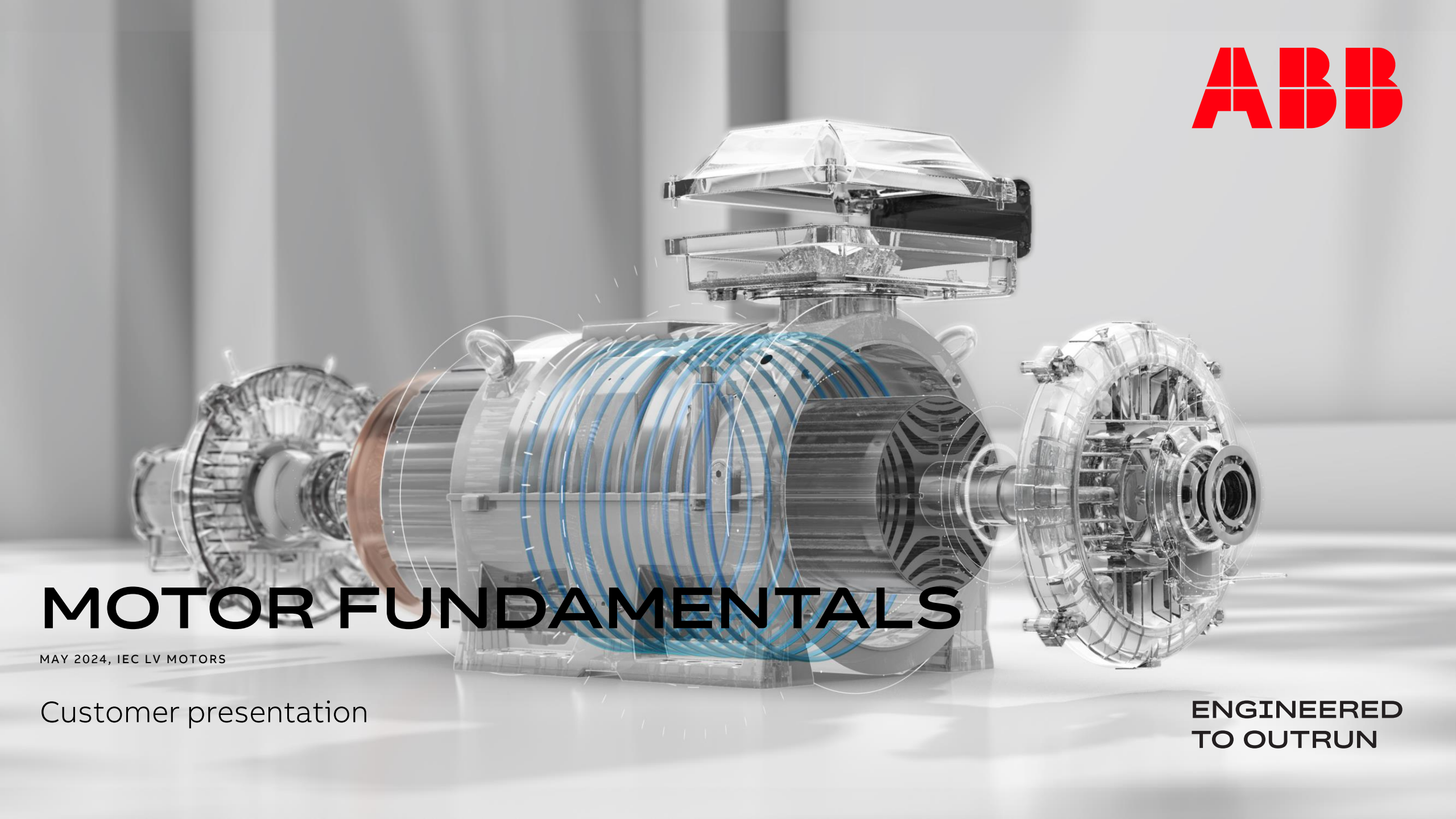


MOTOR FUNDAMENTALS

MAY 2024, IEC LV MOTORS

Customer presentation

ENGINEERED
TO OUTRUN

Agenda
Motor fundamentals

1. Introduction
2. Motor parts and operation fundamentals
3. Motor specification
4. Motor selection criteria

01

INTRODUCTION

Motor Fundamentals

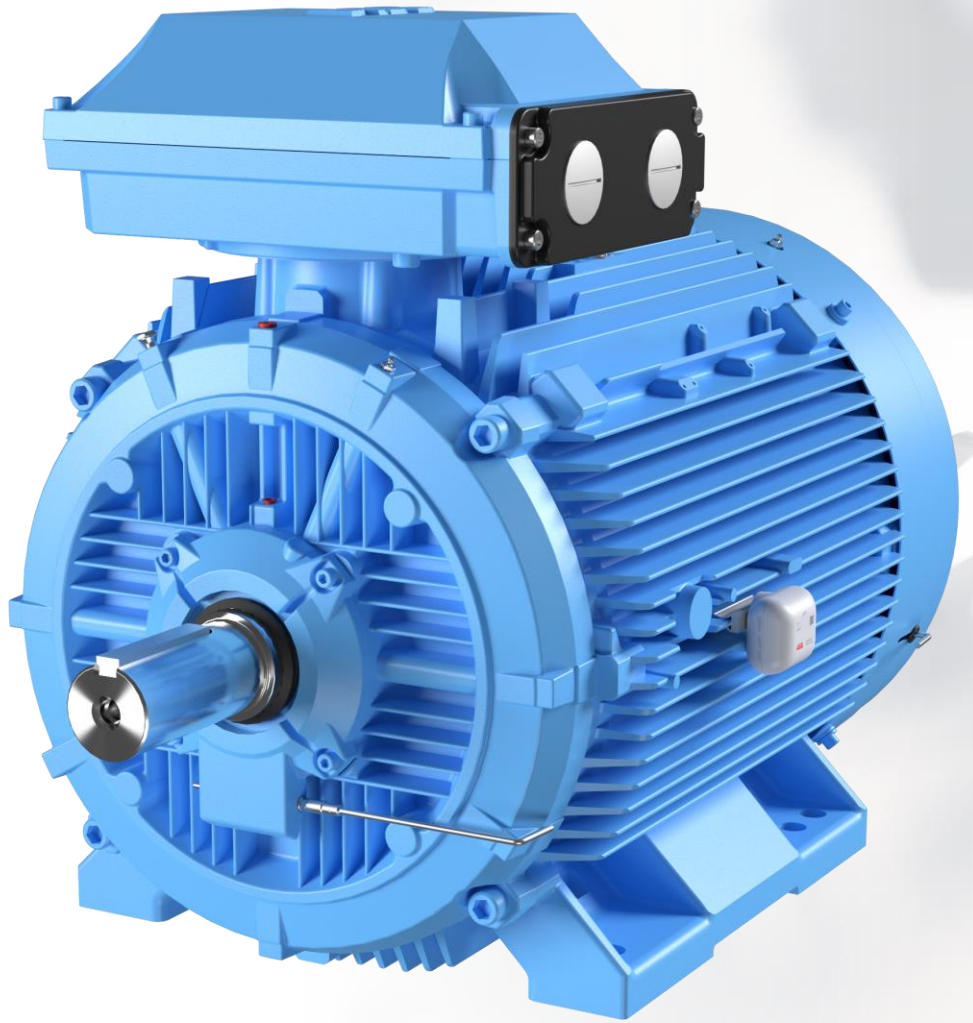
Different types of motors

There are **three** types of basic electric motors

- Alternating current (AC) motors
  - **Asynchronous motors** (Induction motors)
  - **Synchronous motors**
    - SynRM
    - Permanet Magnet motors (PM)
- **Direct current** (DC) **motors**

Induction motor

- The most common used electrical motor
- Low maintenance
- 3-phase and 1-phase
- Mainly used for industrial applications such as centrifugal pumps, fans, compressors etc.



