General

Technical Section Y of the catalog contains useful information pertaining to the selection, mounting, alignment and control of clutches and brakes in general. Formulas, symbols and units are also identified. It is recommended that Section Y be reviewed before attempting to size a specific product for an application.

Element Torque Adjustment

The catalog element torque ratings $\mathbf{M_r}$ are based upon an effective pressure $\mathbf{p_r}$ of 75 psi (5,2 bar). Torque ratings must be adjusted for operating pressure $\mathbf{p_o}$, parasitic loss $\mathbf{p_p}$ and operating speed **n**.

Maximum allowable operating pressure is dependent upon element construction and frequency of engagement. In general, the pressures listed in the following table should not be exceeded.

Maximum Allowable Pressure		
Model	English	SI
	psi	bar
CB	110	7,6
CM	150	10,3
VC	125	8,6

The elements have an inherent parasitic pressure $\mathbf{p_p}$ required to cause friction shoe contact with its drum which represents the pressure to overcome resiliency of the actuating tube and, for the VC elements, the pressure to overcome friction shoe release springs. Parasitic pressures are given in the following table and must be deducted from the operating pressure.

Parasitic Pressure p_p		
Size	English	SI
	psi	bar
3CB	20	1,38
4 and 5CB	15	1,03
6 and 8CB	5	0,34
10 thru 45CB	2	0,14
All CM's	5	0,34
All VC's	4	0,28

A rotating element must have its torque rating adjusted to compensate for the centrifugal force acting on its friction shoes. The method used is to calculate a compensating pressure $\mathbf{p_c}$ and deduct its value from the operating pressure.

$$p_c = C_S \bullet n^2$$

where p_c = compensating pressure (psi or bar)

C_s = speed constant obtained from element catalog page (psi/rpm^2 or bar/rpm^2)

n = element rpm

Adjusted element torque $\mathbf{M_e}$ is then calculated from:

$$Me = \frac{p_o - p_p - p_c}{p_r} \cdot M_r$$

The adjusted element torque $\mathbf{M_e}$ must then be equal to or greater than the required clutch torque $\mathbf{M_c}$ or brake torque $\mathbf{M_b}$.

Examples 1, 2 & 3 at the end of this section illustrates the use of the above formulas.

Continuous Thermal Capacity

Constricting elements are generally not recommended for continuous slip applications. This type of application is best handled by the expanding, caliper and water-cooled product lines (see Sections C, H and I).

Non-Cyclic Thermal Capacity

Non-cyclic thermal capacity is determined by the element's friction area, drum mass, heat capacity and thermal conductivity. The properties of our standard gray iron drums result in the limits indicated in the Non-Cyclic Energy Capacity Graph. An explanation on the use of this graph follows.

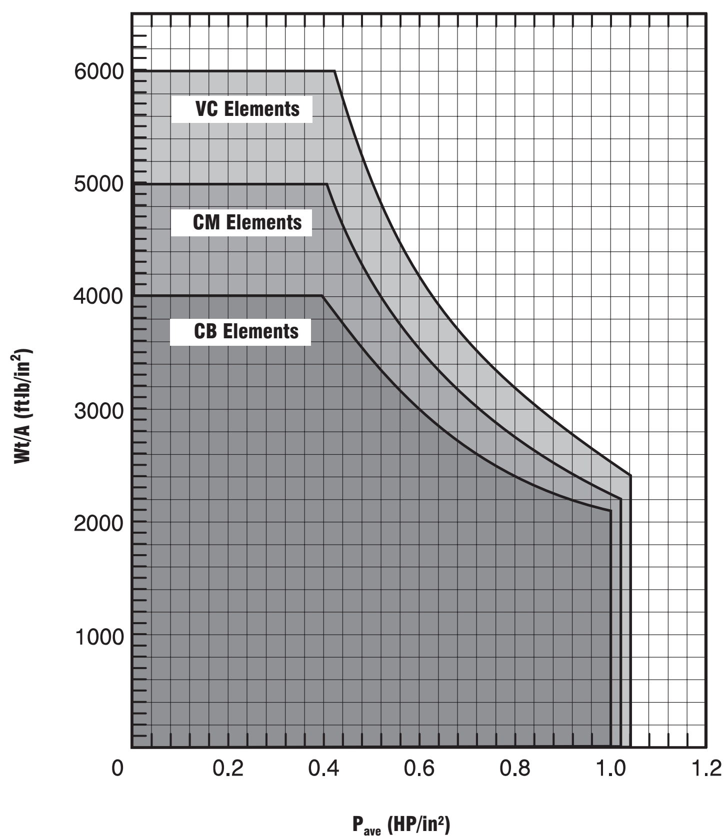
The thermal energy calculated for the load is adjusted to include the energy associated with accelerating or decelerating the components of the tentative clutch and/or brake selection. The adjusted thermal energy $\mathbf{W_t}$ is divided by the element's friction area **A**. Next, the average power loading $\mathbf{P_{ave}}$ is calculated from:

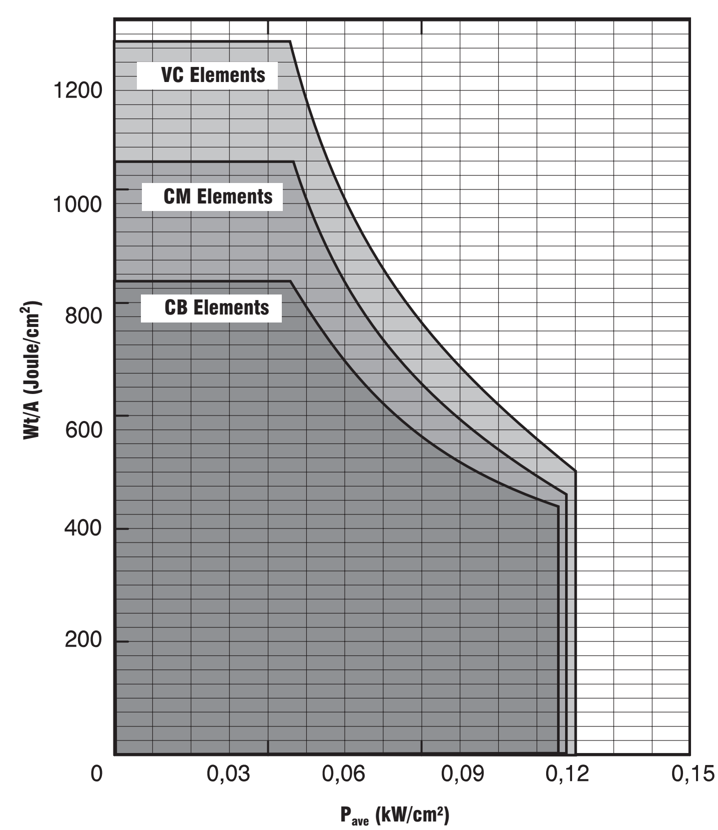
$$P_{ave} = \frac{P_t}{A}$$

The point ($\mathbf{W_t/A}$, $\mathbf{P_{ave}}$) is plotted on the graph. If the point falls below the appropriate product limit line, the selection will handle the thermal load. If it does not, an element having a greater friction area is required.

Example 4 at the end of this section illustrates the use of the graph.

Non-Cyclic Thermal Capacities (Gray iron drums)





Cyclic Thermal Capacity

The cyclic thermal capacity of a clutch or brake is dependent upon the design and arrangement of the mounting components and their operating speed. Components with the smaller inertias should be mounted on the shaft which is started and/or stopped with each cycle. Protective guards should be designed to assure adequate air circulation.

