# Horizontal electric motors

## Fastening guide

An electric motor may be fastened in many ways, depending on the size, application and installation site.

Small motors can be fastened in a rigid structure, or welded directly to a steel plate.

Medium and large motors usually have feet for mounting and fasten as part of the frame, either fused or welded.

The proper installation, alignment and leveling of the base and electric motor, as well as the correct fastening of the motor to the base, are essential for its proper functioning.

In order to reduce the vibration and noise levels and also support the loads during motor starting and stopping, we have developed various ways of fastening electric motors to meet many situations.

The Horizontal Electric Motors Fastening Guide assists those who need to assemble the base and fasten medium and large horizontal electric motors, including information about foundation, base types and fixation types for these motors.

NOTE

The figures and images shown in this document are illustrative and the mechanical and construction characteristics of each project should be evaluated. The information contained in this guide is indicative and does not replace the motor manual information.

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# 1 TERMS DEFINITION

## 1.1 FOUNDATION
The Foundation is a set of structural elements, built in order to withstand the mechanical loads produced by the electric motor installed on it, providing stability, performance and safety for the motors operation.

## 1.2 BASE
The base is the structure used to enable the support, assembly and transport of the electric motor. This base can also be used to support a mounted machine and also often used to ensure interchangeability with another machine already installed.

## 1.3 ANCHOR BASE
The anchor base is the metal structure grouted and anchored to the concrete foundation, used to support and fasten the electric motor.

## 1.4 INTERMEDIATE BASE
The intermediate base, also known as baseplate is the metal structure used between the motor feet and the fastening base of the electric motor.

## 1.5 SOLEPLATE
The set of anchoring plates is composed of soleplates, leveling screws, alignment screws and anchor bolts. The soleplates are leveled, grouted and anchored at the concrete foundation, to support and level the electric motor.

## 1.6 METAL BASE
The metal base is a metal platform for the main support and fastening of the electric motor.

## 1.7 COMMON METAL BASE (SKID)
The common metal base or skid is a metal platform for main support and fastening of the electric motor and driven machine.

## 1.8 ANCHOR BOLT
The anchor bolt, is the element used to anchor the electric motor, inserted in the grouting niches, which adhesion to the concrete is guaranteed by the grout.

## 1.9 GROUT
Grout is a cement fluid or a mixture of mineral aggregates and chemical resin, designed to fill the grouting niches and level the metal plate on the concrete base. It has the mechanical strength higher than the concrete and has no retractable characteristic after curing.

## 1.10 GROUTING NICHE
The grouting niche is the empty volume, molded into the concrete base, designed for the installation of the anchor bolt and then filled with grout.

## 1.11 BASE LEVELING SCREW
The base leveling screws are used under the motor fastening base and serve to move the base vertically allowing its correct leveling.

## 1.12 MOTOR LEVELING SCREW
The motor leveling screws are used in the motor feet and serve to move it vertically allowing the introduction of shims under the motor feet to adjust its leveling.

## 1.13 HORIZONTAL ALIGNMENT SCREW
The horizontal alignment screws are used in the motor base, fixed by screwed supports and positioned at the ends of the electric motor. It allows the motor to move in the horizontal direction (transversal and longitudinal) to adjust its alignment with the driven machine. Normally two screws are used at each end of the electric motor (8 screws per base).

## 1.14 MOTOR FASTENING BOLT
The fastening bolts are used in the motor feet holes to attach it to the base.

## 1.15 ALIGNMENT SUPPORT
The alignment supports are fixed at the base and are designed to mount the horizontal alignment screws. The number of supports must be the same as the number of alignment screws.

## 1.16 SHIM
The shims are used between the base and the motor feet to allow motor leveling adjustment.

## 1.17 DOWEL PIN

The dowel pin is a cylindrical metal rod inserted in holes aligned on the electric motor foot and on the base. It serves as a reference point to control the positioning variations and ensure the alignment in case of motor disassembly and reassembly.

# 2 FOUNDATION

The foundation where the motor will be installed should be smooth, flat, without vibration and stable enough to withstand the loads originating from starting, operating or in case of motor short circuit.