02

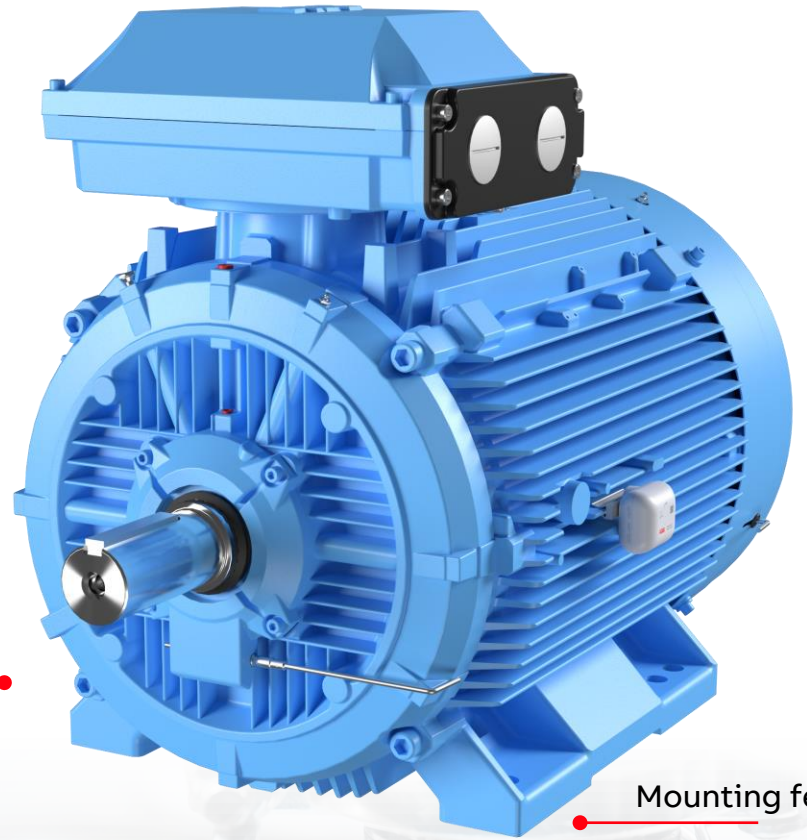
MOTOR PARTS AND OPERATION FUNDAMENTALS

Motor Fundamentals

Induction motors

Shaft

- Shaft coming out of the end shield on one side, we have the shaft end that transmit torque from the motor to the driven application.
- The side where you have the shaft end is referred to as the drive end or D end. The opposite side is referred to as non drive end or ND end
- Majoity of the motors are bi-directional

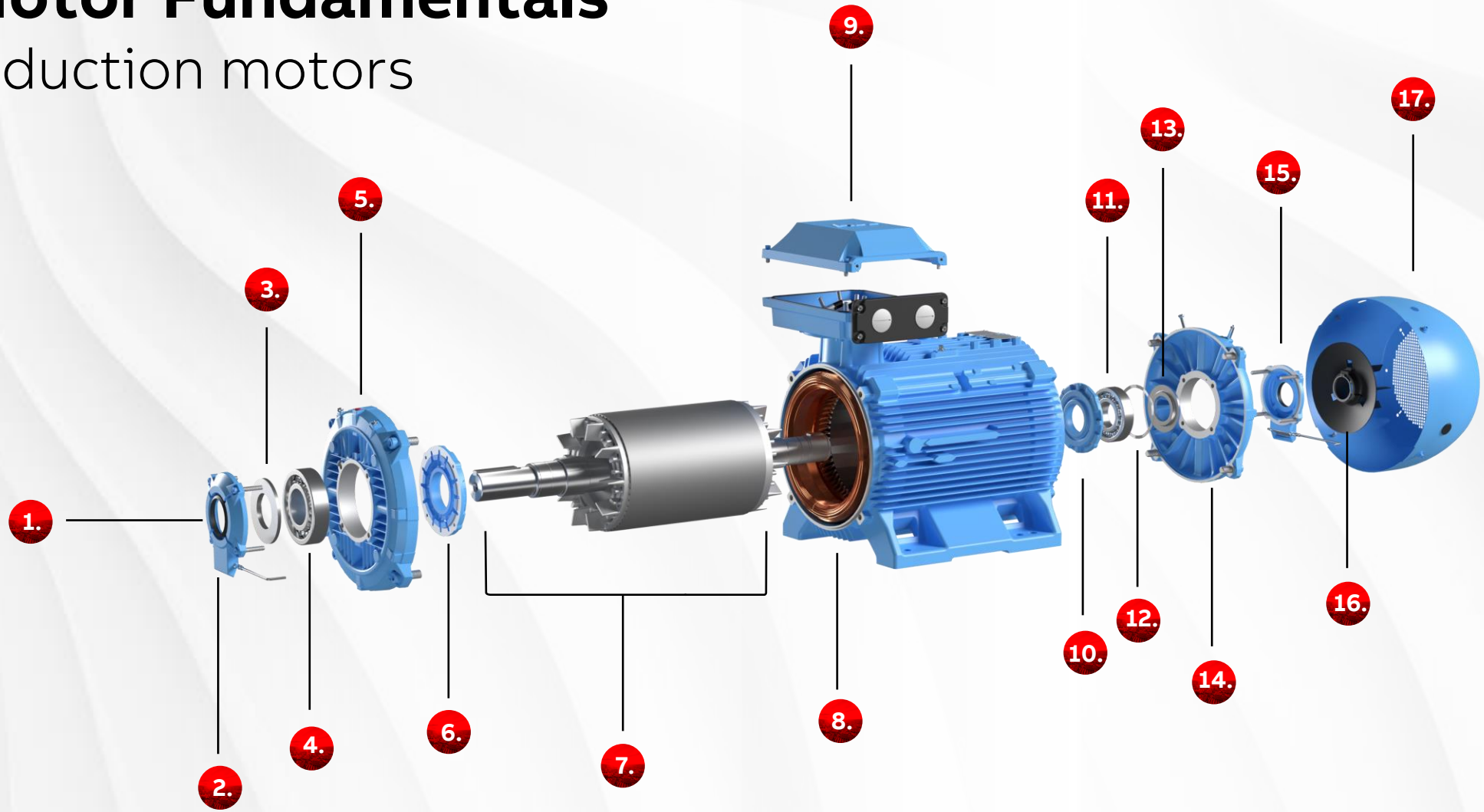


Stator frame

- The stator house holds the stator package and protects the active inner parts from the environment.
- Another task of the stator house is to help the with the heat transfer from inside the motor to the outside, this is the reason why motors often have cooling ribs to increase the surface for better heat dispersion.
- We can also find mounting feet and lifting lugs on the stator house.

Motor Fundamentals

Induction motors



Motor Fundamentals

Induction motors

1.

Grease relief valve

A flexible seal installed around to prevent fluid leakage or debris from entering the machinery

2.

Bearing cover

Encloses and shields a bearing from external contaminants

3.

Valve disc

Controls the flow of fluid by opening or closing the passage

4.

Bearing

Supports and reduces friction between moving parts, allowing rotation

5.

End shield

Fixates the bearings holding the shaft and protecting the inside of the motor from the environment.

6.

Inner bearing cover

A cover situated on the inner side of a bearing to protect and retain lubrication within the bearing assembly

7.

Rotor with shaft

The rotating component, coupled with the shaft, that generates mechanical energy

8.

Stator inside of the frame

The stationary part of an electric motor, which interacts with the rotor to produce electromagnetic force and rotation

9.

Terminal box and terminals

On top of the motor we have the terminal box that houses the connectors which is used for connecting the motor to the electrical network.

Motor Fundamentals

Induction motors

10.

Bearing cover

A protective cover that encloses and shields a bearing from external contaminants

11.

Bearing

Supports and reduces friction between moving parts, typically allowing rotation or linear movement

12.

Preloading spring for bearings

Used to apply a controlled preload to bearings, ensuring proper operation and reducing vibration

13.

Valve disc

The movable component of a valve that controls the flow of fluid by opening or closing the passage

14.

End shield

Fixates the bearings holding the shaft and protecting the inside of the motor from the environment.

15.

Bearing shield

A protective cover or enclosure that shields a bearing from external contaminants

16.

Fan

Used to circulate air or coolant to dissipate heat and maintain optimal operating temperatures

17.

Fan cover

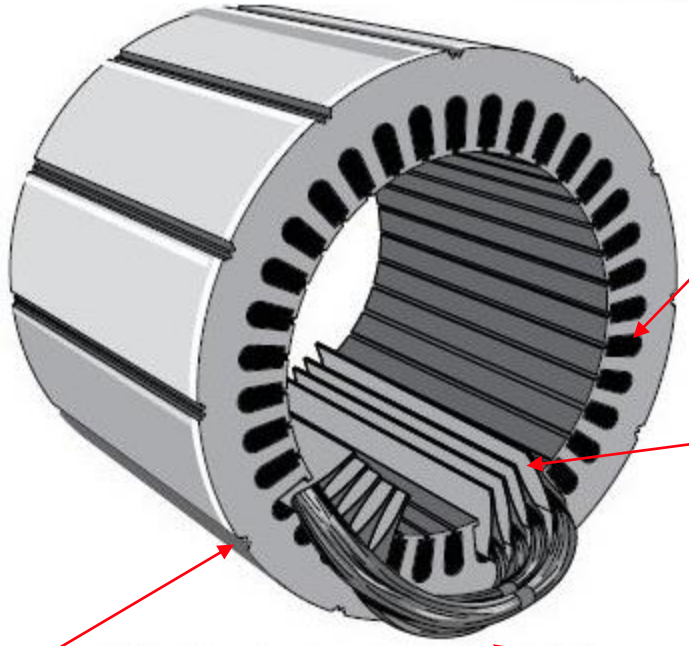
Protects and directs the airflow created by the fan mounted on the shaft over the motor housing