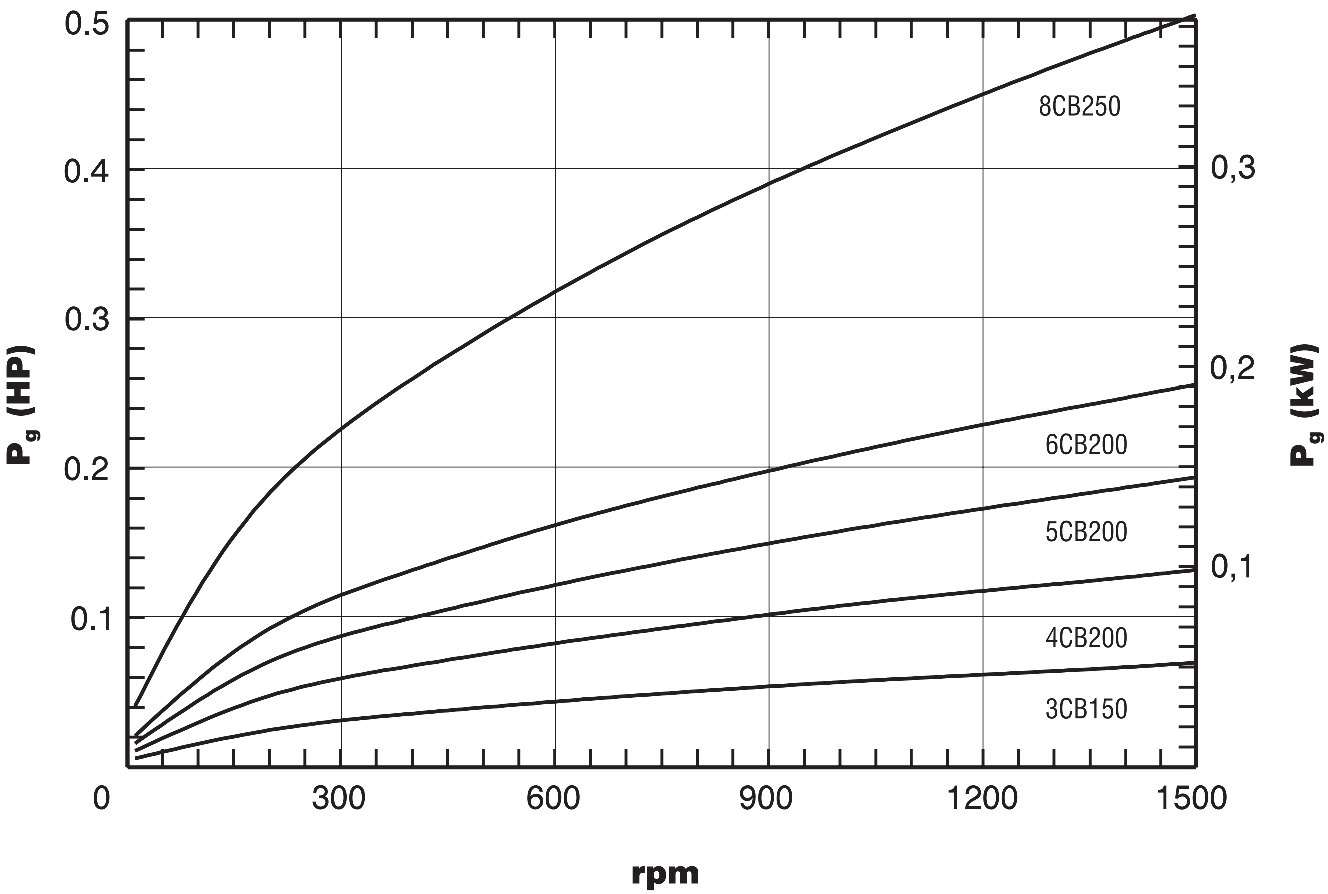
Cyclic thermal capacities $\mathbf{P_c}$ for CB and VC elements are determined from the following graphs. CM elements are not recommended for cyclic duty because the thermal requirement can be handled more efficiently by a smaller diameter VC element. The capacities are for applications having the drum and hub on the driven side of the installation. Elements should have the maximum number of tube inlets. The capacities $\mathbf{P_g}$ obtained from these graphs must be multiplied by the appropriate arrangement factor $\mathbf{K_t}$ given in the table.

$$P_c = P_g \cdot K_t$$

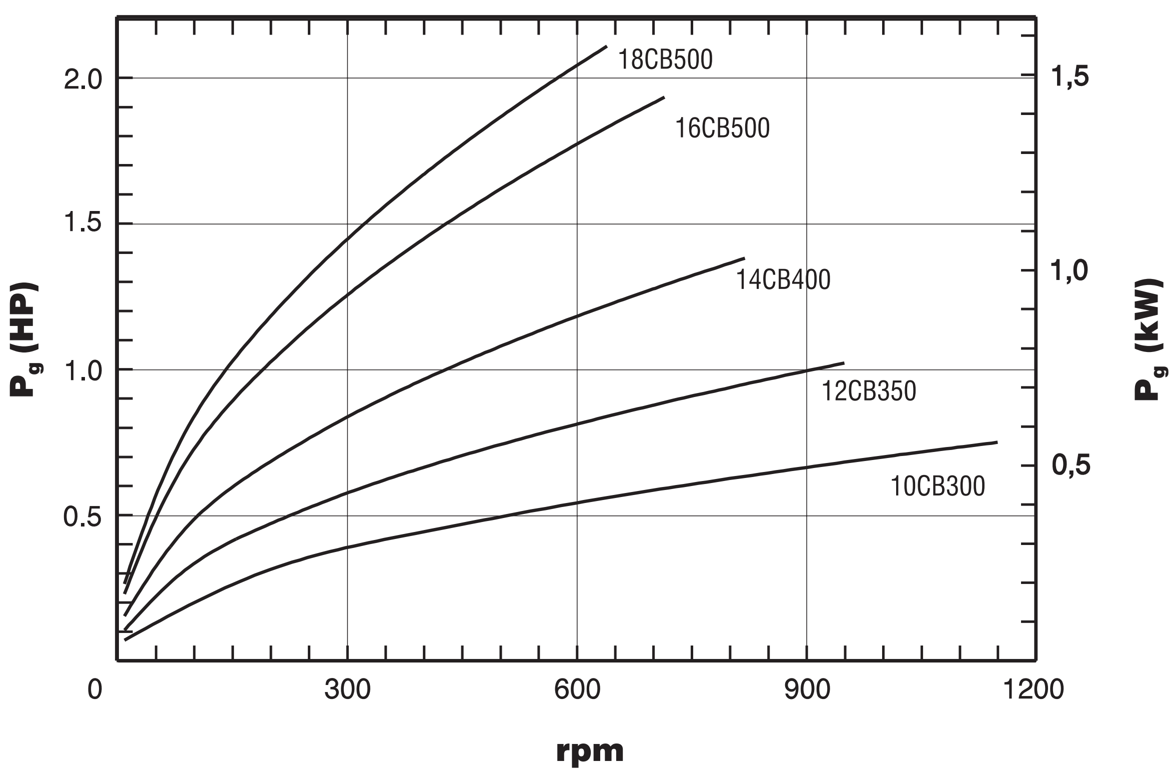
The element's cyclic thermal capacity $\mathbf{P_c}$ must be greater than or equal to the thermal power requirement.

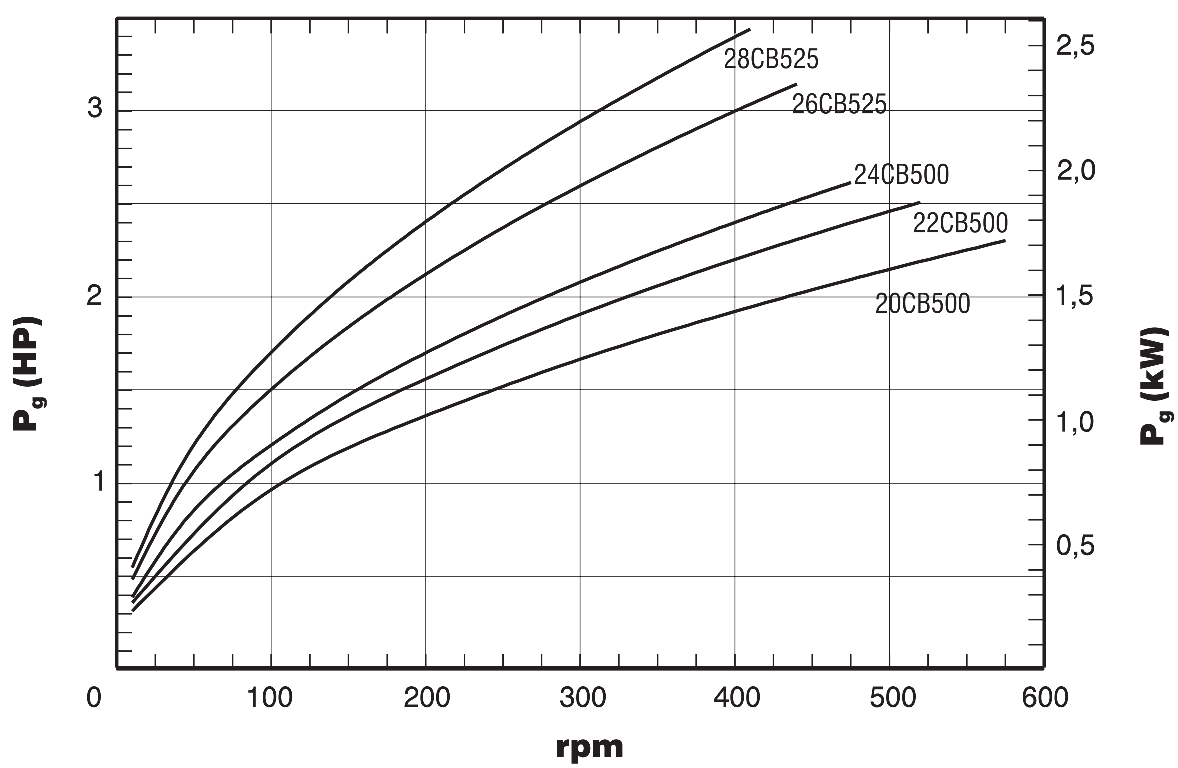
Example 5 at the end of this section illustrates the use of these graphs.