## 2.1 FOUNDATION DESIGN

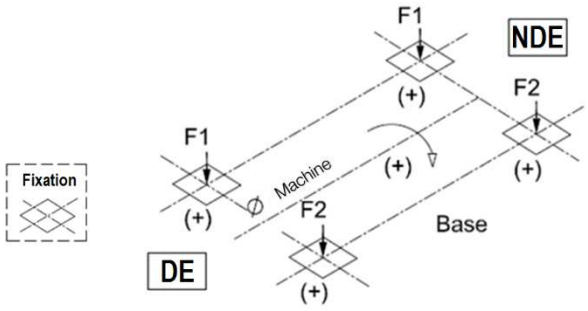
The foundation design should consider the adjacent structures to the motor, to prevent influence of any other equipment, in order to provide safe operating conditions with maximum accessibility.
You should consider the following characteristics:

a) The foundation construction, must consider not only the values and action way of the loads, but must also meet the limits of deformations and vibrations;
b) The conservation state, estimate of the maximum applied loads, type of foundation and fixation, as well as vibration levels transmitted by neighboring constructions;
c) The efforts generated by the driven load during operation should be considered as part of the foundations design;
d) In order to avoid resonance vibration with the motor, the foundation natural frequency, together with the motor natural frequency, must have clearance of 15% or more from the excitation frequencies. The excitation frequencies for electric machines are: 1x and 2x rotation frequency and 1x and 2x the power grid frequency;
e) The fastening method of the motor on the foundation, the supplies of air, water, oil and connecting cables trays, as well as the location of the grouting niches should be considered prior to construction of concrete base;
f) The grouting niches position and the foundation height must be according to the design specifications.
g) The foundation must be designed to allow that leveling plates are placed under the motor feet, in order to ensure a setting range and facilitate the possible future installation of a replacement motor. The fastening base and the motor shaft height have a certain manufacturing tolerance, which is compensated by leveling plates (shims) which can be of galvanized carbon steel or of stainless steel.

## 2.2 FOUNDATION LOADS

The foundation and the bolts used in the motor fastening must be designed to withstand the maximum sudden mechanical torques, which occurs whenever the motor is started or in the event of short circuit.

### Foundation loads calculation




The maximum loads of the motor on the foundation can be calculated by the following equations:

$$F1 = 0{,}5 \times g \times m - \left(\frac{4 \times Cmax}{A}\right)$$

$$F2 = 0{,}5 \times g \times m + \left(\frac{4 \times Cmax}{A}\right)$$

Where:
F1 and F2 = Loads on each motor side (N);
g = gravity acceleration (9,8 m/s$^2$);
m = motor mass (kg);
Cmax = motor maximum torque (Nm);
A = distance (m) between fastening holes in the motor feet (front view).

# 3 FASTENING BASE

The base has the function of supporting and fastening the frame of the electric motor. It is, therefore, the interface of the motor with the installation site (concrete base or metal surface).
The choice of the base type depends on the mounting, size, installation site and application of the electric motor.

NOTE

The fastening base is not part of the motor supply scope and must be requested as a separate component.

The base types commonly used in electric motors installation are: anchor base, common metal base (skid), intermediate base or baseplate, and soleplate.

## 3.1 ANCHOR BASE

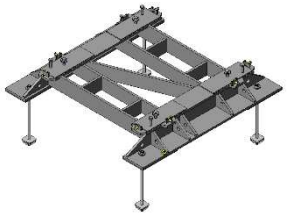


*Figure 3.1: Example of anchor base*

The anchor base is the metal structure that is anchored and grouted on the concrete base to support and fasten the electric motor. Typically used in projects that require adjustment of the motor shaft height, to obtain a correct alignment between the electric motor and the driven load. Often, it is necessary to use shims to adjust the motor on the anchor base surface.

## 3.2 COMMON METAL BASE

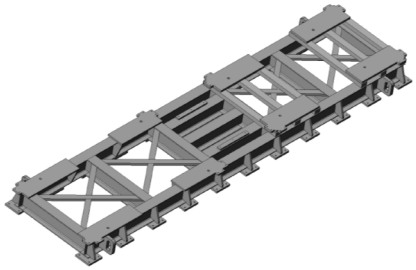


*Figure 3.2: Example of common metal base*

The common metal base or skid is a structure made of welded steel profiles whose purpose is to combine the mounting of electric motor and driven machine, thus forming a module. This module formed by the metal base may be grouted directly in a concrete base or fixed to a larger structure off the ground, such as platforms, vessels, metal structures or towers.
It is typically used by equipment manufacturers (pumps, fans, compressors, generator set, etc.), because it presents ease of installation and alignment of the equipment, promoting more agility in transport and installation.

