> Electric motors <

4.1 GENERAL PRINCIPLES

The electric motors normally installed on all Mistral fans listed in the catalogue are asynchronous, single phase or three phase, totally enclosed finned, selfventilated, for continuous duty, as per UNEL and IEC standards.
These standardization foresee, for each power, fixed shaft dimensions, position and distance of the fixing holes at the feet of the frame for B3 type and on flange for the B5 type. (Bib. Ref. UNEL 13113 ÷ 13118 and IEC72). Therefore in case of replacement of the motor, the operation is facilitated both in the fixing at the support base and in the connecting at the impeller hub.
During fan installation it is necessary to check the rotation sense of the impeller only if the fitted motor is threephase. In the case of single phase motors, however, the correct rotation sense is preset by MISTRAL Aspiratori-Ventilatori S.r.l. during the final test and the terminals to be connected to line wires, are marked with red paint.
The electric motors installed by MISTRAL Aspiratori-Ventilatori S.r.l. are chosen for a correct operation of the fan in continuous duty and for the performances shown in the catalogue.
The size tables also show the PD^2 values of the impellers.
This datum allows the checking of the starting up time, that is useful in special operating conditions. In any case, when the operation is not continuous , it must be specified to us when ordering. The electric motors normally supplied have a voltage of 230/400 V. up to a power of 7,5 kW. For bigger powers, unless stated differently, the motors have a voltage of 400/690 V., in order to carry out the star delta starting and thus reduce the starting currents.
The motors normally supplied are foreseen for an ambient temperature not higher than 40 °C and for an attitude not higher than 1000 m above sea level according to the CEI standards 2-3 and 2-4.
For temperature up to 50 °C and for particularly humid ambient MISTRAL Aspiratori-Ventilatori S.r.l. supplies motors with tropicalized winding on request. If the ambient temperature is higher and/or the attitude of the installation is over 1000 m. above sea level, it is necessary to specify it when ordering because the power output of the motor is reduced, as indicated in Table III.
When a fan, with a motor directly coupled to the impeller, treats air at high temperature there can be a transmission of heat from the fan to the rotating part of the motor through the shaft. This can compromise the operation of the motor itself. In this case MISTRAL Aspiratori-Ventilatori S.r.l. avoids this defect by inserting a small cooling impeller on the motor shaft (SV construction) to allow the fan to treat airforms with a maximum temperature of 200 °C. This solution is valid as long as the motor cooling air has the characteristics specified by the above mentioned CEI standards.

°C	Power output in % of nominal power
under 30	107
30 - 40	100
45	96
50	92
55	87
60	82

Altitude above sea level (m.)	Power output in % of nominal power
1000	100
1500	97
2000	94
2500	90
3000	86
3500	82
4000	77

table III

4.2 ROTATION SPEED

Asynchronous motors, single or threephase, are constant speed motors.
In fact their rotation is strictly linked to the mains and to the type of winding carried out at manufacture (number of magnetic poles).
More exactly, in an electric asynchronous motor two speeds can be distinguished:
***1) Synchronous speed:** this is the rotation speed of the rotating field, i.e. of the magnetic field generated by the winding placed in the fixed part of the motor (stator).*
***2) Effective rotation speed:** the rotating part of the motor-rotator cannot, because of the resisting couple, maintain the speed of the magnetic field and so undergoes certain slowing down (slipping).*
This speed is not perfectly constant but varies slightly with the load.