Arrangement Factors K_t		
Arrangement	**Single Element**	**Dual Element**
Spider	1.0	1.6
Ventilated Adapter	1.67	2.67
Brake	0.5	0.8

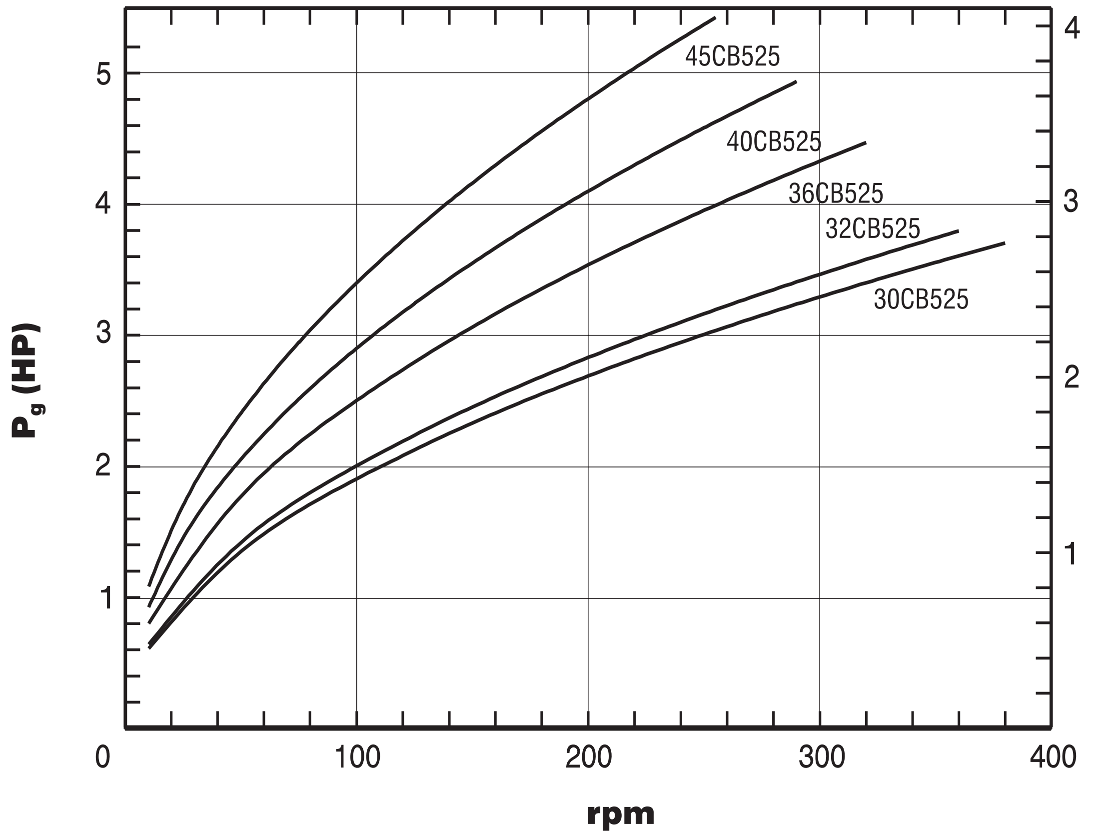


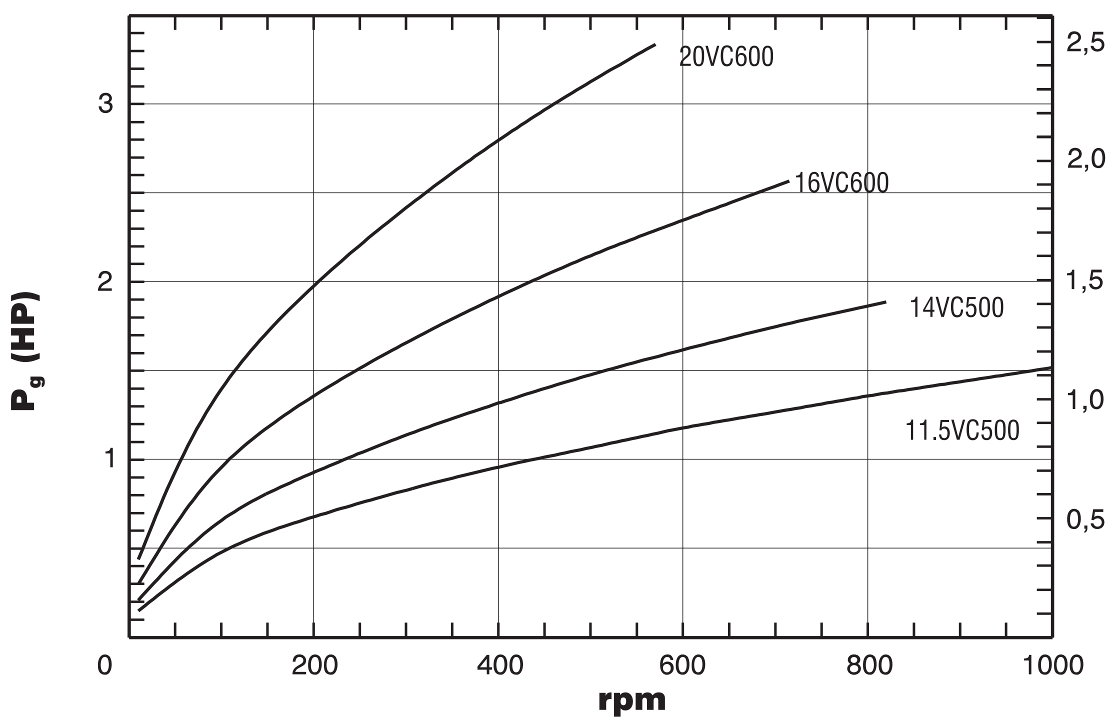
Thermal Capacities



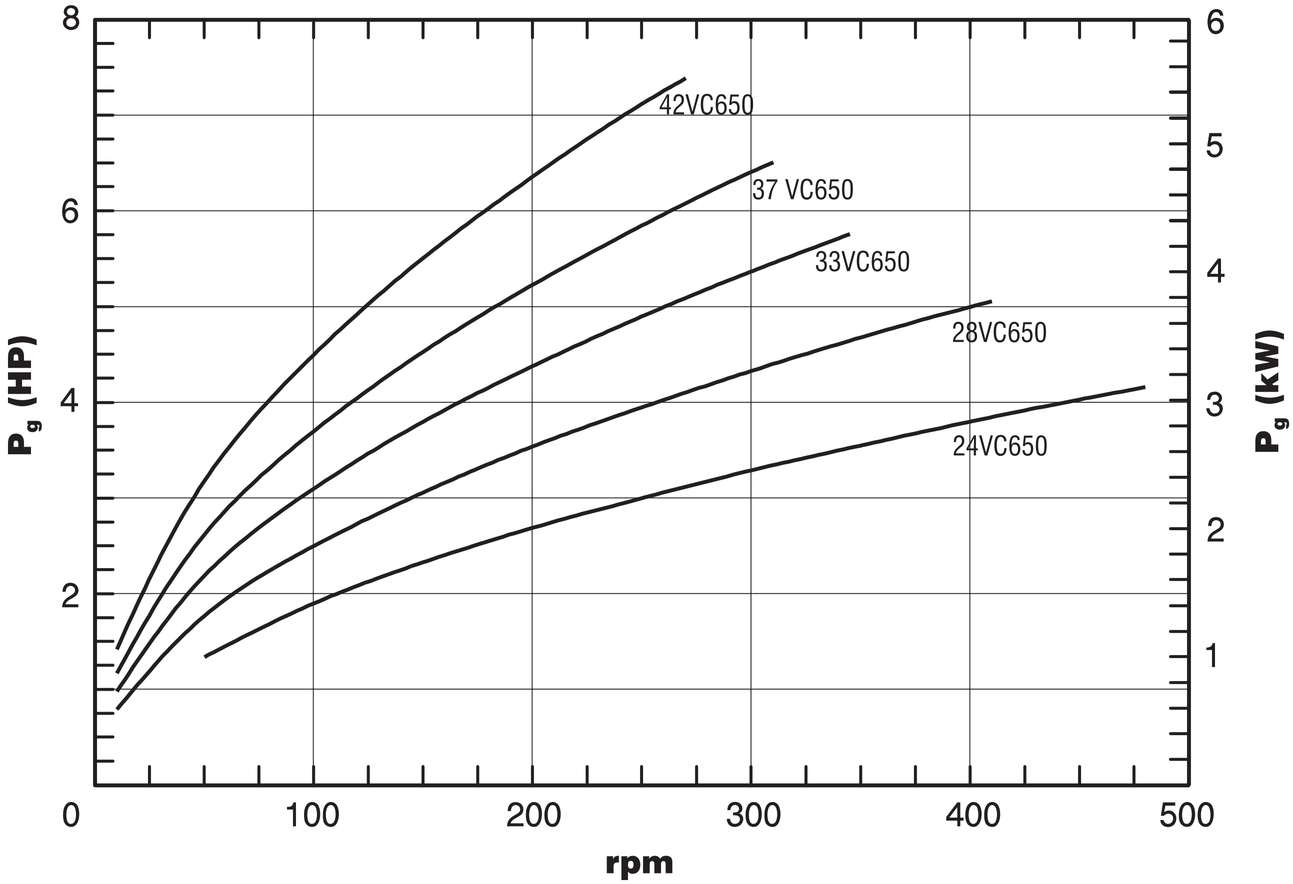


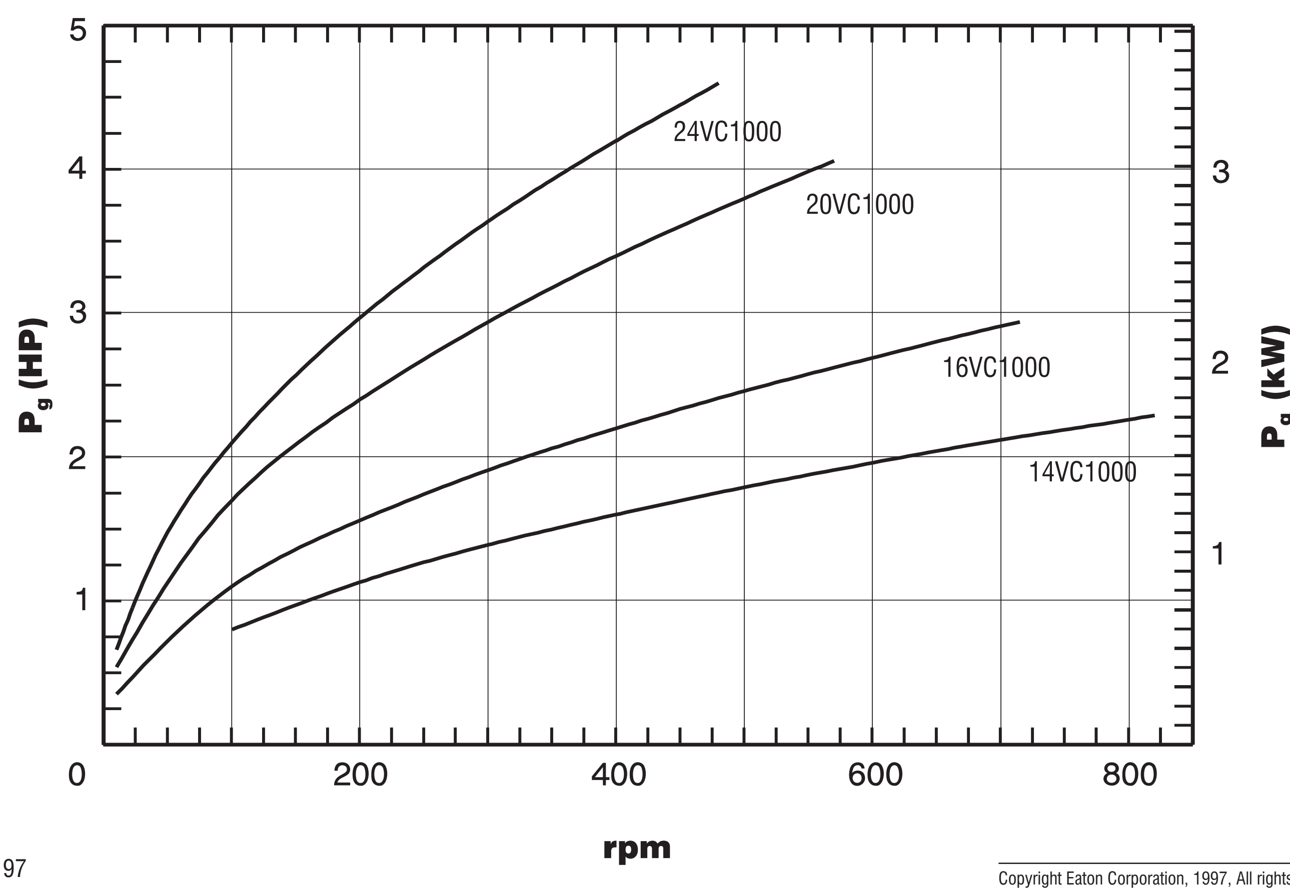
Thermal Capacities



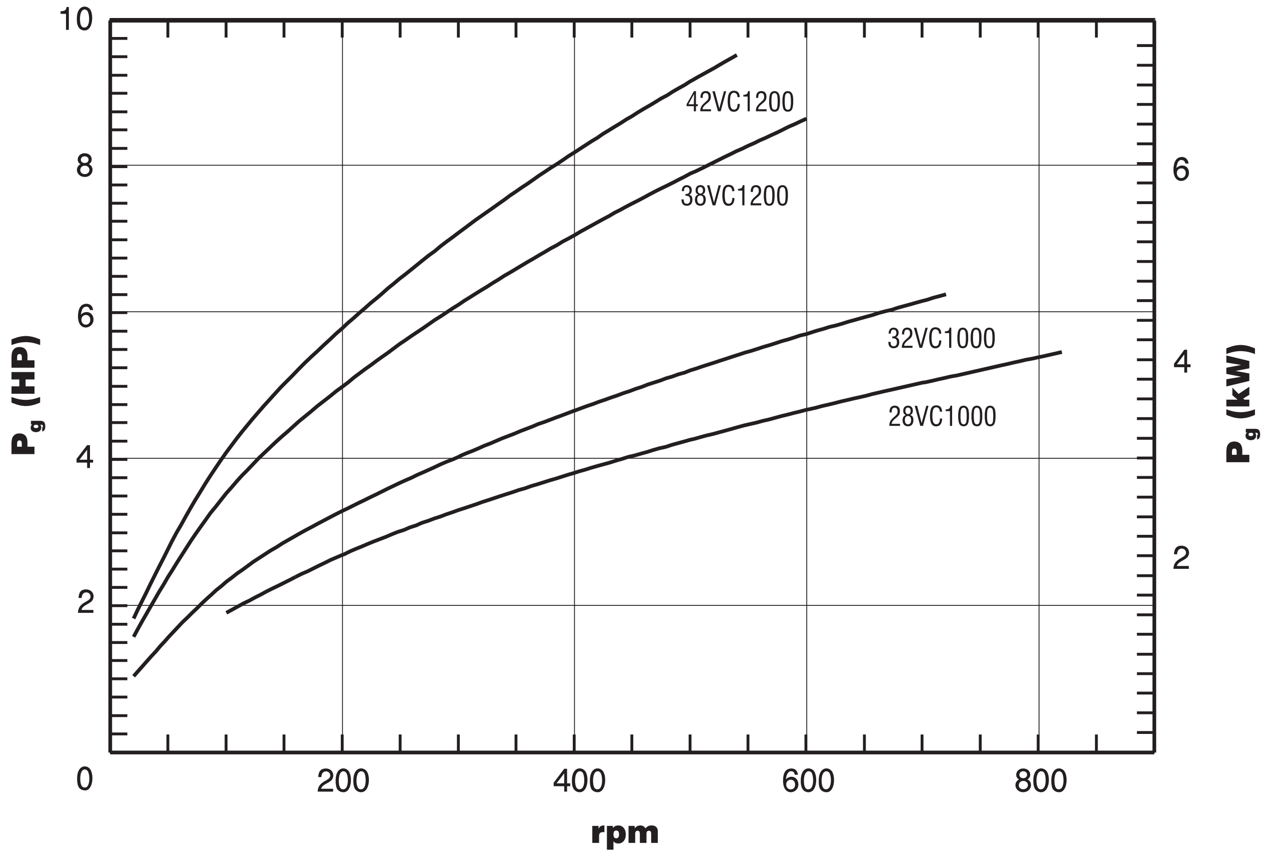


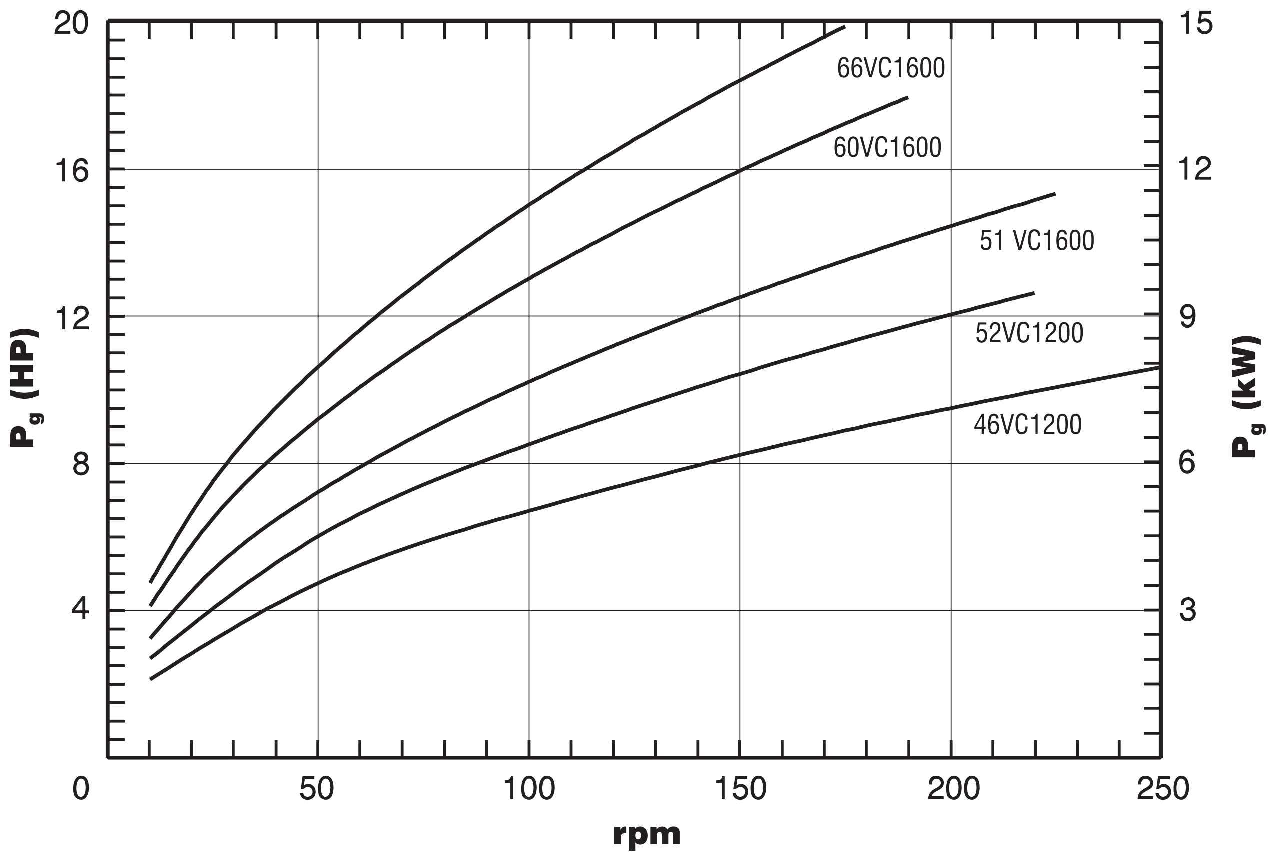
Thermal Capacities





Thermal Capacities





Component Peripheral Velocities

Component velocities must be below the values given in the table. In some applications, components may be required to freewheel at speeds much faster than their engaged running speeds. This must be taken into consideration when calculating their velocities. Velocities are calculated by:

$$v\ (\text{fpm}) = 0.262 \cdot n \cdot D$$

$$v\ (\text{mps}) = 5{,}236\text{E-}05 \cdot n \cdot D$$

where D = outside diameter of component (in or mm).

Maximum Peripheral Speed		
Component	**fpm**	**mps**
Spider	8500	43
Drum	8500	43
Hub	8500	43
Ventilated Adapter	6500	33

Selection Method