## 3.3 INTERMEDIATE BASE

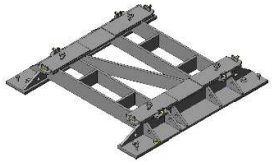


*Figure 3.3: Example of intermediate base*

The intermediate base or baseplate is the metal structure used to support and fasten the electric motor. Typically used in projects that require adjustment of the motor shaft height, to obtain a correct alignment between the electric motor and the driven load. Commonly used in replacement motors or to accommodate the interchangeability of motors used in more than one position in the plant.

## 3.4 SOLEPLATES

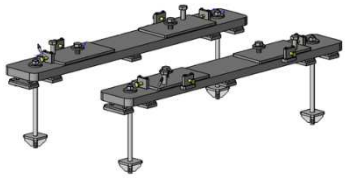


*Figure 3.4: Example of soleplate*

The set of anchoring plates is composed of soleplates, leveling screws, shims, alignment screws and anchor bolts.
The structure of the soleplates is designed based on motor size and the loads that it will apply to the base. The purpose of the set of soleplates is to ensure a well-finished surface, flat and rigid to fasten the motors.
To adjust and level the base surface, leveling screws and shims are used.
The motor is fastened to the soleplates by bolts, through the motor feet holes.
Soleplates are used in large motors with great foundation loads.

# 4 BASE PREPARING

## 4.1 FOUNDATION CHARACTERISTICS

The primary and secondary concrete material used in bases for medium and large electric motors should meet the following characteristics:

Primary concrete (foundation)
Minimum resistance class: C15, as DIN1045-1 Standard
Minimum compression tension: 15 MPa

Secondary concrete (grouting)
Minimum resistance class: C20, as DIN1045-1 Standard
Minimum compression tension: 20 MPa
Use only non-retractable concrete, respecting the level exactly as specified in the project.

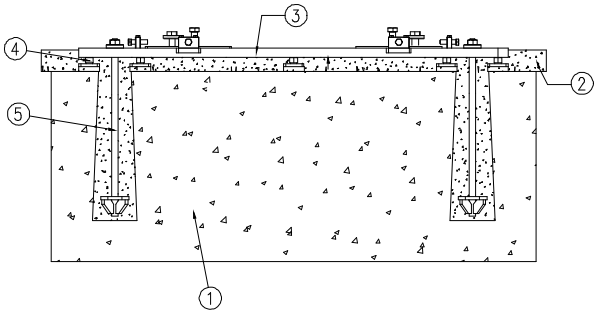



*Figure 4.1: Example of foundation with fastening by soleplates*

*Legend of Figure 4.1:*
1. Foundation (primary concrete)
2. Grouting (secondary concrete)
3. Soleplate
4. Leveling screws
5. Anchor bolts

NOTE

The foundation and grouting are not part of the motor supply scope.

## 4.2 FOUNDATION PREPARING

The preparing of the foundation to receive the base and the electric motor must meet the following criteria:
- Any dust or dirt on the foundation must be swept or vacuumed;
- It must be then washed and rinsed.
- If there are oil and/or grease deposits, they must be removed.
- The foundation walls which will be the grouted, including the grouting niches, must have rough surfaces to give the correct grip, based on the grout manufacturer's recommendations.

## 4.3 MOTOR BASE PREPARING

The procedure to prepare the electric motor base can vary with the base type and the materials used.
The materials used in the base installation must be prepared as follows:
1) Position the leveling screws (if any) over the concrete base;
2) Clean the machined parts that are coated with anti-corrosive using suitable solvent;
3) Make sure that the base surfaces that will be in contact with the grout, are not painted, so there is good contact of these parts to the secondary concrete (grout). If the parts to be grouted are painted, the paint should be scraped and the surface cleaned with an appropriate solvent;

For the cleaning process mentioned in the previous items, Alkydic Diluent 1024 is normally used.

