed with adhesive tape.

also refer to Cable glands in NPT

## Bearing insulation

Bearings can be insulated for 1LA/1PQ motors, shaft heights 280 and 315.
This is possible for 1LG motors from shaft height 225, which are fed from a drive. The relevant option is L27

## Bearing temperature detectors

Bearing temperature detectors can be provided for 1LA motors from shaft height 280 and 1LG motors from shaft height 180.
Bearing temperature detectors(these bearing temperature detectors are generally PT100). 1 or 2 PT100 bearing temperature detectors can be provided for each bearing.
Either a 2 or 3-conductor circuit can be used for the bearing temperature detectors. However, in this case, the number of terminals must be taken into account.
For example, option A72 (4 terminals) or option A80 (12 terminals) especially in conjunction with additional options which require auxiliary terminals.

## b/l

= bill of lading (sea freight)

## Breakdown torque

breakdown torque = pull-out torque (synchronous motors)

## Class I Division 1 group A - D

Motors according to EN 60 034 or EN 50 018 (1MJ6) are no longer permitted for type of construction IM B3.
This results from the EPACT legislation as we cannot manufacture 1MJ motors with the required
efficiencies in compliance with EPACT.
1MJ motors are permissible in other types of construction (with the exception of IM B3).
The limit temperature of 180°C is specified for "Group C".

## Class II Division 1 group E - G

Here, dust explosion-protected EPACT motors, in accordance with EN 60 034, should be used
with "Version for Zone 21" (options, M34 or M38)
For Group G, according to NEMA, a limit temperature of 180°C is specified;
however, the SIEMENS certificate is issued for 125°C.
Customers must be informed about this!
A check must be made in the motor plant!

## Class III Division 1

In this case, EPACT motors, listed in the Catalog, in compliance with EN 60 034 should be used

## Class I Division 2 group A - D

Now, only the following are permitted: EPACT motors for Zone 2 in compliance with IEC 79-15 (options M72 / M73)
(stamped: Ex nA II T3)
For "Group C" a limit temperature of 180°C is specified; however, the SIEMENS certificate is issued for T3 (= 200°C)
In this case, a check must be made in the motor plant.

## Class II Division 2 group E - G

Here, dust explosion-protected EPACT motors in accordance with EN 60 034 should be used
with "Version for Zone 21" (options, M34 or M38)
For Group G, according to NEMA, a limit temperature of 180°C is specified;
however, the SIEMENS certificate is issued for 125°C.
Customers must be informed about this!
In this case, a check must be made in the motor plant!

## Class III Division 2

In this case, EPACT motors, listed in the Catalog, in compliance with EN 60 034 should be used.

## Conductor size acc. to AWG

AWG = **A**merican **W**ire **G**auge

| | |
|---|---|
| # 6/0 = 170.3 mm² | # 8 = 8.35 mm² |
| # 5/0 = 135.1 mm² | # 9 = 6.62 mm² |
| # 4/0 = 107.2 mm² | # 10 = 5.27 mm² |
| # 3/0 = 85.0 mm² | # 11 = 4.15 mm² |
| # 2/0 = 67.5 mm² | # 12 = 3.31 mm² |
| # 0 = 53.4 mm² | # 13 = 2.63 mm² |
| # 1 = 42.4 mm² | # 14 = 2.08 mm² |
| # 2 = 33.6 mm² | # 15 = 1.65 mm² |
| # 3 = 26.7 mm² | # 16 = 1.31 mm² |
| # 4 = 21.2 mm² | # 17 = 1.04 mm² |
| # 5 = 16.8 mm2 | # 18 = 0.823 mm² |
| # 6 = 13.3 mm² | # 19 = 0.653 mm² |
| # 7 = 10.6 mm² | # 20 = 0.519 mm² |

## CT or ct

**C**urrent **T**ransformer
Current transformers are not included in the scope of supply!

## DE

DE = **D**rive **E**nd of the motor

## DIP 321

= **D**ust **I**gnition **P**roof 21
In this case, dust explosion-protected motors for Zone 21 should be used!