Two selection procedures are discussed in Section Y. The analytical method results in an optimum selection for the drive whereas the service factor method may result in an under or oversized unit. Whenever possible, the analytical method should be used. The procedure to follow for constricting products is discussed below followed by the service factor procedure.

Procedures for specialized machines or equipment used in particular industries are given in Section X.

Analytical Method

The steps to follow are:

1. Determine the torque requirement.
2. Determine the thermal requirement.
3. Determine the mounting arrangement, mounting space and shaft diameters.
4. Make a tentative selection from steps 1,2 and 3.
5. Adjust the torque rating of the tentative selection to reflect the operating pressure and speed and determine if it still meets the requirement.
6. Adjust the thermal requirement to include the energy of the clutch and/or brake components which are accelerated or decelerated and determine if it is within the tentative selection's capacity.
7. Check drum and spider peripheral velocities to determine if they are within the components operational limits given in the table.

Refer to catalog Sections X and Y to determine the requirements for Step 1 and 2. Step 3 requires some measurements be made to ensure the arrangement does not interfere with the surroundings. If the tentative selection does not meet the requirements of Step 5, 6 and 7, a larger element or a smaller dual element should be considered. Steps 4 thru 7 should then be repeated for the new selection. If the new selection still does not meet the requirements of steps 5 and 6, a different product line should be considered. If the selection does not meet the requirements of Step 7, it may be possible to fabricate the components of other materials which can withstand the stresses associated with fast operating speeds.

Service Factor Selection Method

Obtain the service factor **SF** from the Service Factor Table given in Section Y. If the machine or equipment is not listed use the service factor for a machine which performs a similar function. Multiply the prime mover power $\mathbf{P_p}$ by the service factor to obtain the design power $\mathbf{P_D}$.

