TABLE 1. REASONABLE HORSEPOWER DESIGN LIMITS FOR STANDARD MOTOR VOLTAGES

POWER SUPPLY	STANDARD MOTOR VOLTAGE	SUGGESTED MINIMUM HORSEPOWER	SUGGESTED MAXIMUM HORSEPOWER
Alternating 1-phase	115	None	1
	230	None	15
Alternating 3-phase	110	None	15
	220	None	200
	440-550	1	1000
	2300	50	6000
	4000	100	7500
	4600	250	8000
	6600	400	None
Direct	115	None	30
	230	None	500
	550-600	1	None

(1) mechanical arrangement including position of motor and shaft, portability desired, drive connection and space limitations; (2) speed range desired; (3) horsepower requirement; (4) torque; (5) inertia; (6) frequency of starting.

1. *Mechanical Arrangement.* Arrangement of the driven machine usually determines whether a *horizontal* or *vertical* motor is needed. Horizontal motors are more generally available and less expensive; most grease-lubricated ball-bearing motors will operate in either position. Fractional-horsepower waste-packed sleeve-bearing motors are satisfactory for short periods of vertical operation where no thrust is involved.

If shaft is *tilted* for momentary operation, special construction of bearing housings will be required for oil-ring-lubricated sleeve-bearing motors, to avoid loss of lubricant. In case of long periods of tilted operation, bearings suitable for end thrust may be necessary. Ball-bearing motors with grease lubrication are suitable for tilted operation.

Most motors are suitable for mounting with base above a horizontal shaft or to one side of the shaft, provided the end shields are rearranged. If, during operation, the angle of the motor (with regard to the horizontal shaft) changes more than 10 or 12 deg, a ball-bearing motor will usually be required. Sleeve-bearing motors are also applicable within the angle given if modified oil gages are provided.

On portable machines, motors of greater compactness and less weight than standard may be required, and special bearing construction may be needed, except for ball-bearing motors. Direct connection should always be considered where machine speed coincides with available motor speed.

Maintenance, efficiency, power factor, space and initial cost will determine the choice between *direct connection* and other methods, such as *belt*, *chain* or *gear* drive. When direct connection is possible (where parts of the driven machine, such as shaft or bearings, are common with the motor structure) a *built-in* construction may be advantageous.

Belt Drive. Diameters and widths of pulleys or sheaves and center distances are factors in determining motor-bearing pressures and shaft deflection. Table 3 shows

TABLE 2. PREFERRED VOLTAGE RATINGS FOR A-C SYSTEMS AND EQUIPMENT*

NOMINAL SYSTEM VOLTAGE	RATED MOTOR VOLTAGE	
	Polyphase	Single-phase
120	110	115
120/208	220	115
240	220	230
480	440	
600	550	
2400	2300	
4160	4000	
4800	4600	
6900	6600	

* From EEI-NEMA Interim report Preferred Voltage Ratings for A-C Systems and Equipment.

TABLE 3. HORSEPOWER LIMITS FOR TWO-BEARING MOTORS
Flat & V-Belt and Chain Drive

MOTOR SPEED Rpm	FLAT BELT DRIVE Max Hp	V-BELT & CHAIN DRIVE Max Hp
Above 2400-3600 Including	20	20
1800-2400	30	40
1200-1800	40	75
900-1200	75	125
750- 900	125	200
720- 750	150	250
560- 720	200	300

limits for two-bearing motors and limits of good practice for belting. Flat belts should not run at greater speeds than about 5000 fpm. Application of flat belting to vertical-shaft motors is difficult.

Chain Drive. Application limits are shown in Table 3. The chain manufacturer should be consulted when higher horsepower and speed ratings are involved, so that the best drive on a basis of quietness and economy of operation may be selected.

Gear Drive. Compactness and arrangement of drive often indicate *gear motors*, which are obtainable in a variety of mechanical constructions with speed ratios of 3 to 1 upwards, and are generally limited to about 75 hp maximum. Where the pinion of ordinary spur gearing is mounted on the motor shaft, two-bearing motors should be limited to horsepower ratings shown in *chain-drive* column of Table 3. Maximum pitch-line speed with steel pinions is about 1400 fpm.

The selection of the motor part of a *gear-motor* is the same as for a conventional motor.

Space limitations may affect the choice of motor and require (a) built-in construction, (b) a gear-motor, (c) forced ventilation using an external blower, or (d) a small frame with Class B insulation permitting higher temperature rise.

2. *Speed Range.* Where more than one speed or a range of speeds is required, one of the motor types listed in Table 4 may be applicable, depending upon the power supply and the speed range required. Those marked (*) have relatively wide speed regulation, which may make them unsuitable for some loads.

3. *Horsepower Requirement.* The horsepower required by the driven machine determines the motor rating. Where the load varies with time, a horsepower vs. time curve will permit determination of the peak horsepower required, and the calculation of the root-mean-square (rms) horsepower indicating the proper motor rating from a heating standpoint. In case of extremely large variations in load, or where shut-down, accelerating, or decelerating periods constitute a large portion of the cycle, the rms horsepower may not give a true indication of the equivalent continuous load, and the motor manufacturer should therefore be consulted.

Where the load is maintained at a constant value for an extended period (varying

TABLE 4. SPEED RANGES FOR VARIOUS TYPES OF MOTORS

POWER SUPPLY	TYPE	SPEED RANGE
Single Phase a-c	*Brush-shifting repulsion motor	3:1
	*Capacitor-motor with tapped winding	2:1
	Multi-speed capacitor-motor	2 or 3 fixed speeds
Poly-phase a-c	Multi-speed squirrel-cage	2, 3 or 4 fixed speeds
	*Wound-rotor motor	2:1
	*2-speed wound-rotor motor	4:1
	Brush-shifting shunt motor	20:1
	*Brush-shifting series motor	3:1
	Squirrel-cage motors with variable frequency supply	Very wide range
	Motor-Generator Set—D-c Drive Motor	Very wide range
	Rectifiers—D-c Drive Motor	Very wide range
d-c	Shunt-wound standard *constant-speed* motor with field control	2:1 in some cases
	*D-c motor with armature control	Wide
	Adjustable-speed motor	From 3:1 to 6:1
	Shunt motor with adjustable voltage supply	Very wide

* Speed regulation relatively wide. Unsuitable for some loads.