## Enclosure made of ferrous metals

The enclosure or motor frame is manufactured out of ferrous materials
i.e. gray cast iron (1LA6, 1LG4 motors etc.) without steel (1MJ8 motor version)

## External earthing (grounding)

External earthing (grounding) connection; this is provided as standard for all motors with gray cast iron frames.

1LA6225 –315, 1LG4/6 18 – 31, 1LA8; 1MA6225 – 315; 1MJ6225 - 315

## FLC

FLC = **F**ull **L**oad **C**urrent = rated current

## FLT

FLT = **F**ull **L**oad **T**orque = rated torque

## Ia/In =<6.5/6.0 or similar

Starting current/rated current<6.0/6.5 --- please inquire in the plant. It is necessary to make a theoretical check.
It may then be necessary, if possible, to use a non-standard winding.

Jacking bolts

Adjusting bolts (only possible for HV motors)

## KTA

KTA Kernkraftwerkstechnische Anlagen [plants and systems for nuclear power stations/utilities]

These inquiries must be carefully checked for these types of plants and systems

## L10 liftime acc. to ISO R 281-1

Nominal bearing lifetime in $10^6$ revolutions
This can be calculated by specifying the axial and radial forces at the drive end

## LHS

LHS left hand side - when viewed from the drive end

The terminal box is located on the lefthand side when viewed from the drive end.

This can be specified in the order designation using code K10.

## LRC

LRC Locked Rotor Current= starting current

## LRT

LRT Locked Rotor Torque= starting torque

## Locked rotor time

locked rotor time (hot / cold); also: safe stalled time

## Lubrication data

Lubrication instructions and information – these are specified as standard on a supplementary plate (lubrication information plate) for all motors with re-lubrication device, also for option K40
(bearing type, drive end and non-drive end, grease type, grease quantity when re-lubricating
(bearing type, drive end and non-drive end, grease type, grease quantity when re-lubricating
and lubrication intervals). The lubrication information plate

is manufactured out of stainless steel from frame size 80 and above!

## Cooling methods

Cooling types, new in accordance with EN 60 034-6
**IC410** = non-ventilated, without fan

1LP motors

**IC411**= self-ventilated with a fan mounted on the shaft or a fan driven by the motor

1LA/1LG, 1MA and 1MJ motors

**IC416**= forced cooling using a separately-driven fan or another cooling medium

1LA/1LG motors with option G17 or 1PQ motors

also refer to Cooling types

## Mil norm

motors acc. to MN

## Motors acc. to MN

This signifies motors which are in compliance with "Military Standards ..." !!
It is not permissible that a quotation is provided! (refer to the Export regulations!)
Mil norm

## Mounting a half coupling

= mounting a half coupling on the motor shaft. This is only possible for frame sizes 180 – 315
(option L10, on request)

## Stainless steel nameplate

Stainless steel rating plates, provided as standard from frame size 90 onward.
Special version on request for frame sizes 56 – 71!

also refer to Rating plate

## Nameplate in acc. to IEC 34-1

The rating plate is now in compliance with the valid Standard EN 60 034 (stamped)

also refer to Rating plate

## NDE

NDE = **N**on **D**rive **E**nd of the motor

## NEMA design A-D

Winding design in accordance with NEMA.

NEMA design A = standard 1LA/1LG winding without Ia/ In specification
NEMA design B, C or D = special version, only on request
(In this case, only NEMA design A is possible!)

also refer to NEMA - MG1 and NEMA regulations and Code letter acc. to NEMA MG1

## NEMA - MG1

NEMA Standards Publication Motors and Generators
= ANSI C 52.1 ..
For 1LA7 motors with option D30 = electrically stamped in accordance with NEMA:
NEMA MG 1-12 with code letter
(In this case, only NEMA design A is possible!)

also refer to NEMA regulations and Code letter acc. to NEMA MG1

## NEMA 4

Degree of protection of the frame/enclosure according to NEMA; NEMA 4 = IP56

NEMA enclosure 4 = water tight and dust tight = IP5

also refer to NEMA regulations

## NLC

NLC = **N**o **L**oad **C**urrent

## NPT

**N**ational **P**ipe **T**aper

also refer to Cable entry thread in NPT / thread hub size in NPT ; u. cable glands in NPT

## Polarization index

The polarization index is only relevant for HV motors.