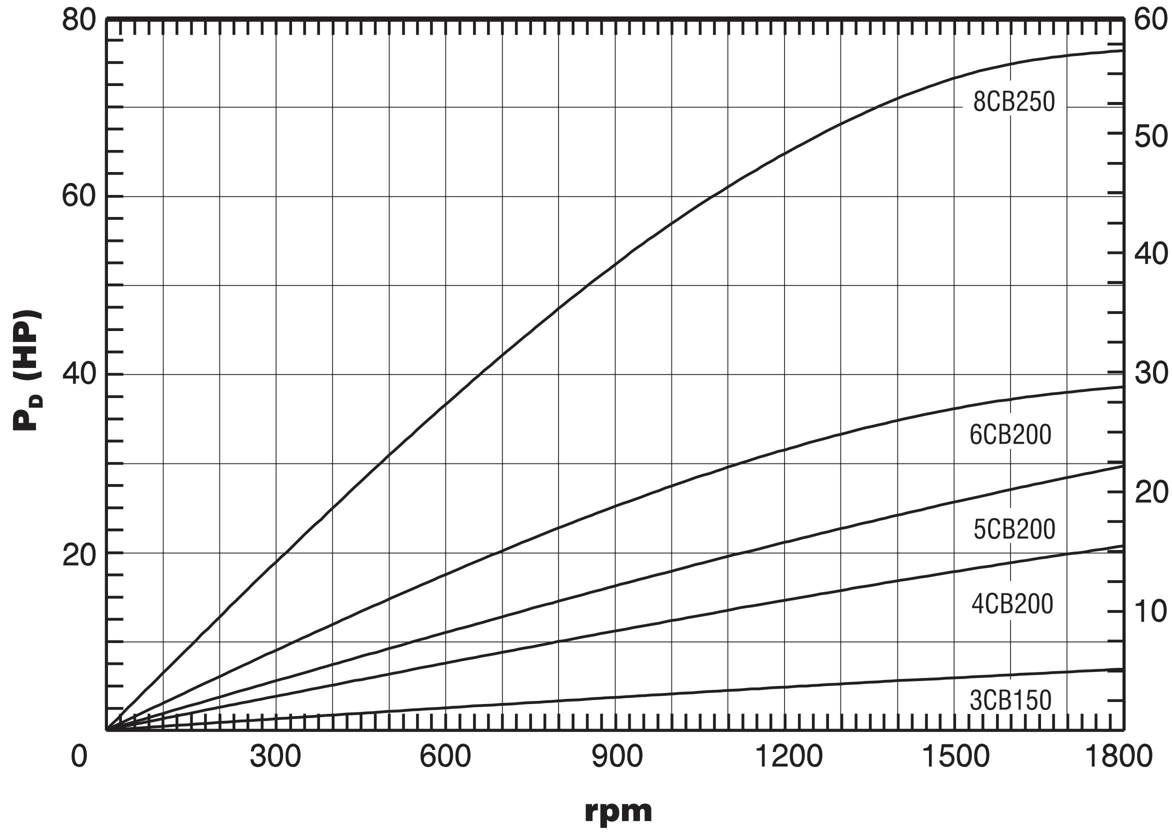
$$P_D = P_p \cdot SF$$

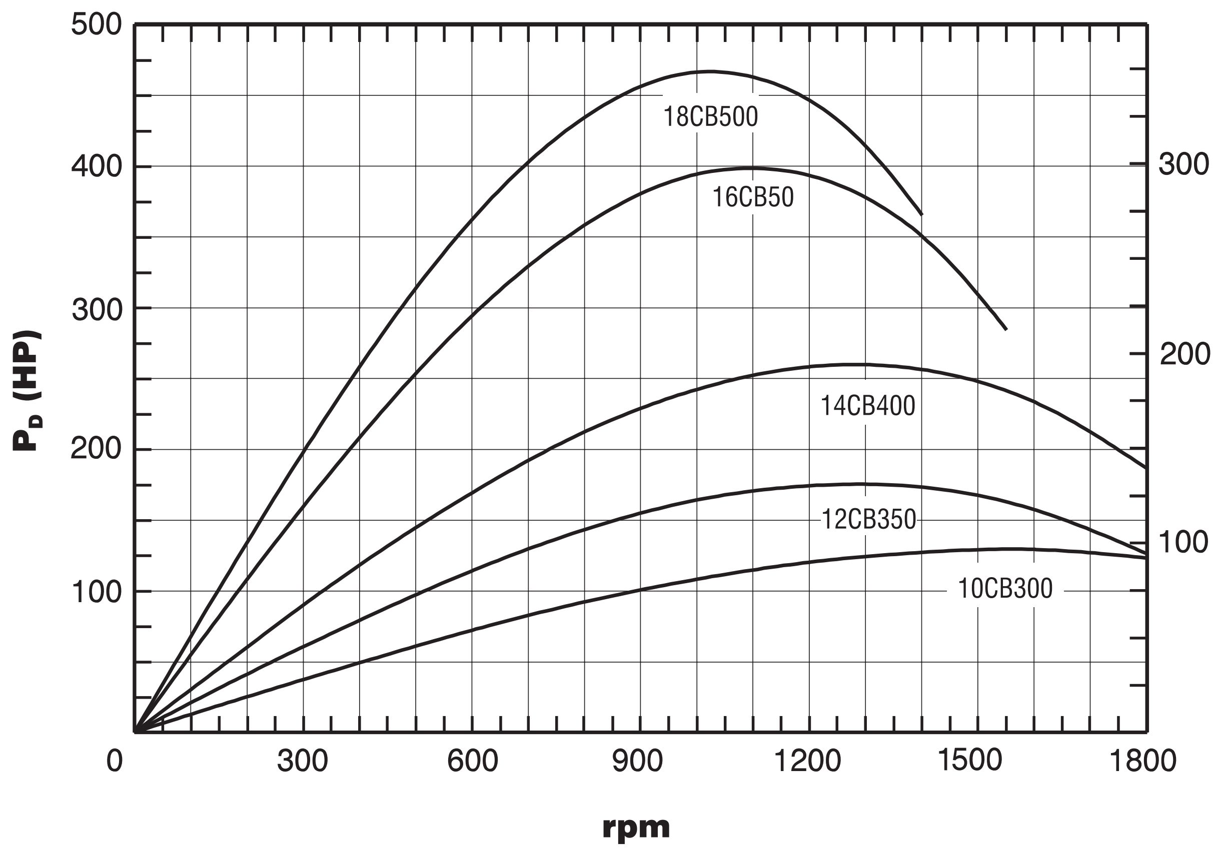
For clutch applications operating at 75 psi (5,2 bar), use the design power graphs to select an element which has the design power capacity at the element's operating speed. These graphs are for single clutch elements. Dual clutch elements have twice the capacity shown.

For clutch applications operating at other pressures, or for stationary brake elements the service factor is applied to the prime mover's torque $\mathbf{M_p}$ referred to the clutch or brake shaft.

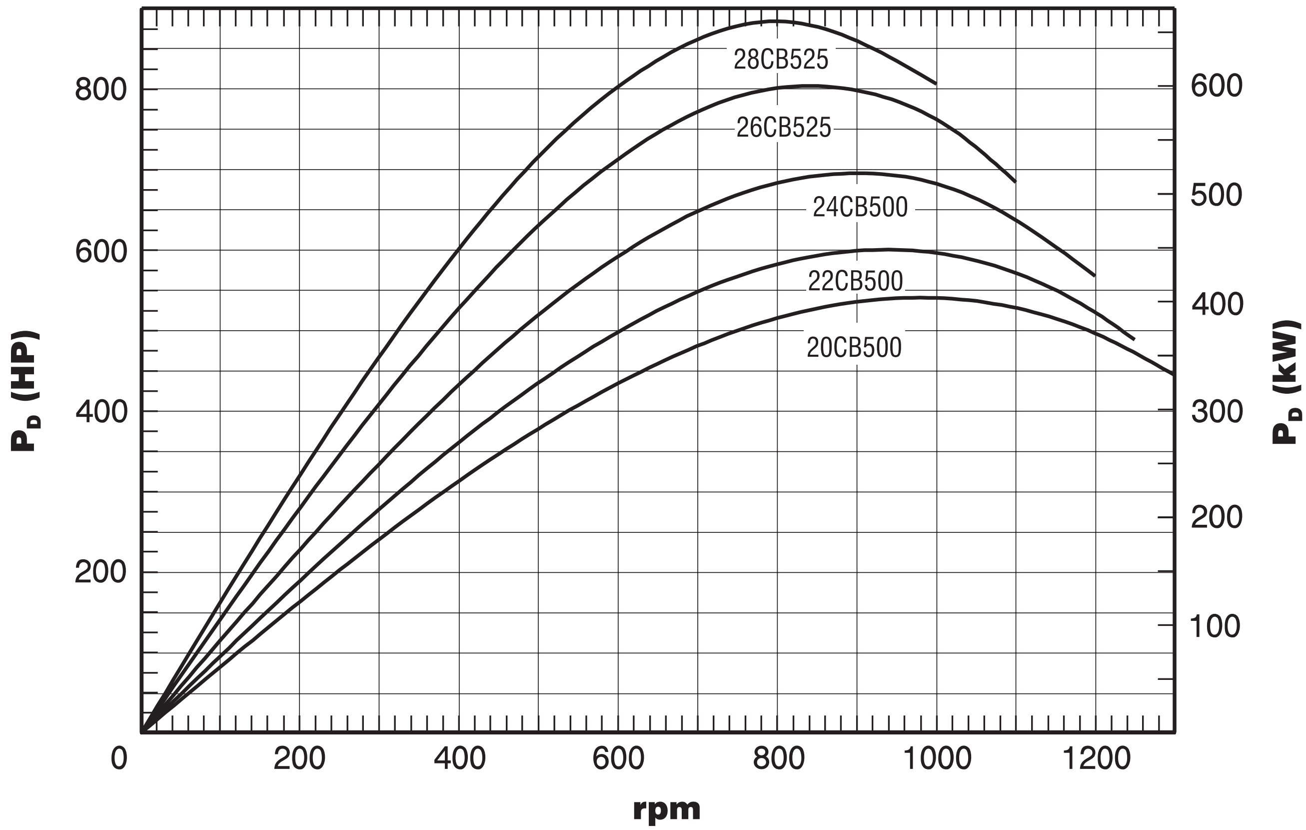
The required clutch torque M_c or the required brake torque M_b is used to make a tentative element selection. The element torque rating M_r is adjusted for operating speed and pressure as explained earlier. The adjusted element torque M_e, must be equal to or greater than M_c or M_b.