Motor Fundamentals

Induction motors

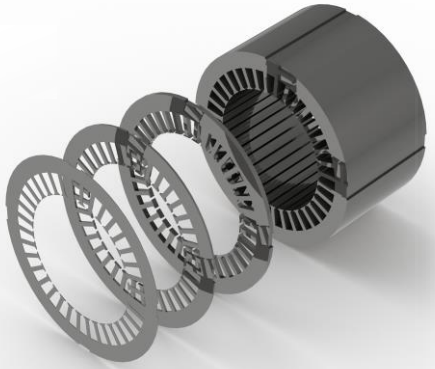
Stator

- Consist of steel sheets (0,5 mm thick) welded or cleated to a stator stack
- In the stator slots the Cu coils are placed and protected with insulation material (slot liners)
- The package of coils and stator stack is impregnated to fixate the coils to get additional electrical insulation



Stator slots
To confine the Cu coils

Slots liners
To electrical and mechanical protect the coils



Stator stack
Electrical steel sheets in a stack

Winding

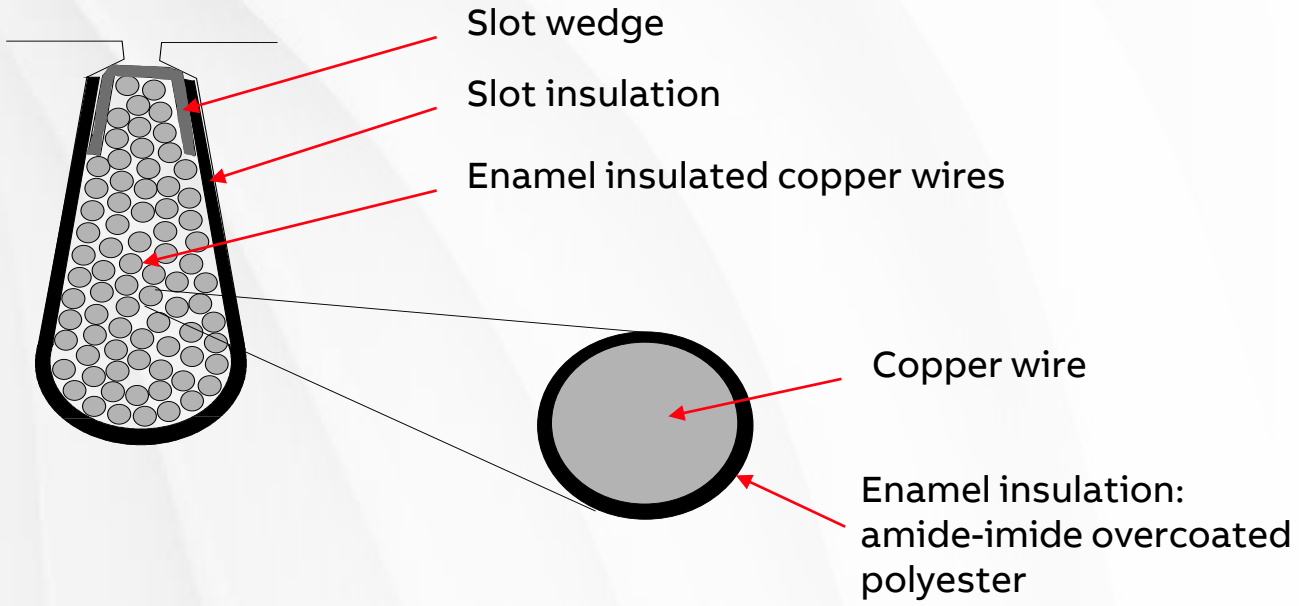
- Cu coils in stator slots
- Picture displays partial winding
- Winding outside the stator is called winding overhang or coil ends

Motor Fundamentals

Induction motors

Winding

This is called random wound winding which we are using in our IEC LV Motors or factories. Our machine factory use form wound winding and it means that winding is done from copper bars instead of wires.



Motor Fundamentals

Induction motors

Impregnation

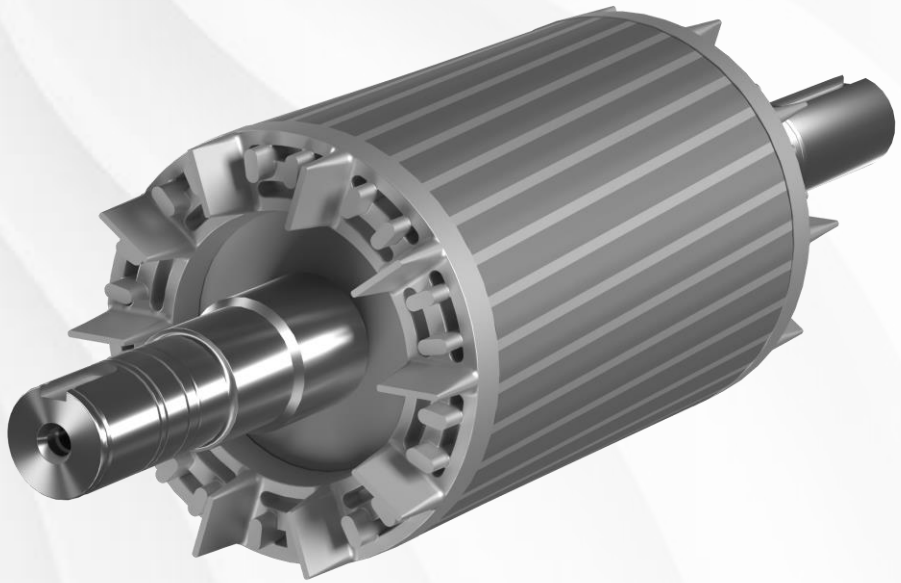
- To fill empty space between conductors
- Help the winding to withstand both electrical and mechanical stress.
- To improve the thermal conductivity from winding to stator frame.

Impregnation methods

- Dipping impregnation.
- Dip and roll impregnation.
- Trickle impregnation.
- Vacuum impregnation

Motor Fundamentals

Induction motors

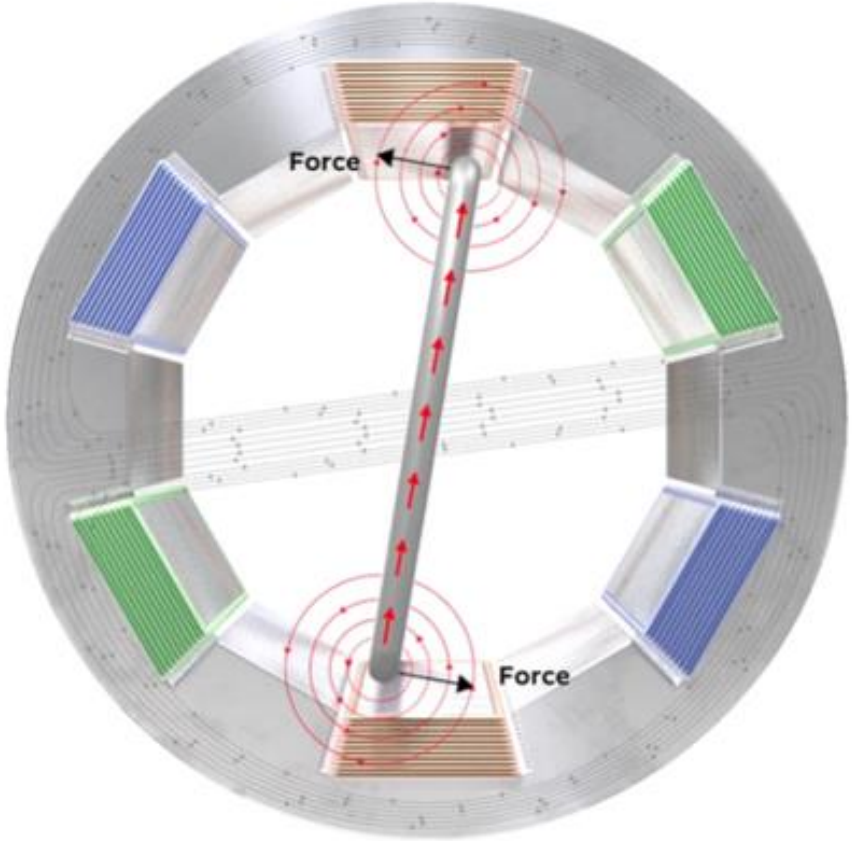


Rotor

- Consist of steel sheets (0,5 mm thick) hold together by a casted Al cage
- The Al forms both short-circuit rings at end of rotor as well as conductors (cage) through the rotor sheets
- The rotor is clamped on a shaft before assembly the motor
- Inside the rotor slots we usually have aluminum windings that are casted together with short-circuit rings
- The rotor core helps conducting the magnetic field from the stator to the rotor windings.