## PTC

= positive temperature coefficient
also refer to Winding temperature detectors

## Pull-in torque

**Pull-in torque = starting torque**

## Pull-up torque

Pull-up torque

## rms current

rms = **r**oot **m**ean **s**quare **current** (rms or RMS or r.m.s.)

## Residual field 100%

All of our motors can be powered-up after a power failure against 100% residual field.

## RHS

RHS right hand side - viewed from the drive end

The terminal box is located on the righthand side when viewed from the drive end

This can be specified in the order designation using code K10

## RTD

RTD= **R**esistance **T**emperature **D**etector
(options A60, A61 for the winding)

## Service factor 1.15

= service factor 1.15 - is not possible as standard
This requirement is in accordance with NEMA
1LA5/ 1LA6/ 1LA7/ 1LG motors ex stock / have SF= 1.1
1LA5/ 1LA6/ 1LA7/ 1LG motors have, with option C11: SF= 1.1
1LA8 motors from frame size 400 have, with option C11: SF= 1.05 F/F
1MA/ 1MJ motors: Not possible with SF (this has not been certified)
However, SF 1.15 is possible with a supplementary plate (option Y82) and the following stamp: Reduced standard output (= Pn x 0.95) SF 1.15 F/F

## Squirrel-cage rotor

All of our squirrel-cage rotors have an aluminum cage winding.
We cannot offer copper cage windings.

## Successive starts from cold

Number of successive starts when the motor is in a cold condition

## Temperature rise 80K

80K temperature rise corresponds to F/B

## Terminal box shall be segregated from the motor enclosure

This is provided as standard for 1MJ motors as a result of the flameproof bushing plate.

## Vibration severity limits acc. to IEC34-14

Vibration severity limits acc. to EN 60 034-14 (previously IEC 34-14 and VDE 0530-14)

## Winding temperature detectors

Winding temperature detectors: In this case, 3 or 6 PTC thermistors are embedded in the winding
These can be ordered by specifying option A11 and A12 or A15 and A16 for EExd motors

## Reduced output (de-rating)

The result after multiplying the reduction factors - ambient temperature, installation altitude and utilization of the temperature rise Class - is displayed in the ‘Factor’ field. "Effective output at the shaft - definition" is pre-assigned. In addition, any reduction factor can be defined in this field.