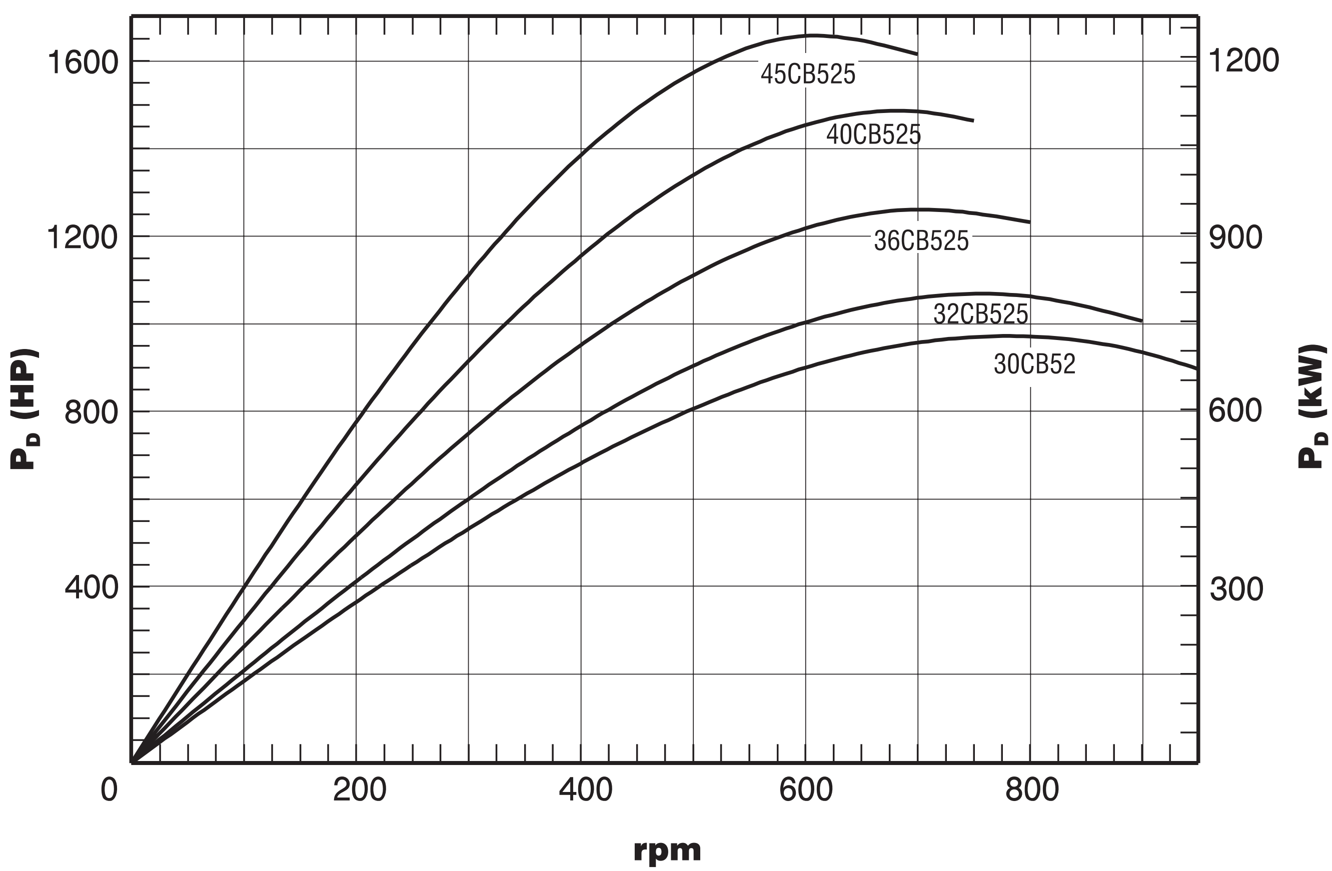
Power Capacities





Power Capacities





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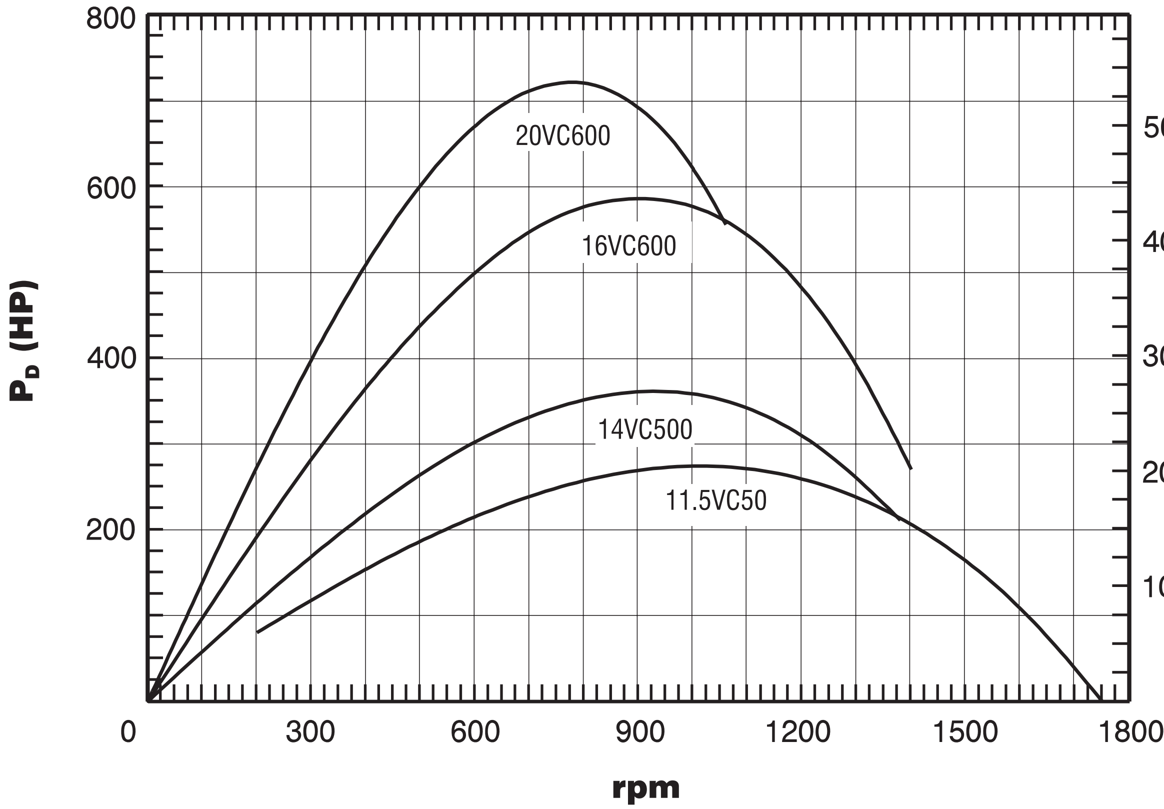