Motor Fundamentals

Induction motors



- The operation of the AC motor is based on a 3-phase electrical network
- The motor windings are connected to the feeding network, the rotating magnetic field of the network creates a rotating magnetic field for the motor stator
- The magnetic field of the stator cuts the short-circuited cage winding of the rotor, current flows in the rotor
- The rotor "follows" the rotating magnetic field of the stator
- The difference between the magnetic field of the stator and the speed of the rotor is the term slip.
- The rotor always rotates slower than the magnetic field of the stator = Asynchronous motor

03

MOTOR SPECIFICATION

Motor Fundamentals

Induction motors

Speed – Magnetic field

- The speed of the rotating field is constant
- It rotates at synchronous speed
- Synchronous speed is depending on:
  - Frequency
  - Pole number of the winding

$$n_s = \frac{60 \cdot frequency}{pole\ pair} \text{ rpm}$$

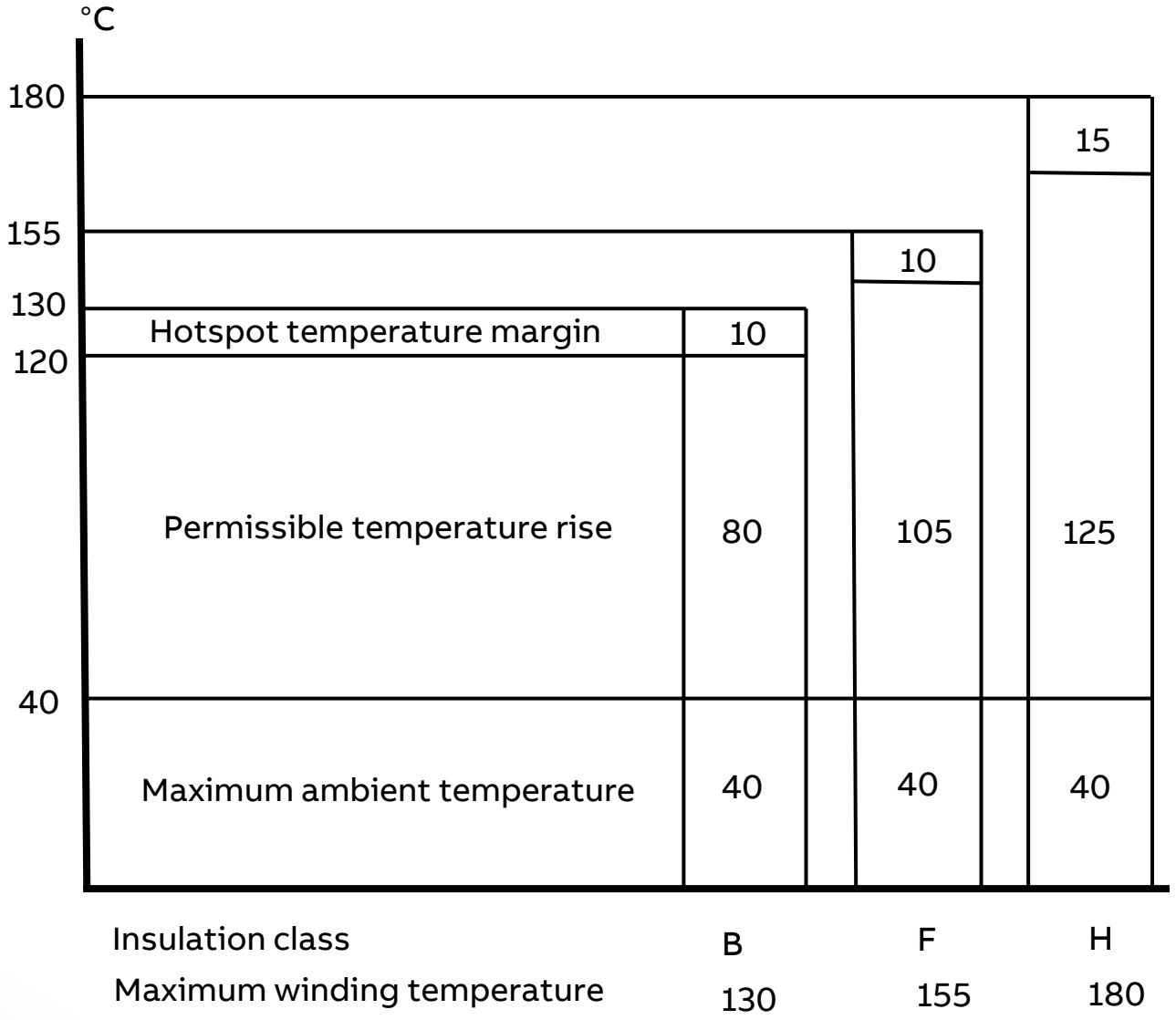
$$n_s = \frac{2 \cdot frequency \cdot 60}{pole} \text{ rpm}$$

Motor Fundamentals

Induction motors

Insulation

ABB uses class F insulation, which, with temperature rise class B, is the most commonly required insulation system for industrial motors.



Motor Fundamentals

Induction motors

Ambient temperature and high altitudes

Ambient temperature, °C	30	40	45	50	55	60	70	80
Permitted output, % of rated output	107	100	96,5	93	90	86,5	79	70
Height above sea level, m	1000	1500	2000	2500	3000	3500	4000	
Permitted output, % of rated output	100	96	92	88	84	80	76	

A standard motor is designed for ambient tempereature range -20 °C upto +40 °C

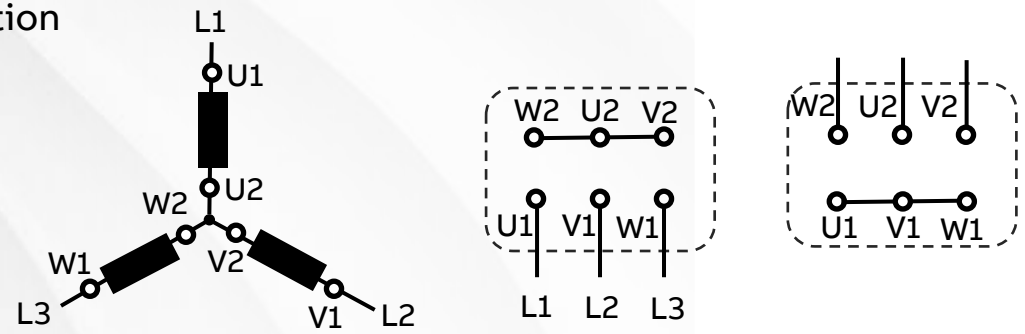
Motor Fundamentals

Induction motors

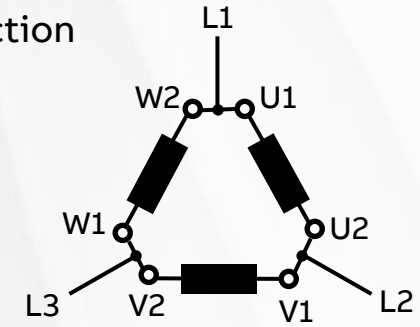
Connections

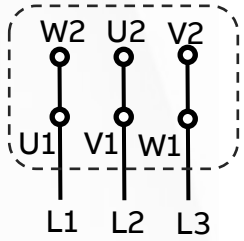
For example **S**=230VD/**400VY** or **D**=**400VD**/690VY

Y - Connection



Δ - Connection





Motor Fundamentals

Induction motors

Standards

ABB Motors and Generators build motors and generators to comply with international IEC and CENELEC standards.

Within the European Union, ABB takes into account relevant EU-regulations, VDE-regulations, and DIN standards.

Motors conforming to other national and international specifications are also available.

All ABB motor production units are ISO 14001 certified and conform to applicable EU directives.

Modify. Brief about used standars.

Motor Fundamentals

Induction motors

Cooling

A designation system concerning the method of cooling is based on the standard IEC 60034-6.

ABB can deliver motors with the following cooling options.