# 5 BASE INSTALLATION

## 5.1 ANCHOR BASE INSTALLATION

The following steps refer to an example of anchor base installation for fastening the electric motor, as shown in Figure 5.1:

1) The primary concrete base should be ready, noting the niches where the anchor bolts will be inserted.
2) Clean the anchor bolts (10) and wrap the straight part of them with three or four layers of masking tape. This will allow the bolts to be tensioned when applying tightening torque, without breaking or causing cracks in the grout;
3) Lift the anchor base (8) enough to enable the anchor bolts installation;
4) Fit the anchor bolts into the base so that the top of the bolts will be (1 to 2 mm) above the nuts upper surface;
5) Place the anchor base, guiding the anchor bolts into the grouting niches;
6) Place supporting plates between the leveling screws and the anchor base;
7) Support the anchor base on the primary concrete surface in its end position;
8) Carry out the leveling and alignment of the anchor base with reference to the driven machine shaft. For leveling, use the leveling screws (9) under the anchor base. For alignment, move the entire anchor base until it lines up with the driven machine;
9) Carry out the grouting of the anchor bolts niches and wait for the proper curing time;
10) After the grout cures, support the electric motor on the anchor base and pre-tighten the anchor bolts with 50% of the recommended torque;
11) Check the anchor base leveling and alignment. If it does not meet the required tolerances, drop the anchor bolts and adjust again. Pre-tighten the anchor bolts again with 50% of the rated torque and check the leveling and alignment. If necessary, readjust until the required tolerances are satisfied;
12) Remove the motor from the base;
13) Close the gaps between the anchor base and the primary concrete in order to prevent any grout leakage during the anchor base grouting;
14) Wedge the anchor base against the primary concrete (12) to prevent any displacement during the grouting;
15) Carry out the anchor base grouting and wait the proper curing time.

ANCHOR BASE

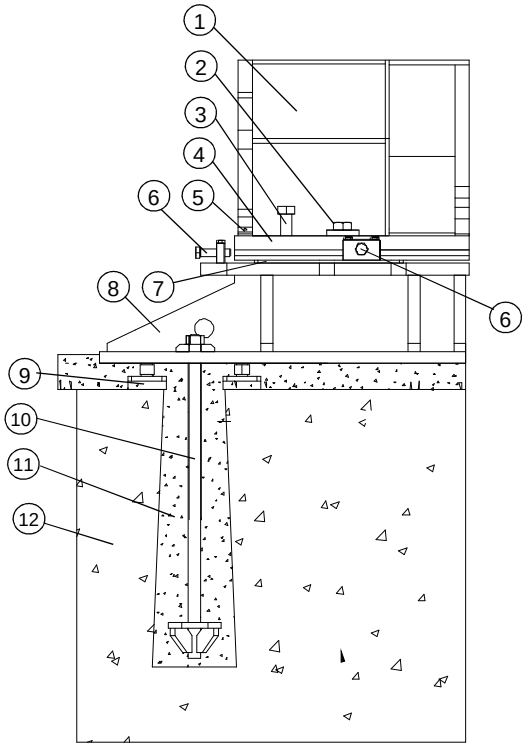



*Figure 5.1: Example of anchor base installation*

*Legend of Figure 5.1:*

1. Motor
2. Motor fixation bolt
3. Motor leveling screw
4. Motor foot
5. Dowel pin
6. Horizontal alignment screw
7. Shims
8. Base
9. Base leveling screw
10. Anchor bolt
11. Grout
12. Primary concrete

## 5.2 INTERMEDIATE BASE INSTALLATION

The following steps refer to an example of intermediate base installation for fastening the electric motor, as shown in Figure 5.2:

1) The base for fastening the intermediate base (11) should be prepared, cleaned and leveled;
2) Lift the intermediate base (8) and install the intermediate base fixation bolts (10);
3) Position the intermediate base, guiding the fastening bolts of the intermediate base into the threaded holes of the base;
4) Support the intermediate base on the fastening base surface (11) in the end position;
5) Carry out the leveling and alignment of the intermediate base with reference to the driven machine shaft. For leveling, use the leveling screws (9). For alignment, move the entire intermediate base until it lines up with the driven machine;
6) Support the electric motor on the intermediate base and pre-tighten the base fixation bolts with 50% of the recommended torque;
7) Check the intermediate base leveling and alignment. If it does not meet the required tolerances, drop the base fixation bolts and adjust again. Pre-tighten the base fixation bolts again with 50% of the rated torque and check the leveling and alignment. If necessary, readjust until the required tolerances are satisfied;
8) Tighten the base fixation screws with nominal torque.