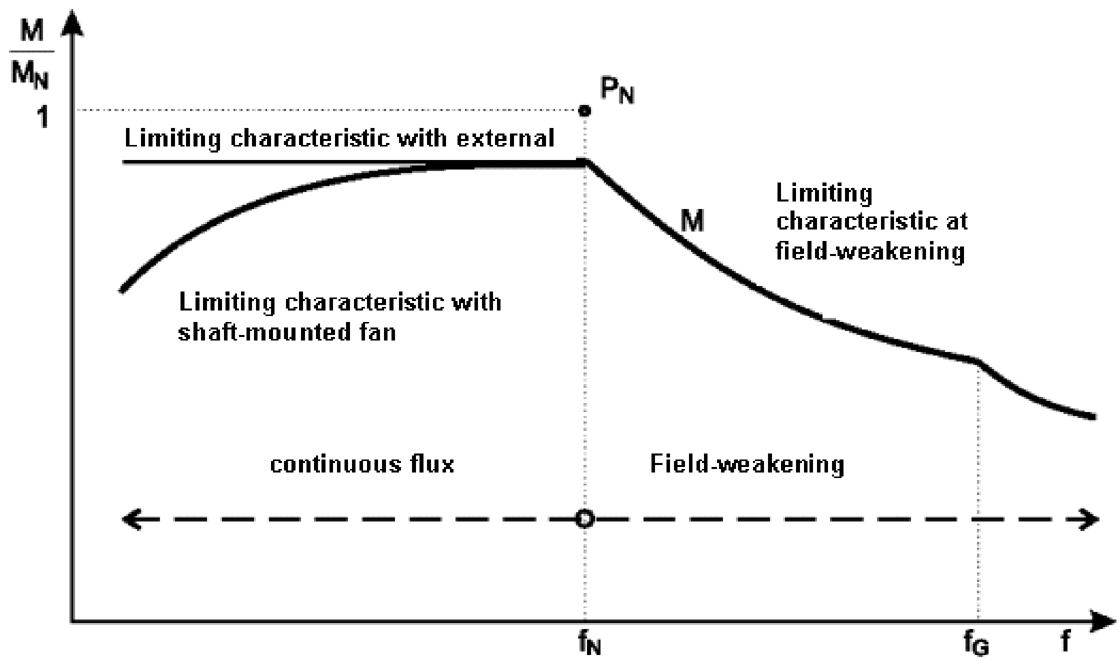
Three-phase motors fed from drives

Three-phase squirrel-cage asynchronous motors can be operated directly connected to the line supply, with a constant voltage and frequency, as well as from an AC drive with variable voltage and frequency.

Depending on the connection, the operating behavior of the motors changes. When connected to the line supply, the motors operate at an almost constant speed with sinusoidal voltages and currents. Continuous, low-loss speed control is possible using AC drives. These are connected between the line supply and the motor. However, the motor voltages and motor currents are then no longer sinusoidal.

The conditions which change with respect to line supply operation, must be taken into account when selecting the motors.

When engineering electric drives, the speed-torque characteristic of the motor and driven machine are important. For asynchronous motors which are connected directly to the line supply, the speed-torque characteristic is of importance. However, for drive operation, it is especially the limit characteristic of the torque which should be carefully observed.



Picture 6: Continuous flux and Field-weakening range

also refer to: Motor - drive - selection ,

## Limit torque characteristic

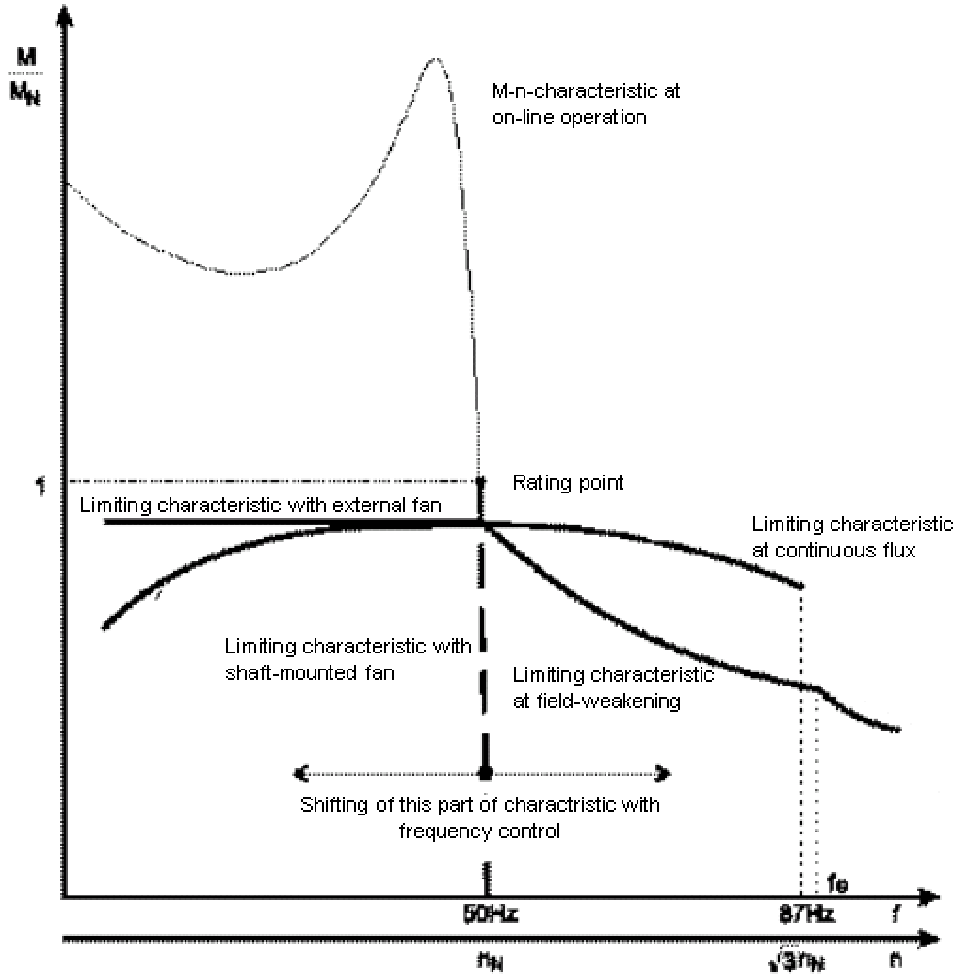
A typical motor torque characteristic when connected directly to the line supply is shown in the following diagram. It is shown with the starting torque, pull-up torque and stall torque.