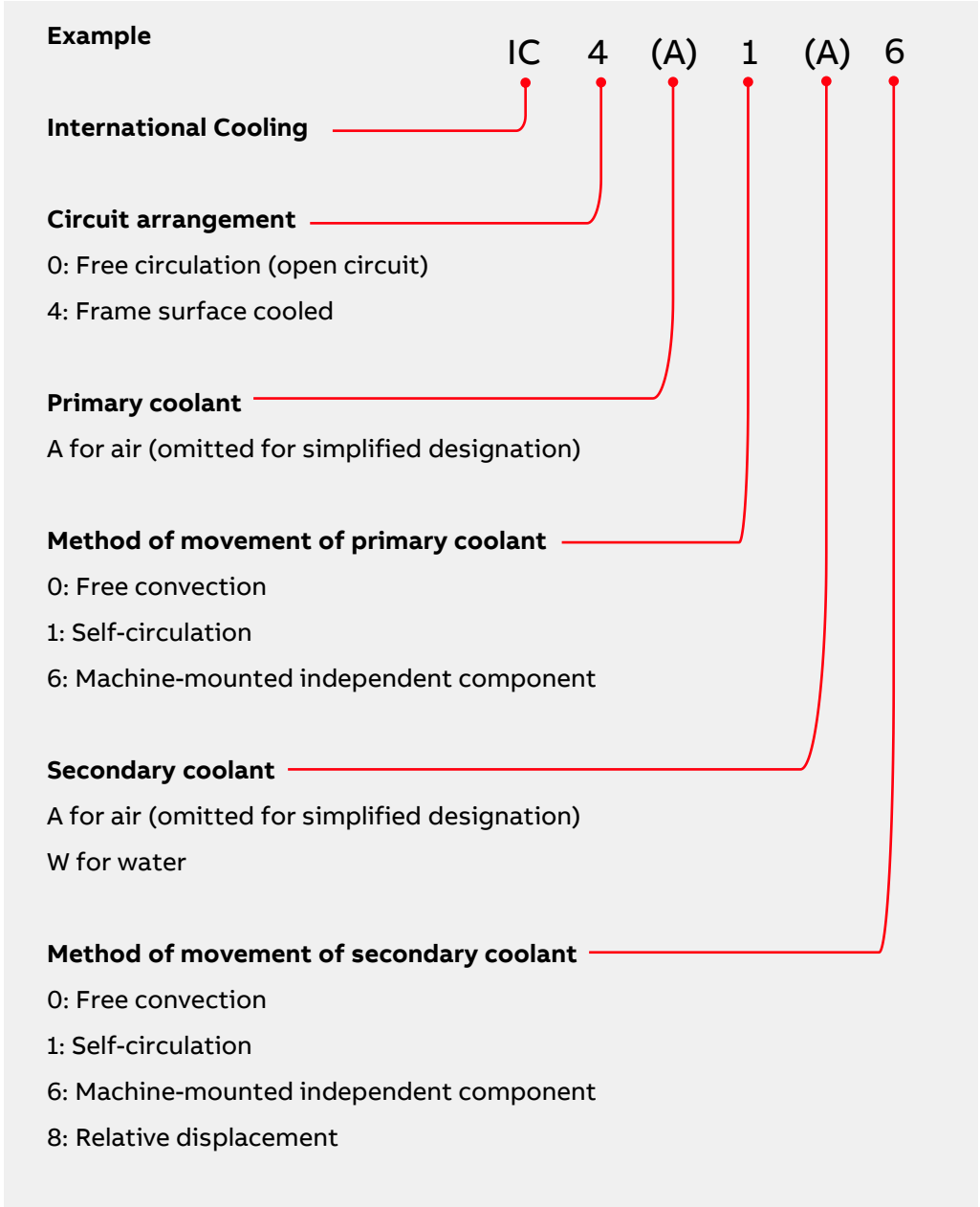
IC 410: totally enclosed motors without a fan

IC 411: totally enclosed standard motors, frame-surface cooled with a fan

IC 416: totally enclosed motors with auxiliary fan motor

IC 418: totally enclosed motors, frame-surface cooled without a fan

IC 31W: inlet and outlet pipe or duct circulated: water-cooled motors



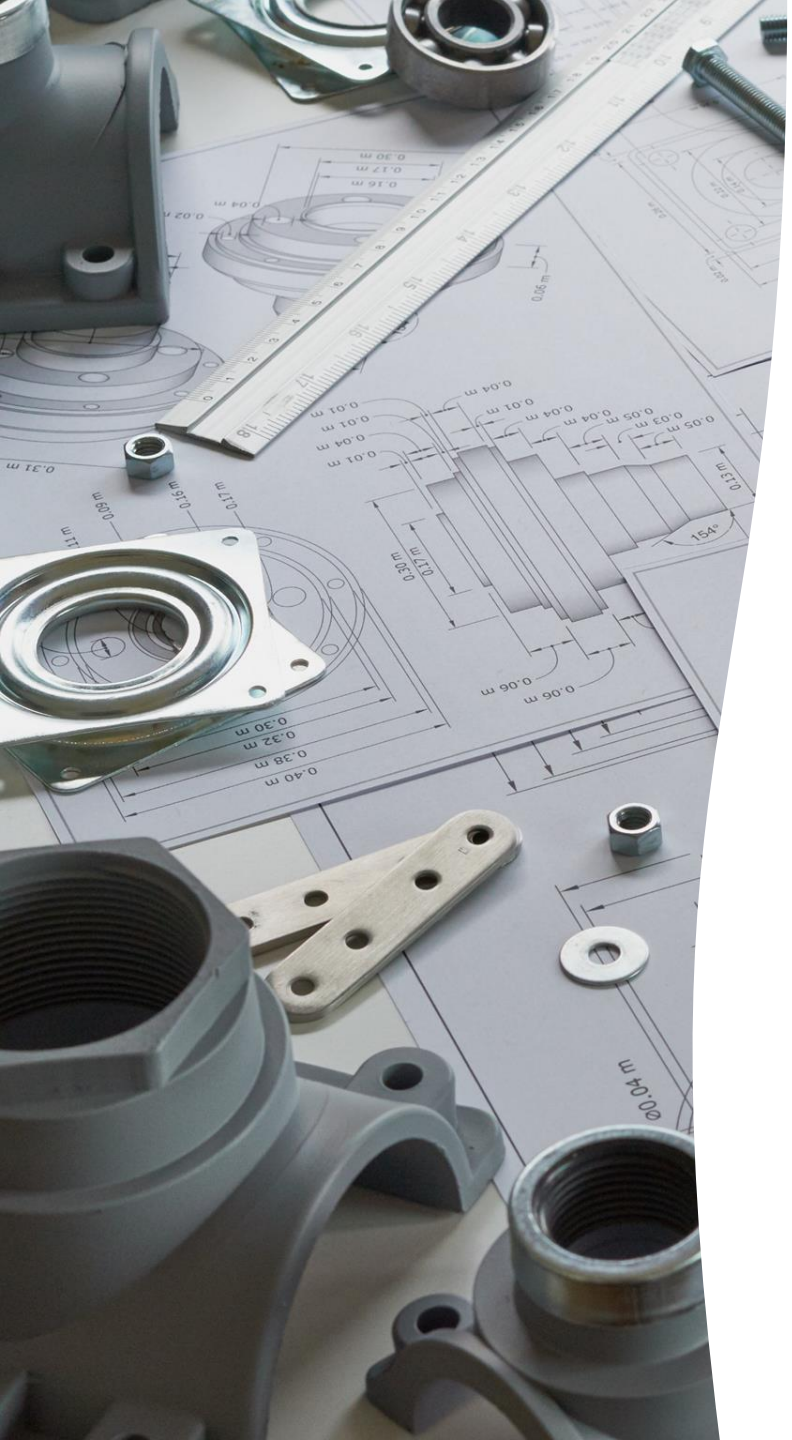
Motor Fundamentals
Induction motors

Motor dimensions

In Europe, the CENELEC standard EN 50347 lays down data for rated output and mounting, i.e. shaft height. It covers totally enclosed fan-cooled squirrel-cage motors at 50 Hz, frame sizes 56 M to 315 M.

Standard output

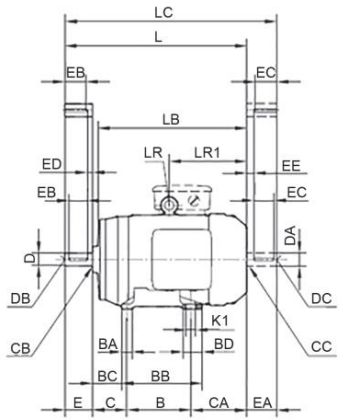
Frame size	Shaft extension diameter		Rated output				Flange number	
	2 poles mm	4, 6, 8 poles mm	2 poles kW	4 poles kW	6 poles kW	8 poles kW	Free holes (FF)	Tapped holes (FT)
56	9	9	0.09 or 0.12	0.06 or 0.09			F100	F65
63	11	11	0.18 or 0.25	0.12 or 0.18			F115	F75
71	14	14	0.37 or 0.55	0.25 or 0.37			F130	F85
80	19	19	0.75 or 1.1	0.55 or 0.75	0.37 or 0.55		F165	F100
90S	24	24	1.5	1.1	0.75	0.37	F165	F115
90L	28	24	2.2	1.5	1.1	0.55	F165	F115
100L	28	28	3	2.2 or 3	1.5	0.75 or 1.1	F215	F130
112M	38	28	4	4	2.2	1.5	F215	F130
132S	38	38	5.5 or 7.5	5.5	3	2.2	F265	F165
132M	38	38	-	7.5	4 or 5.5	3	F265	F165
160M	42	42	11 or 15	11	7.5	4 or 5.5	F300	F215
160L	42	42	18.5	15	11	7.5	F300	F215
180M	48	48	22	18.5	-	-	F300	
180L	48	48	-	22	15	11	F300	
200L	55	55	30 or 37	30	18.5 or 22	15	F350	
225S	55	60	-	37	-	18.5	F400	
225M	55	60	45	45	30	22	F400	
250M	60	65	55	55	37	30	F500	
280S	65	75	75	75	45	37	F500	
280M	65	75	90	90	55	45	F500	
315S	65	80	110	110	75	55	F600	
315M	65	80	132	132	90	75	F600	

