TABLE 3. CLASSIFICATION OF MOTORS

	TYPE	SPEED CHARACTERISTICS	FULL VOLTAGE		HP RANGE	APPLICATION SEE FOOTNOTES (a) TO (e)
			Starting Torque	Starting Current		
	Constant Speed Drives					
Polyphase a-c	Squirrel-cage general purpose Design A	Constant	Normal 1-2.5 times[f]	High 6-8 times	All	(a) Fans and (c) centrifugal pumps and centrifugal compressors
	Squirrel-cage Design B	Constant	Normal 1-2.5 times[f]	Normal 5-6 times	Medium Small	(a) Fans and centrifugal pumps and centrifugal compressors
	Squirrel-cage Design C	Constant	High 2-2.5 times[f]	Normal 5-6 times	Medium Small	(b) Reciprocating pumps (c) and compressors started loaded
	Squirrel-cage Design F	Constant	Low 1.25	Low 4 times	Medium Large	Fans, centrifugal pumps and compressors
	Wound rotor	Constant or variable	High 1-2.5 times (with secondary control)	Low 1-3 times	All	(a) Hoists (b) reciprocating pumps and compressors (c) and frequent (e) or hard start
	Synchronous high speed	Exactly constant	Normal 0.75-1.75 times	Normal 5-7 times	Medium Large	(a) Fans and centrifugal pumps and centrifugal compressors
	Synchronous low speed	Exactly constant	Low 0.3-0.4 times	Low 3-4 times	Medium Large	(a) Reciprocating compressors starting unloaded
Single phase a-c	Two value capacitor	Constant	High	Normal	Small	(b) Pumps and compressors
	Permanent split capacitor	Constant	Low	Normal	Fractional	(a) Fans, Blowers
	Capacitor start	Constant	Moderate	Normal	Small Fractional	(a) Fans and pumps
	Repulsion Induction	Constant	High	Normal	Medium Small	(a) Fans (b) pumps and compressors
	Split phase	Constant and adjustable	Normal	Normal	Fractional	(a) Fans (b) pumps and compressors (d) fans—direct
	Adjustable Speed Drives					
Polyphase a-c	Squirrel-cage high slip. Transformer adjustment	Variable	Normal	Normal	Medium Small	(a) Fans
	Squirrel-cage separate winding or regrouped poles	Constant multi-speed	Normal or high	Normal or low	All	(a) Fans (b) pumps and (c) compressors
	Wound rotor	Variable	High (with secondary control)	Low	All	(a) Fans (b) centrifugal pumps and compressors
Single phase a-c	Repulsion	Variable	High	Normal	Low and Fractional	(a) Fans, centrifugal pumps (b) compressors
	Capacitor low torque tapped winding	Variable two speed	Low	Normal	Fractional	(d) Fans, drect
	Capacitor low torque transformer adjustment	Variable	Low	Low	Fractional	(d) Fans
	Split phase regrouped poles	Constant	Normal	Normal	Fractional	(d) Fans

a. Drives having medium or low starting torque and inertia (WR^2) such as fans and centrifugal pumps or reciprocating pumps and compressors started unloaded.
b. Drives having high starting torques, such as reciprocating pumps and compressors started loaded.
c. Similar to (a) except where frequent or hard starting (large WR^2) requires a higher starting and accelerating torque.
d. Fans direct connected.
e. Stoker drives.
f. Torque depends on hp rating and speed. See *NEMA* Standard MG1-4.10 on Motors and Generators.

time is prolonged by high WR^2 and high load torques. In general, driven machines starting more than 4 to 6 times per hour may require special motors and control.

ALTERNATING CURRENT MOTORS

Alternating current motors are divided into two main classifications: *polyphase* and *single phase* (see Table 3), according to the type of power supply. They are further subdivided by type of motor winding.

When polyphase power is available it is usually found more economical to apply polyphase motors in preference to single phase motors. A typical 5 hp, 1200 rpm capacitor start-induction run single phase motor, for instance, will cost approximately twice as much as the corresponding three phase *Design B* squirrel-cage motor. In addition, the polyphase motor has the advantage of higher efficiency.

TABLE 4. LOCKED-ROTOR CURRENT OF THREE-PHASE, 60-CYCLE MOTORS AT 220 VOLTS[a, b]

HP	DESIGN B, C, AND D Amperes	DESIGN F Amperes	HP	DESIGN B, C AND D Amperes	DESIGN F Amperes
1 or less	24[c]	..	30	435	270
1½	35	..	40	580	360
2	45	..	50	725	450
3	60	..	60	870	540
5	90	..	75	1085	675
7½	120	..	100	1450	900
10	150	..	125	1815	1125
15	220	..	150	2170	1350
20	290	..	200	2900	1800
25	365	..			

[a] The locked-rotor current of three-phase, 60-cycle, constant-speed, induction motors, measured with rated voltage and frequency impressed and with rotor locked, shall not exceed the tabulated values.
[b] Locked-rotor current at other voltages shall be inversely proportional to the voltage.
[c] For 1 hp or less the value is given per hp.

Polyphase Motors

The three types of polyphase motors are: *squirrel-cage induction* motors, *wound rotor induction* motors, and *synchronous* motors.

Squirrel-cage motors are specific by *NEMA* standards providing a variety of speed and torque characteristics. *Design A* motors provide normal starting torque at starting current in excess of *Design B* motors, and are suitable for constant speed application to equipment such as fans and blowers. *Design B* motors provide normal starting torque with *NEMA* starting current values shown in Table 4, which are acceptable by many power companies for full voltage starting. They are used for the same type of application as *Design A*. *Design C* motors provide high starting torque with starting current same as *Design B*, and are used on compressors started without unloaders, and on reciprocating pumps. *Design D* motors have high slip* and are used with flywheels for widely pulsating loads on equipment such as reciprocating compressors and pumps where other motors would draw high peak currents. *Design F* Motors have low starting current and low torques. They are used on power systems of limited capacity. Careful application must be made since the low breakdown torque provides only limited safety margin for overload or low voltage conditions. A drop in voltage, for instance, could cause the motor to stall.

Figs. 1 and 2 illustrate the characteristics of squirrel-cage motors. The motor operates under load from near synchronous speed at light load to

* Refer to Glossary at end of chapter.