INTERMEDIATE BASE

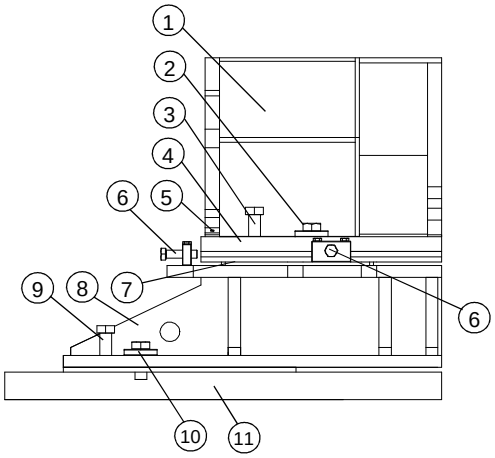



*Figure 5.2: Example of intermediate base installation*

*Legend of Figure 5.2:*

1. Motor
2. Motor fixation bolt
3. Motor leveling screw
4. Motor foot
5. Doweling pin
6. Horizontal alignment screw
7. Shims
8. Intermediate base
9. Base leveling screw (optional)
10. Intermediate base fixation bolt
11. Base for fastening the intermediate base

## 5.3 SOLEPLATE INSTALLATION

The following steps refer to an example of soleplate installation for fastening the electric motor, as shown in Figure 5.3.

1) The primary concrete base (12) should be ready, noting the niches where the anchor bolts (10) will be inserted;
2) Clean the anchor bolts (10) and wrap the straight part of them with three or four layers of masking tape. This will allow that the bolts be tensioned when applying the tightening torque, without breaking or causing cracks in the grout;
3) Lift the soleplate (8) enough to enable the installation of the anchor bolts;
4) Fit the anchor bolts in the soleplate so that the top of the bolts are (1 to 2 mm) above the nuts upper surface;
5) Place the soleplate, guiding the anchor bolts into the grouting niches;
6) Support the soleplate on the primary concrete surface in its end position;
7) Carry out the leveling and alignment of the soleplate with reference to the driven machine shaft. For leveling, use the leveling screws (9) under the soleplate. For alignment, move the entire soleplate until it lines up with the driven machine;
8) Carry out the grouting of the anchor bolts niches and wait for the proper curing;
9) After curing the grout, support the electric motor on the soleplate and pre-tighten the anchor bolts with 50% of the recommended torque;
10) Check the soleplate leveling and alignment. If it does not meet the required tolerances, drop the anchor bolts and adjust again. Pre-tighten the anchor bolts again with 50% of the rated torque and check the leveling and alignment. If necessary, readjust until the required tolerances are satisfied;
11) Remove the motor from the base;
12) Close the gaps between the soleplate and the primary concrete in order to prevent any grout leakage during the soleplate grouting;
13) Wedge the soleplate against the primary concrete (12) to prevent any displacement during the grouting;
14) Carry out the soleplate grouting (11) and wait the proper curing time.