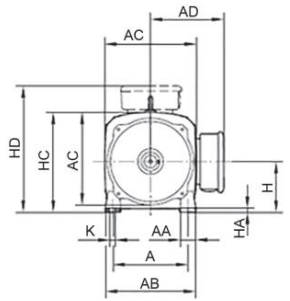


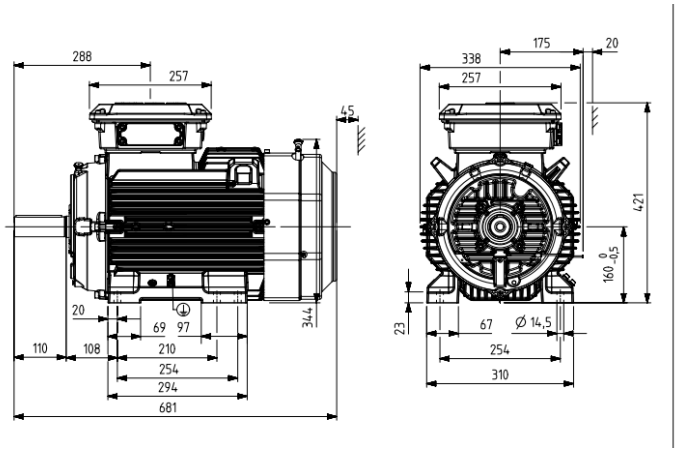
Motor Fundamentals

Induction motors

IEC 60071-1







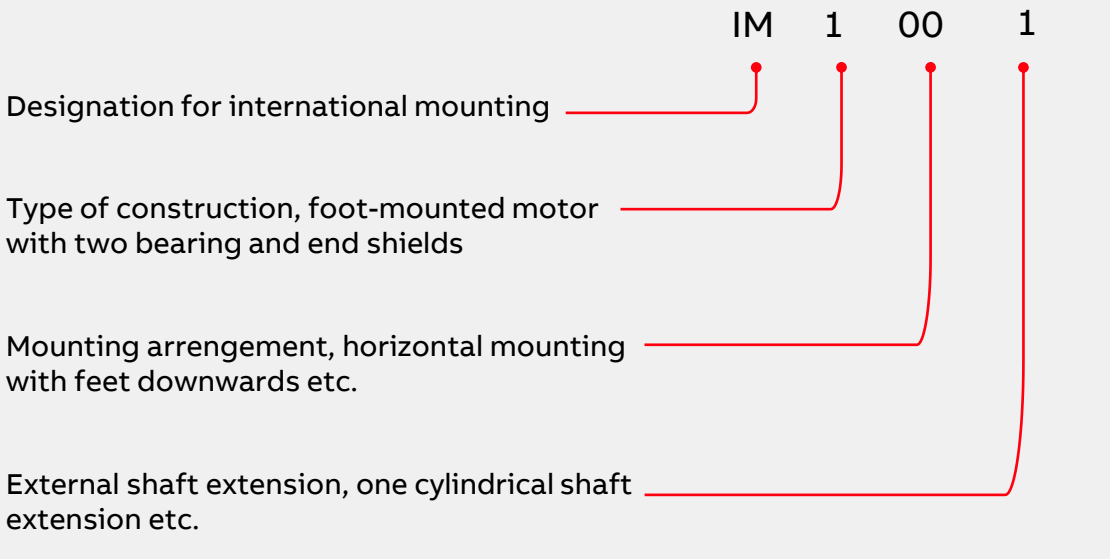
IEC / EN 60072-1 Dimensions and output series for rotating electrical machines

Motor Fundamentals

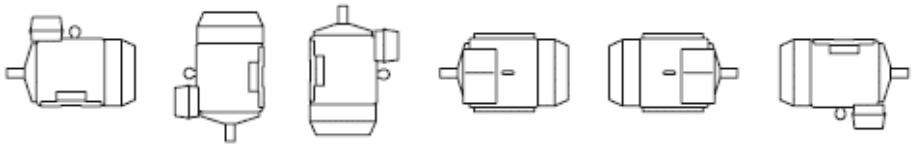
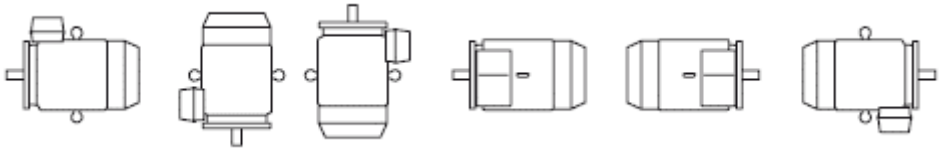
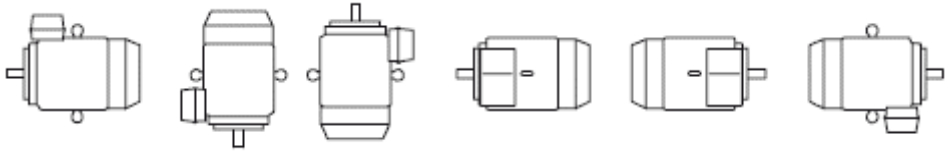
Induction motors

Mounting arrangements

Example of designations according to Code II



Examples of common mounting arrangements

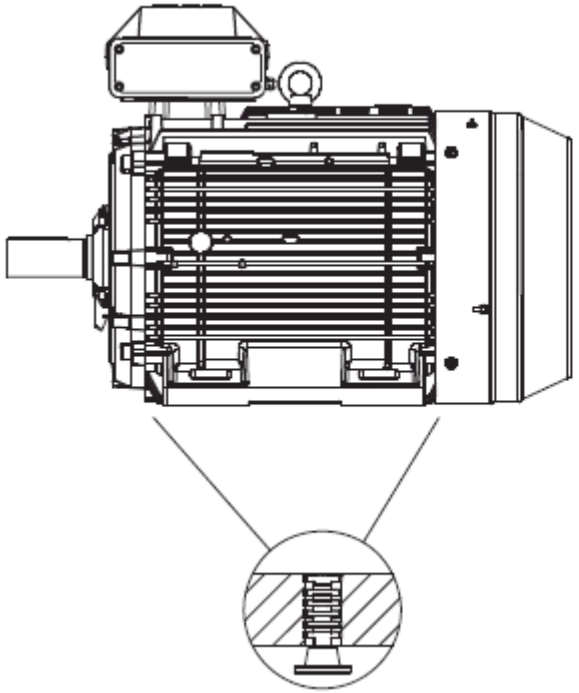
Code I	IM B3	IM V5	IM V6	IM B6	IM B7	IM B8
Code II	IM 1001	IM 1011	IM 1031	IM 1051	IM 1061	IM 1071
Foot-motor						
Code I	IM B5	IM V1	IM V3	*)	*)	*)
Code II	IM 3001	IM 3011	IM 3031	IM 3051	IM 3061	IM 3071
Flange-mounted motor, large flange with clearance fixing holes						
Code I	IM B14	IM V18	IM V19	*)	*)	*)
Code II	IM 3601	IM 3611	IM 3631	IM 3651	IM 3661	IM 3671
Flange-mounted motor, small flange with tapped fixing holes						