For drive operation, generally only the steep area shown by the dotted lines is used from the complete speed-torque characteristic (M-n characteristic). By controlling the voltage and frequency, which is possible when using a drive, this range can be shifted in parallel towards low speeds by reducing the frequency. Higher frequencies, at constant flux, shift these ranges in parallel and for field weakening, with reducing gradient, to the right to higher speeds. The torque which is continually available is entered in the diagram as limit characteristic.

The limit characteristic specifies, for constant flux, the thermally permissible torque in continuous operation.

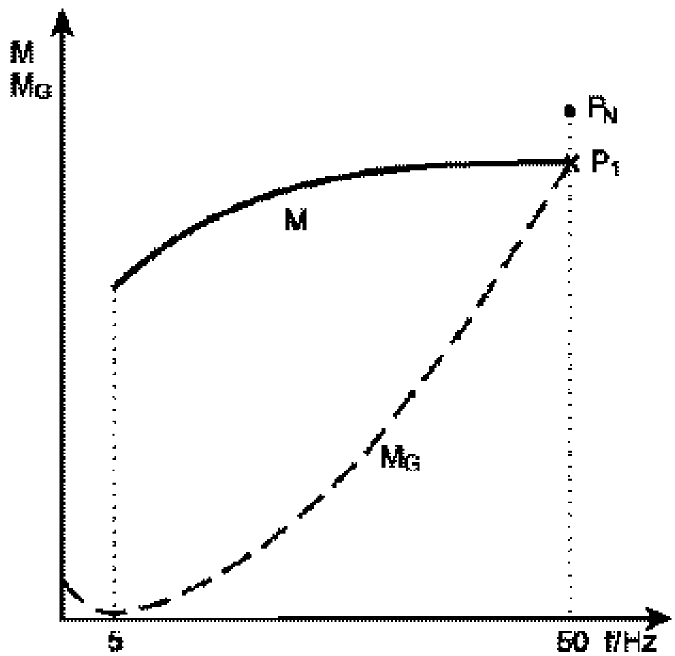
At the limit torque, the motor temperature rise in continuous operation does not increase above that temperature specified for its particular temperature Class.

Operation at "Zero" speed is generally possible.


M
M_N
M-n-characteristic at
on-line operation
1
Rating point
Limiting characteristic with external fan
Limiting characteristic
at continuous flux
Limiting characteristic with
shaft-mounted fan
Limiting characteristic
at field-weakening
Shifting of this part of charactristic with
frequency control
fe
50Hz
87Hz
f
n_N
√3n_N
n

## Drive operation with a square-law load torque

Centrifugal pumps and fans ( blowers ) have a load torque which increases with the square of the speed. From the diagram, it can be seen that a motor with its own shaft-mounted fan is always suitable. The load torque is always less than the motor torque.




## Rotary pulse encoder

Often, rotary pulse encoders are used with variable-speed control systems for three-phase motors.

In this case, a differentiation is made between open-loop speed control (V/Hz control) and closed-loop control.

For open-loop speed control, the motor is operated from the AC drive according to a permanently set V/Hz characteristic, with or without rotary pulse encoder. In this case, the rotary pulse encoder is only used to sense the speed.

For closed-loop speed controlled operation, a motor connected to an AC drive always requires a rotary pulse encoder with feedback to the AC drive.

