

should always be referred to the electrical manufacturer for recommendations.

Synchronous motors are provided with built-in damper windings on the rotor and operate during the starting period similarly to squirrel-cage motors. After the motor is nearly up to speed, field excitation is applied and the motor draws into step at synchronous speed. After excitation is applied the motor runs at exactly constant speed and will remain at this speed until a load approaching the pull-out load is reached, whereupon the motor pulls out of synchronism and stops.

In applying synchronous motors consideration must be given to the torque the motor can develop on pull-in, that is, at the instant when field excitation is applied. Table 2 tabulates typical application requirements of synchronous motor drives, listing starting, pull-in, and pull-out torques.

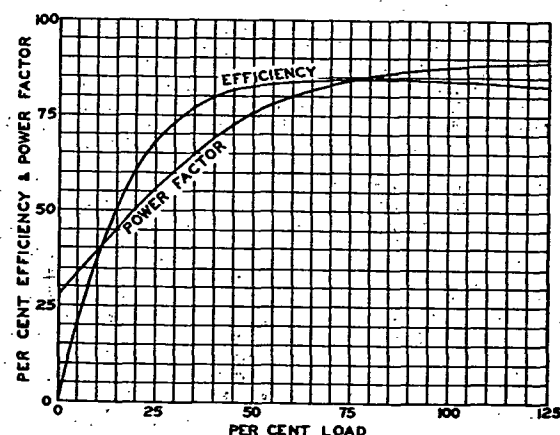


FIG. 6. VARIATION OF EFFICIENCY AND POWER FACTOR WITH LOAD FOR A TYPICAL 5 HP, 4 POLE 60 CYCLE, CLASS B, SQUIRREL-CAGE MOTOR

Typical specifications for synchronous motors are shown on page 640.

Multi-Speed motors provide flexibility in many types of drives. Synchronous motors can be furnished only with a 2 to 1 ratio in speed, single winding. Squirrel-cage induction motors may be 2, 3 or 4 speed. Two-speed induction motors are usually of single winding type, having a 2 to 1 speed ratio such as 600 rpm and 1200 rpm, or may be double winding. Three-speed induction motors are always two winding, and four-speed motors are usually two winding with a 2 to 1 speed ratio in each winding. Motors can be provided in constant torque, varying torque or constant horsepower ratings. The constant horsepower type of motor is considerably larger than the constant torque motor due to the fact that the same horsepower must be developed at either reduced speed or high speed.

In selecting two-speed motors for fan, pump, blower, or compressor applications, it is usually found that two winding motors are more expensive than the single winding type. The control cost for two-speed,

two winding motors, however, is more economical, and therefore the combined price of both motor and control for the two winding motor is only slightly higher. Because of the improved performance of the two winding motor and because of the factor of safety provided by two independent windings, the increased cost is frequently considered worth the difference.

Single Phase Motors

Single phase induction motors inherently develop no starting torque and are provided with auxiliary windings and devices for starting purposes. The motors are classified as to the type of auxiliary winding provided.

Capacitor Start-Induction Run motors develop high starting torque

TYPE OF SQUIRREL-CAGE MOTOR	100 STARTING TORQUE 200 % OF FULL LOAD TORQUE	200 STARTING CURRENT 400 % OF FULL LOAD CURRENT	100 MAXIMUM TORQUE 200 % OF FULL LOAD TORQUE	90 EFFICIENCY AT 85 FULL LOAD - 1/2	90 POWER FACTOR AT FULL LOAD - 1/2	2 SLIP AT 4 FULL LOAD - 1/2
CLASS A						
CLASS B						
CLASS C						
CLASS D						

* SAME AS STARTING

FIG. 7. COMPARATIVE PERFORMANCE OF SQUIRREL-CAGE MOTORS OF 30 HP AND SMALLER SIZES

with low starting current and are used for all types of constant speed heavy duty drives such as compressors, pumps, and stokers. During the starting period, a winding with a capacitor in series is connected in the motor armature circuit and when the motor comes up to speed a centrifugal switch cuts the capacitor and second winding out of the circuit.

Capacitor motors, which are ideally suited for small fan drives, are similar to the capacitor start-induction run type except that the capacitor is not cut out when running.

Repulsion Start-Induction Run motors develop extremely high starting torque. They are supplied with a short-circuiting switch which cuts out the commutator when the motor comes up to speed. These motors are suitable for applications such as industrial compressors where high break-away torque is required and where commutator and brush noise are not factors.

Split Phase motors have a high resistance auxiliary winding which is in the circuit during starting but is disconnected through the action of a centrifugal switch as the motor comes up to speed. Under running conditions it operates as a single phase induction motor with one winding