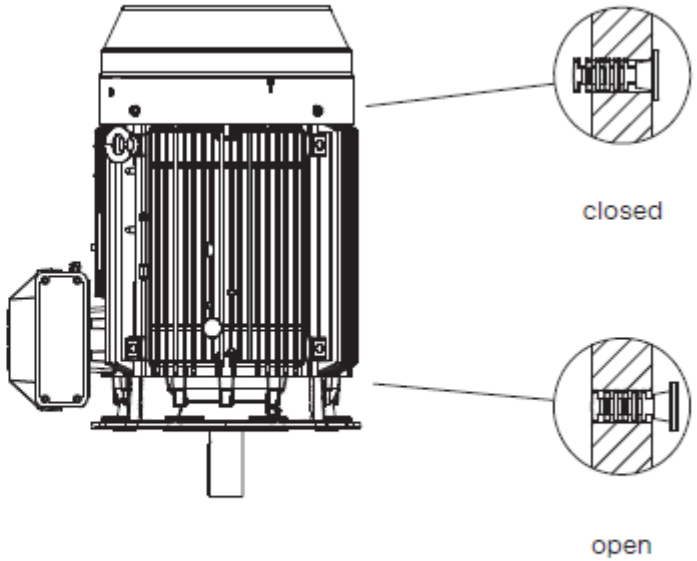
*) Not stated in IEC 60034-7

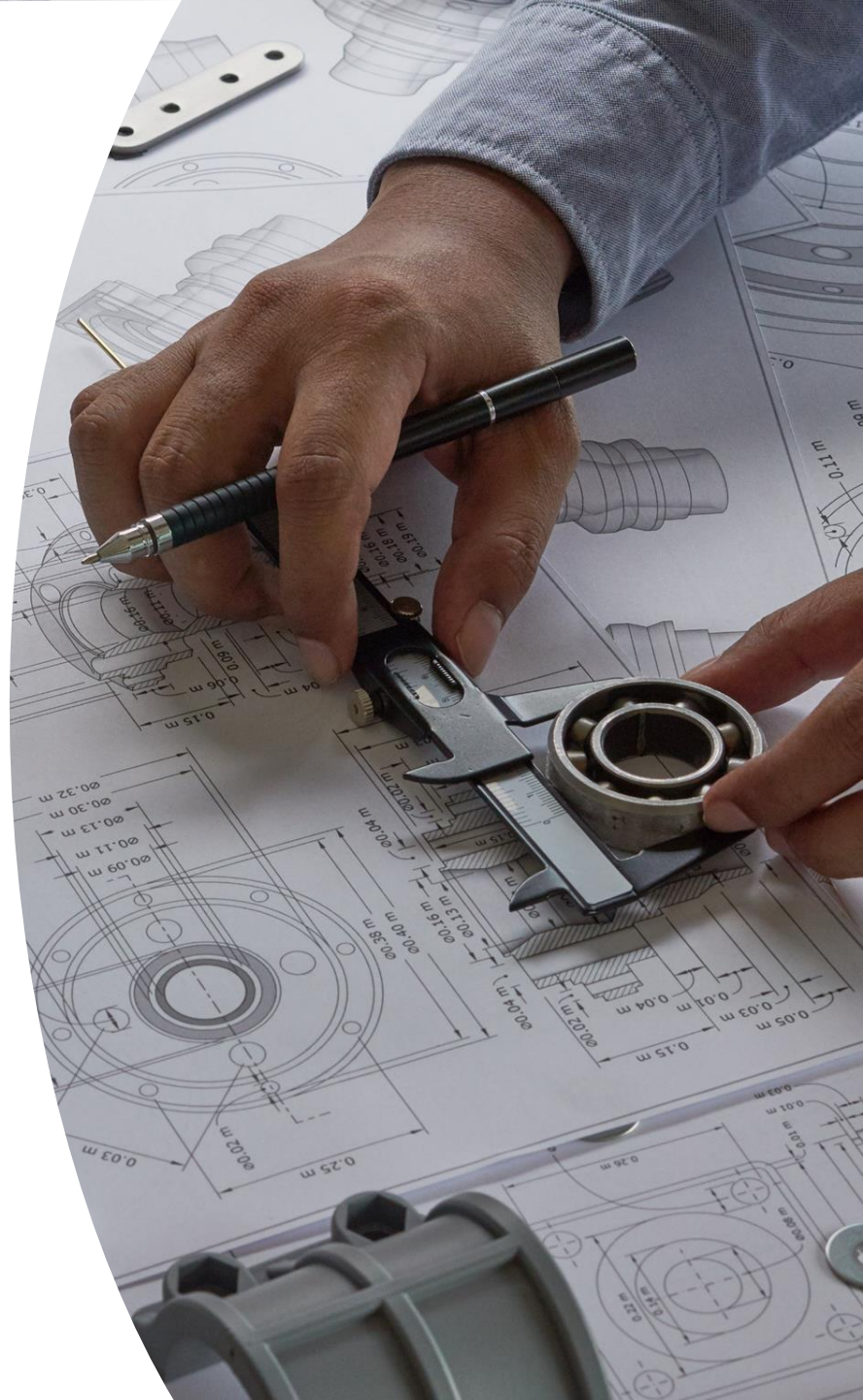
Motor Fundamentals

Induction motors

Motors that will be operated in very humid or wet environments, should be provided with drain holes







Motor Fundamentals

Induction motors

Surface treatment

The surface treatment categorization of ABB motors is based on the ISO 12944 standard.

Corrosity category	Outdoor atmospheres	Indoor atmospheres	Use in ABB motors
C1, very low	Not used	Heated buildings with clean atmospheres	Not available
C2, low	Atmospheres with low level pollution, mostly rural areas.	Unheated buildings where condensation may occur, such as depots and sports halls.	Not available
C3, medium	Urban and industrial atmospheres, moderate sulfur dioxide pollution. Coastal areas with low salinity.	Production rooms with high humidity and some air pollution; food processing plants, laundries, breweries, dairies.	Standard treatment
C4, high	Industrial areas and coastal areas with moderate salinity.	Chemical plants, swimming pools, coastal ship- and boatyards.	Optional treatment, variant code 115 or 717
C5, very high	Industrial areas and coastal areas with high humidity and aggressive atmosphere.	Buildings or areas with nearly permanent condensation and high pollution.	Optional treatment, variant codes 711 or 754
CX, extreme	Coastal and offshore areas with high salinity.	Buildings or areas with nearly permanent condensation and high pollution.	Optional treatment, variant code 719

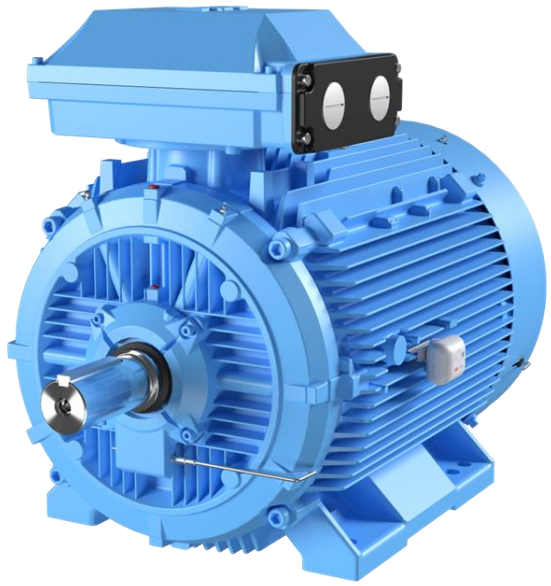
04

SELECTION CRITERIA

Motor selection criteria

Basic information to select motor

- Area Classification
- Power (kW)
- Speed (rpm)
- Voltage (V) and Frequency (Hz)
- End user country
- Frame size
- Frame material
- Mounting
- Environment
- Specification
- VSD (Variable speed drive)



Motor selection criteria

Frame size

Cenelec

In Europe, the CENELEC standard EN 50347 lays down data for rated output and mounting, i.e. shaft height. It covers totally enclosed fan-cooled squirrel-cage motors at 50 Hz, frame sizes 56 M to 315 M.

Compact

Smaller frames than cenelec descripes

Output kW	Type	Foot-mounted Product code	B3 Price BU	Output kW	Type	Foot-mounted Product code	B3 Price BU
3000 r/min = 2 poles	Cenelec			3000 r/min = 2 poles	Compact		
22	M3BP 180MLA 2	3GBP 181 410-A K	2700	22	M3BP 160MLD 2	3GBP 161 440-A K	2550
30	M3BP 200MLA 2	3GBP 201 410-A K	3350	30	M3BP 180MLB 2	3GBP 181 420-A K	3200
37	M3BP 200MLB 2	3GBP 210 420-A K	4410	37	M3BP 180MLC 2	3GBP 181 430-A K	4230
45	M3BP 225SMA 2	3GBP 221 210-A K	5280	45	M3BP 200MLC 2	3GBP 201 430-A K	5040
55	M3BP 250SMA 2	3GBP 251 210-A K	6360	55	M3BP 225SMB 2	3GBP 221 220-A K	6080
75	M3BP 280SMB 2	3GBP 281 220-A K	8210	75	M3BP 225SMC 2	3GBP 221 230-A K	8030
				75	M3BP 250SMB 2	3GBP 251 220-A K	7950
90	M3BP 280SMC 2	3GBP 281 230-A K	9850	90	M3BP 250SMC 2	3GBP 251 230-A K	9540
110	M3BP 315SMB 2	3GBP 311 220-A K	12000	110	M3BP 280SMD 2	3GBP 281 240-A K	11400
132	M3BP 315SMC 2	3GBP 311 230-A K	14500	132	M3BP 280MLA 2	3GBP 281 410-A K	13800
160	M3BP 315MLA 2	3GBP 311 410-A K	17900	160	M3BP 280MLB 2	3GBP 281 420-A K	17000
200	M3BP 355SMA 2	3GBP 351 210-A K	22400	200	M3BP 315MLB 2	3GBP 311 420-A K	21500
250	M3BP 355SMB 2	3GBP 351 220-A K	28200	250	M3BP 315LKB 2	3GBP 311 820-A K	27100
315	M3BP 355SMC 2	3GBP 351 230-A K	35500	315	M3BP 315LKC 2	3GBP 311 830-A K	33700