## Explosion protection for the North American market

The following assignment and types of protection apply when installing motors in hazardous zones for the North American market.

| Division 1 | | | Division 2 | | |
|---|---|---|---|---|---|
| Class 1 | Class 2 | Class 3 | Class 1 | Class 2 | Class 3 |
| Group<br>A / B / C / D | Group<br>E / F / G | ---- | Group<br>A / B / C / D | Group<br>E / F / G | ---- |
| Explosion proof Enclosure in EPACT – Type | Dust explosion protection in EPACT- Type<br>Zone 21 | Cataloge EPACT motors | Non sparking<br>according<br>IEC 79-15<br>Eex nA / Zone 2 | Dust explosion protection in EPACT- Type<br>Zone 21<br>depending on dust-proof requirements | Cataloge EPACT motors |
| Motors from Guatalajara, flame-proof-type for american market in frame sizes 143T (90S) to 449TS (280M) | SIEMENS-motors,<br>dust-proof certificated<br>for Zone 21 | see above | Motors, certificated for Zone 2<br>motors according<br>IEC 79-158 | SIEMENS-motors,<br>dust-proof certificated<br>for Zone 21 | see above |

## Lubrication information plate

Motors with re-lubrication device have a lubrication information plate:
Frame sizes 280 – 315 can, as standard be re-lubricated,and therefore have a re-lubrication information plate.
Frame sizes 100 – 250 have as standard permanent lubrication. These motors can be optionally equipped with a re-lubrication device ( option K40 ). In this case, they are also provided with a lubrication information plate.

The following data is provided on the lubrication plate:

bearings on the drive and non-drive ends

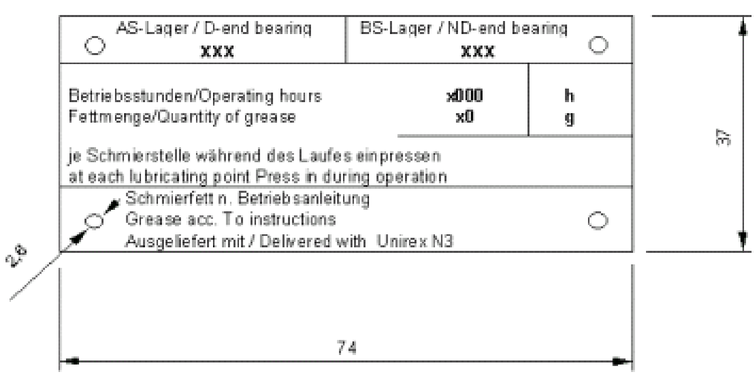
re-lubrication interval

grease quantity (when the bearings are re-lubricated)

type of grease

Material FRE: SHEET STEEL DIN59382-0.5-1.4541.N

Example:




also refer to Re-lubrication device

## Cable glands in NPT

NPT = **N**ational **P**ipe **T**aper

Cable glands with theads in imperial dimensions cannot be supplied. These should be offered to customers who should then install/mount these themselves.

Manufacturer: Example

BARTEC GmbH, D-97980 Bad Mergentheim
Max-Eyth-Strasse 16
Phone: 0049 7931 597-113; Fax: 0049 7931 597-119

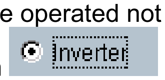
also refer to Cable entry thread in NPT / thread hub size in NPT

## Code letter acc. to NEMA MG1

= breakaway (starting) apparent power [kVA] / active power [HP]
This is classified according to code letter A, B, C ...V
Information about the code letters of 1LA/1LG motors is available on request

## Motor - drive selection

Most of the motors can be operated not just with MM4 drives, but with numerous other drives.

In this case, press button 

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Note:

There are several options or operating conditions which either do not permit drive operation or only in exceptional cases. When selecting such options, line supply operation is automatically selected - i.e. it is assumed that the motor is directly connected to the line supply.

Also refer to:

Motor - MM4 drive selectionMotoren_MM4_Umrichter_Auswahl

Drive operation

Drive operation with square-law load torqueUmrichterbetrieb_mit_quatratischem_Gegenmoment

# Index

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## T

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