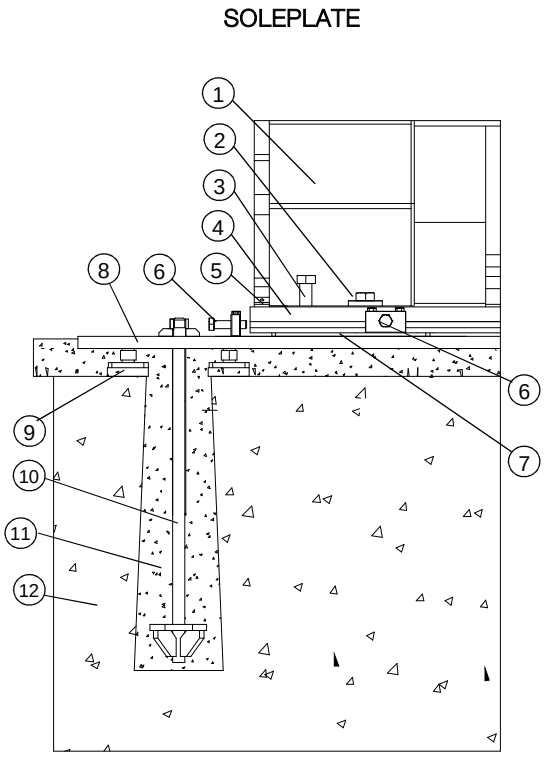



*Figure 5.3: Example of soleplate installation*

*Legend of Figure 5.3:*

1. Motor
2. Motor fastening bolt
3. Motor leveling screw
4. Motor foot
5. Doweling pin
6. Horizontal alignment screw
7. Shims
8. Soleplate
9. Base leveling screw
10. Anchor bolt
11. Grout
12. Primary concrete

# 6 MOTOR INSTALATION ON THE BASE

After the base installation, alignment and leveling, the electric motor may be mounted on the base.
It is recommended to place at least 2 mm of shims on the base. The motor must be lifted and positioned on the base such so that the feet holes match with the base fastening holes.

## 6.1 MOTOR LEVELING

The motor must be supported on the mounting surface with a flatness up to 0.08 mm/m.
In order to facilitate the motor alignment in relation to the vertical plane (leveling) and allow the assembly of shims under the motor, the motor leveling screws are used, as shown in Figure 5.1, Figure 5.2 and Figure 5.3.
The shims installation must be done with care to avoid any unequal support of motor feet that can result in frame torsion.
The shims must be of suitable material (stainless steel or galvanized steel). Common steel plates, paper sheets, pieces of can or electrode, copper plates, etc. should not be used because they can rust, bend, heap or kneading and compromise the motor leveling on the base.

## 6.2 MOTOR ALIGNMENT

The motors is aligned horizontally by the horizontal alignment screws as shown in Figure 5.1, Figure 5.2 and Figure 5.3.
The horizontal alignment supports are installed on the motor fastening base, located in the motor extremities and serve as support for the horizontal alignment screws as shown in Figure 6.1.

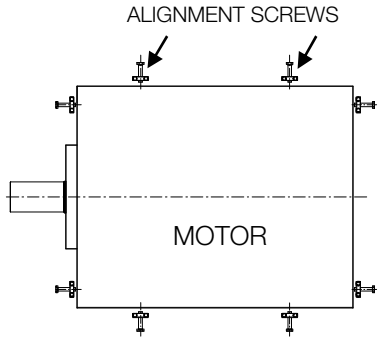



*Figure 6.1: Motor horizontal alignment*

Using the horizontal adjustment screws, the motor can be moved horizontally until the shaft centerline and the driven machine centerline match and the desired distance between the coupling halves is reached. After completing the alignment procedure, the motor fastening bolts at the base can be pre-tightened.

## 6.3 FINAL INSTALATION

The final motor leveling and alignment should be performed, observing the tolerances recommended in the motor installation manual.
When the motor alignment and leveling meet the recommended tolerances, tighten the motor fastening bolts.
Tighten the base anchor bolts (if any) with nominal torque as recommended.

## 6.4 TIGHTENING TORQUES

The recommended tightening torques for the motor fastening bolts are listed in the motor installation manual.
The material and strength class of the bolts used should be rated for the correct tightening torque.
The bolts strength class is usually indicated on the head of the hexagonal bolts.

## 6.5 DOWELING

Once the motor is properly aligned with the driven equipment and the fastening bolts have been installed and tightened, at least two dowel pins must be installed in diagonally opposite motor feet.
The motor usually has a dowel hole per foot to be used in the doweling process.
The doweling procedure consists of deepening the dowel holes in the motor feet by punching through to the motor fastening base.
The motor and base holes are then thinned with a reaming tool and the tapered dowel pins are fitted in the holes.

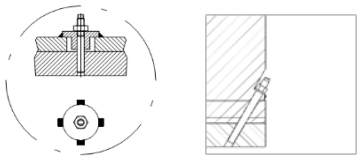


*Figure 6.2: Examples of doweling*

# 7 EXAMPLES OF ELECTRIC MOTORS FASTENING

## 7.1 ANCHOR BASE

## 7.2 INTERMEDIATE BASE

## 7.3 COMMON METAL BASE (SKID)

## 7.4 BASEPLATE

## 7.5 SOLEPLATES

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