Motor selection criteria

Environment

Humid

- Surface treatment C3 (standard)
- Heating elements needed if the motor is at standstill

Salty desalination

- Surface treatment C5
- Heating element
- Stainless steel hardware
- Corrosion protected stator and rotor

Other common variants

- High efficiency IE4
- Low starting current
- High ambient temperature
- Monitoring options (PT100)
- Suitable for VSD operations

Motor selection criteria

Specification

Voltage / Motor winding

- Voltage and variation
- Under voltage starting
- Low starting current
- F/B winding temperature class and temperature rise
- Efficiency
- VSD
  - Reinforced insulation

Motor auxiliaries

- PT100 in winding
- PT100 in bearing
- Heating element
- Auxiliary terminal boxes
- Cable glands

Corrosion resistant

- Better painting (standard C3M)
- Corrosion resistant stator and rotor
- Heating element
- Stainless steel hardware
- IP class (standard IP55)

Documentation

- Test reports
  - Testing procedure
- Data sheets
- Binding drawings
- Painting reports
- Certifications

Motor selection criteria

VSD / Needed variants for the motor

Winding insulation selection

Winding insulation and filters required	
$U_N \leq$ 500 V	Standard insulation
$U_N \leq$ 600 V	Standard insulation + dU/dt filters OR Special insulation (variant code 405)
$U_N \leq$ 600 V	Special insulation (variant code 405) AND dU/dt-filters at converter output
600 V < $U_N \leq$ 690 V Cable length > 150 m	Special insulation (variant code 405)

Insulated bearing selection

Nominal power (P and / or Frame size (IEC)	Precutionary measures
$P_N <$ 100 kW	No action needed
$P_N \geq$ 100 kW OR IEC 315 ≤ Frame size ≤ IEC 355	Insulated non-drive end bearing
$P_N \geq$ 350 kW OR IEC 400 ≤ Frame size ≤ IEC 450	Insulated non-drive end bearing AND common mode filter at the converter

EMC cable glands always (VC 704)

In exceedingly rare cases, bearing currents might still exist even if the measures specified above have been taken. For such installations, there are methods that would provide a remedy.

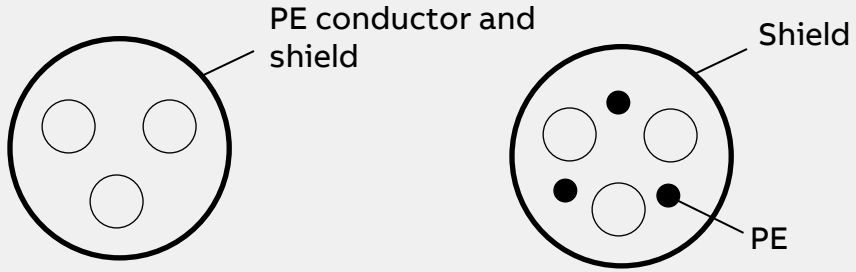
Motor selection criteria

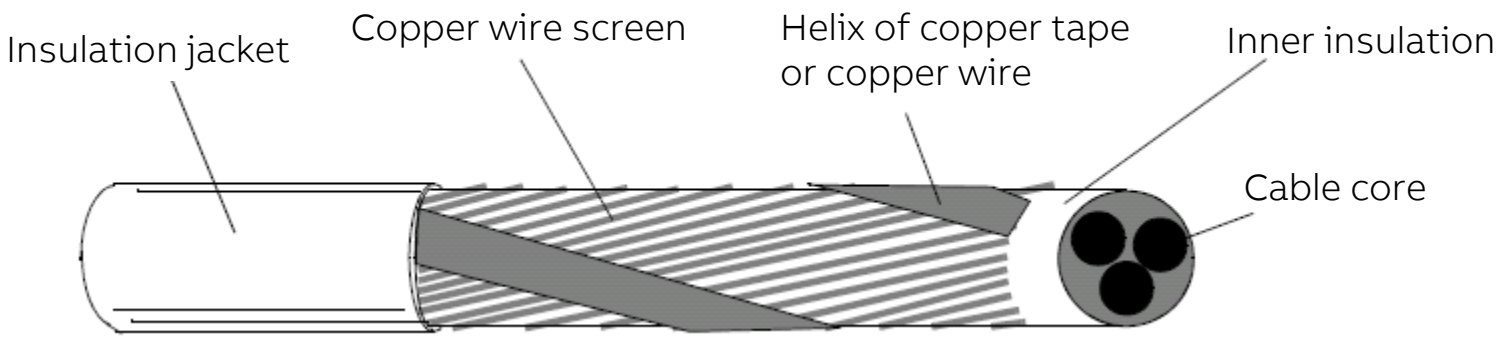
Low voltage motors and EMC

- High switching frequency of inverter causes interferences which can be divided to conductive interference and radiating interference
- Conductive interference can be eliminated with EMC filter
- Radiating interference can be eliminated by using protected and short cables, earthings, and proper distances between the cables
- Power cable: symmetrical shielded cable

Recommended

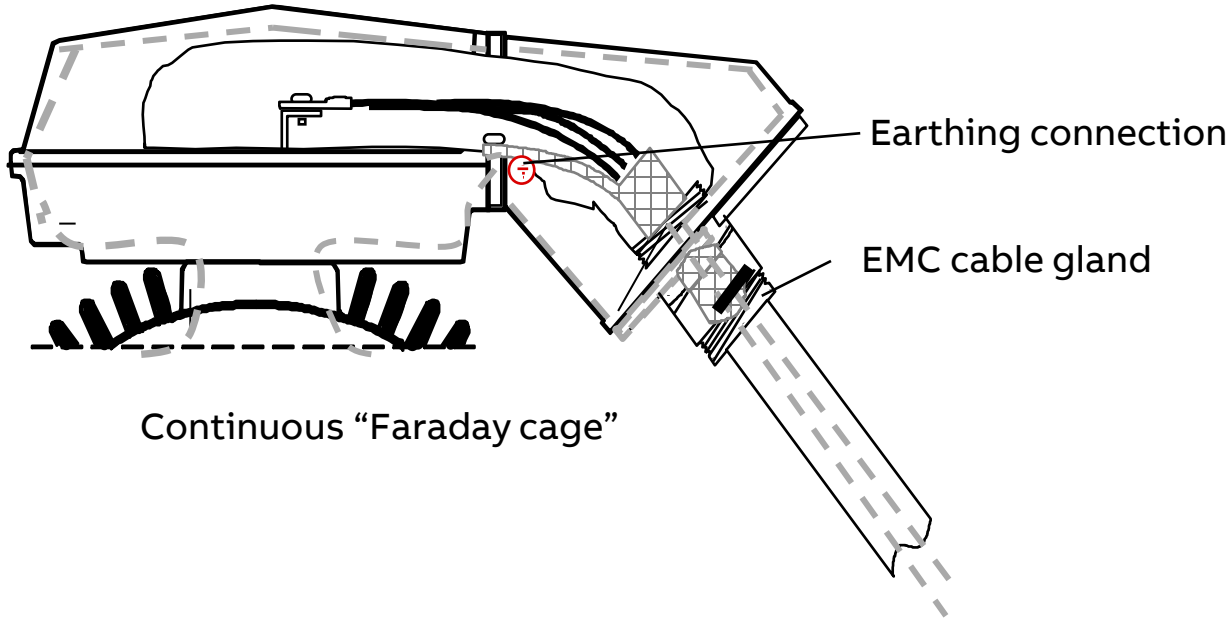
Symmetrical shielded cable: three phase conductors and a concentric or otherwise symmetricallt constructed PE conductor, and a shield





Motor selection criteria

Connecting the motor cable



- Cable shield connected unbreakable from frequency converter to motor
- EMC cable gland or EMC cable box

Motor selection criteria

VSD (variable speed drive)

Maximum speeds of the standard motor

Guideline for maximum speeds

- ABB dimensioning tools take care of that
- Solutions available for higher speeds.

Frame size	Speed r/min 2-pole motor	Speed r/min 4-pole motor
71-100	6000	6000
112-200	4500	4500
225-250	3600	3600
280 SM	3600	2600
280 ML	3600	2300
315 SM, ML	3600	2300
315 LK	3600	2000
355 SM	3800	2000
355 ML	3800	2000
355 LK	3600	2000
400	3600	2000
450	3600	1800


ABB