In table IV the synchronous speed values and the average effective rotor speeds for the different polarities and for the mains frequencies of 50 and 60 Hz are shown.
In the case of direct drive fan the rotation speed of the impeller will be equal to the one of the electric motor and the variations of the fan performances due to the variation of the slipping are practically negligible.
On the contrary, the variations of a fan characteristics are remarkable when we pass from 50 Hz to 60 Hz operation.
In fact, applying the law of similarity, one can say that, as soon as the number of revolutions increases by 20%, the flow rate increases by 20%, the total or static pressure by 44% and the absorbed power by 73%.
Therefore, considering a system with an installed fan fed at 50 Hz, if we want to make a second system with the same characteristics, but with an installed fan fed at 60 Hz, it is necessary to proceed as follows:
a) If the variations in the fan efficiency are acceptable for the new system, the same fan model can be installed but with an electric motor with a suitable, increased power

b) If the performance increase in pressure and flow rate is not acceptable for the system, it is necessary to choose a new fan model consulting the catalogue data referred to 60 Hz, or those to 50 Hz, but applying the laws of similarity.
Normally in the series of fans with standardized impeller diameters, the model valid for the 60 Hz is the one with an impeller diameter immediately smaller than the model used for 50 Hz.

Polarity	50 Hz Speed		60 Hz Speed	
	synchronous	effective	synchronous	effective
2 Poli	3000 g/m	2900 g/m	3600 g/m	3400 g/m
4 Poli	1500 g/m	1440 g/m	1800 g/m	1730 g/m
6 Poli	1000 g/m	960 g/m	1200 g/m	1150 g/m
8 Poli	750 g/m	720 g/m	900 g/m	860 g/m
10 Poli	600 g/m	580 g/m	720 g/m	700 g/m
12 Poli	500 g/m	480 g/m	600 g/m	580 g/m

table IV

4.3 SPEED REGULATION

The rotation speed of the asynchronous electric motor being strictly linked to the mains frequency, each speed variation method must act on the frequency. For this reason variable frequency feeding equipment has been designed to allow to regulate motor rotation speeds in a precise and continuous manner. This is however a very expensive equipment and so it is used only in extraordinary cases, Often, as an alternative, it's preferable to use the direct current electric motor.
However for asynchronous motors with power reduced to a few kW, speed variations are sold on the market and they act not on the frequency but on the mains voltage.
These are based on the slipping phenomenon.
In practice. they slow the rotation speed of the asynchronous motor increasing the slipping under load.
These are inexact regulation methods, and at times dangerous, because they can cause excessive motor heating.
The application to the fan, in this case, can be successfully due to the fact that the shaft torque decreases very rapidly with the reduction of the number of revolution (according to the similarity law it decreases with the power of the three of the number of revolutions).
We advise contacting the Companies, supplying such equipment, to find out about their correct use. When the speed variation of the fan impeller is requested only at the setting up phase of a system, it is useful to adopt the belt driving.
Changing the rations between the pulley diameters all the desired speeds can be obtained and the fan performance can be adapted accurately to the system requirements (see paragraph 2.10).

4.4 FORMULAS

The formulas most frequently used, to calculate the various quantities linked to the asynchronous motor operation are shown underneath.

Synchronous speed

$$n = \frac{2 \bullet f}{p} \bullet 60$$

where:
n = revolution per minute
f = frequency (Hz)
p = pole number

Current absorbed from mains

- Three phase motor

$$I = \frac{1000 \bullet P_r\ (kW)}{\sqrt{3} \bullet V \bullet \cos\varphi \bullet \eta} \qquad I = \frac{736 \bullet P_r\ (CV)}{\sqrt{3} \bullet V \bullet \cos\varphi \bullet \eta}$$

- Single phase motor

$$I = \frac{1000 \bullet P_r \bullet kW}{V \bullet \cos\varphi \bullet \eta} \qquad I = \frac{736 \bullet P_r \bullet CV}{V \bullet \cos\varphi \bullet \eta}$$

where:
I = Absorbed current in Amperes
V = Mains voltage in Volts
P_r = Power at the shaft
φ = Phase angle
η = Efficiency

Starting time

$$t_a = \frac{4 \bullet \Sigma PD^2 \bullet n}{9{,}55 \bullet C_{bm}}$$

where:
t_a = Starting time in seconds
ΣPD^2 = Sum of the PD^2 of the various rotating parts in kgm • m^2 (rotor, impeller, ecc.)
C_{bm} = Medium accelerating torque in N • m
n = Rotation speed in revolutions per minute