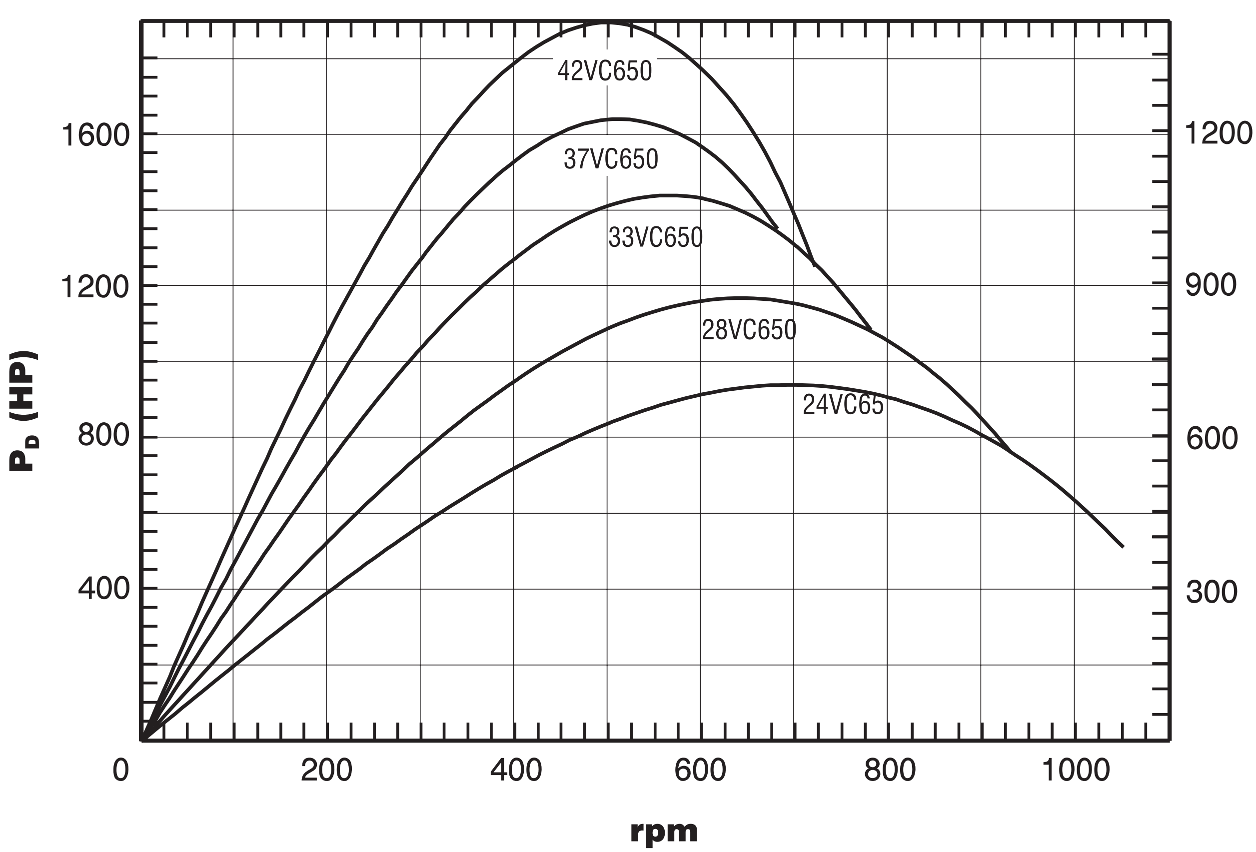
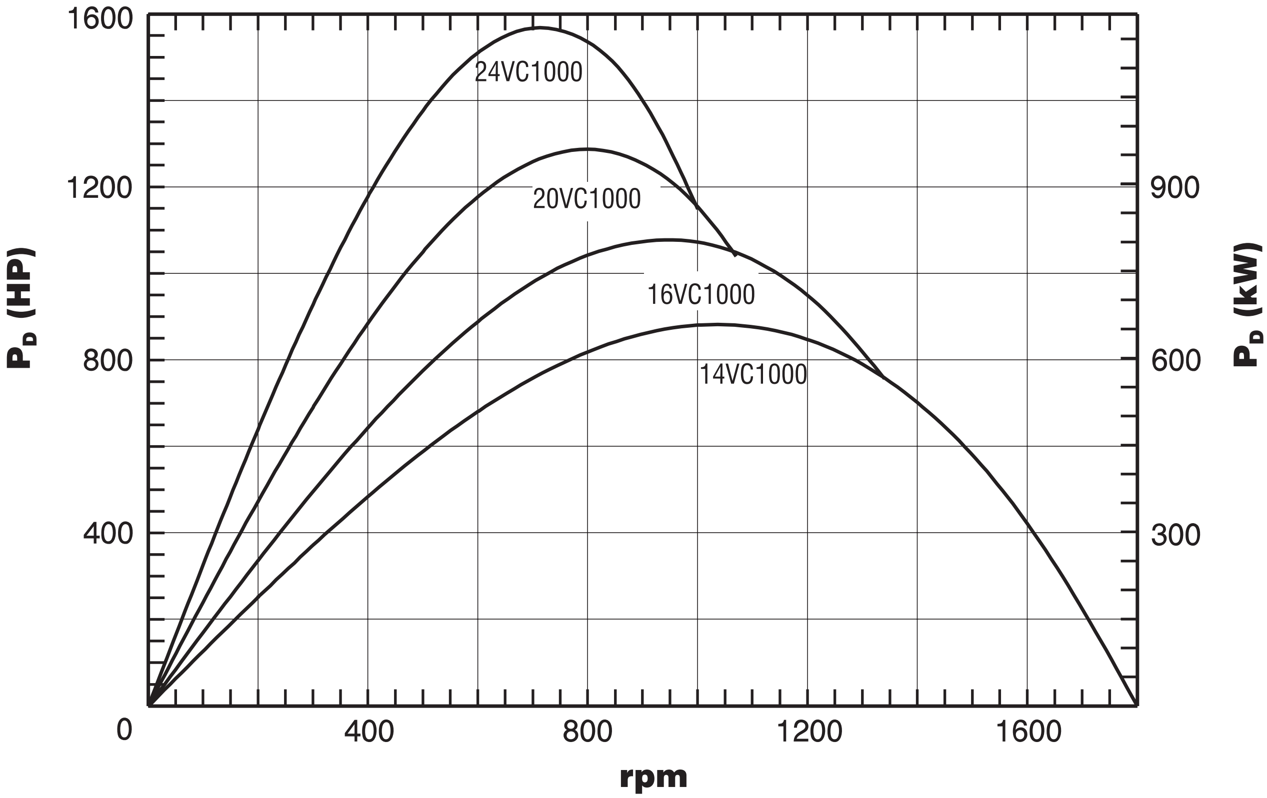
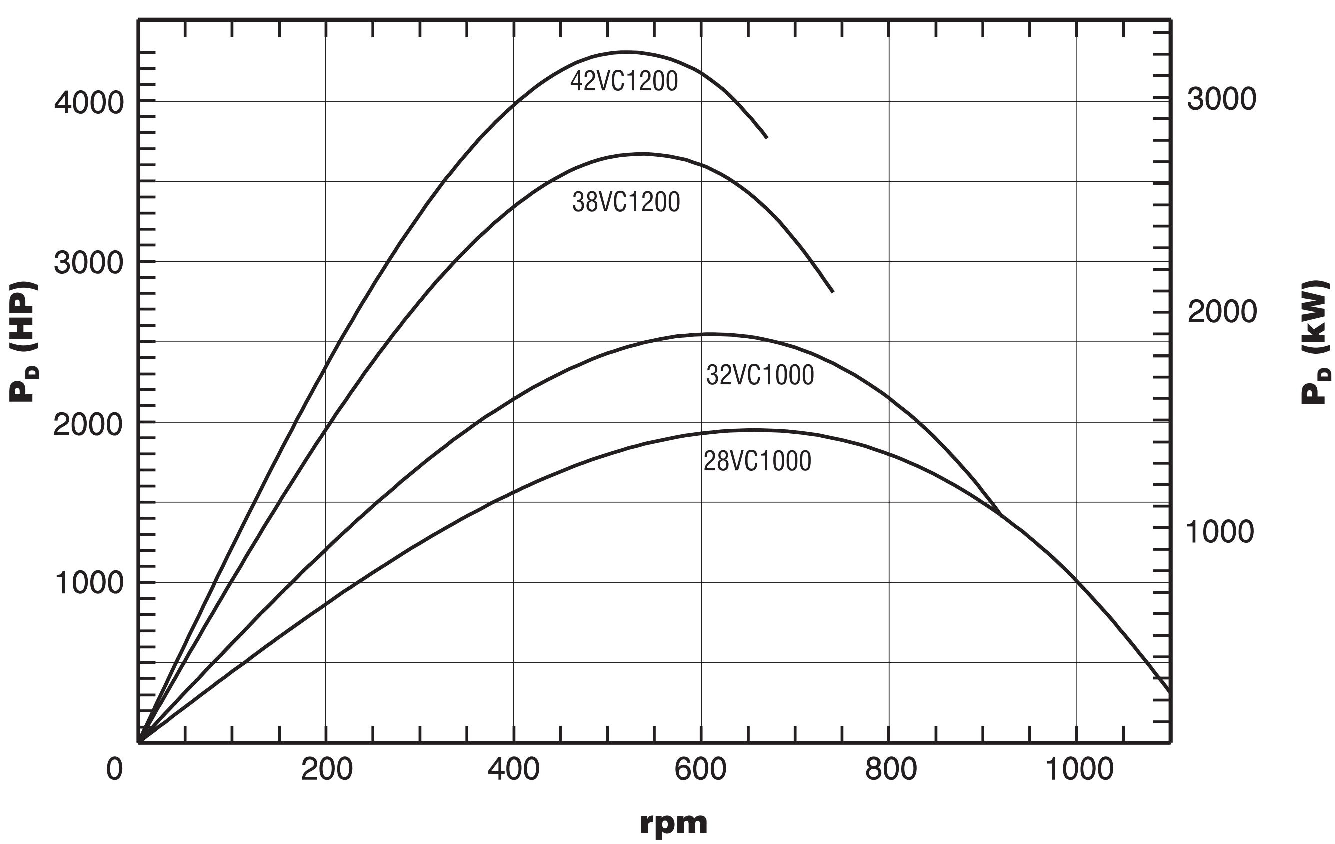




Power Capacities





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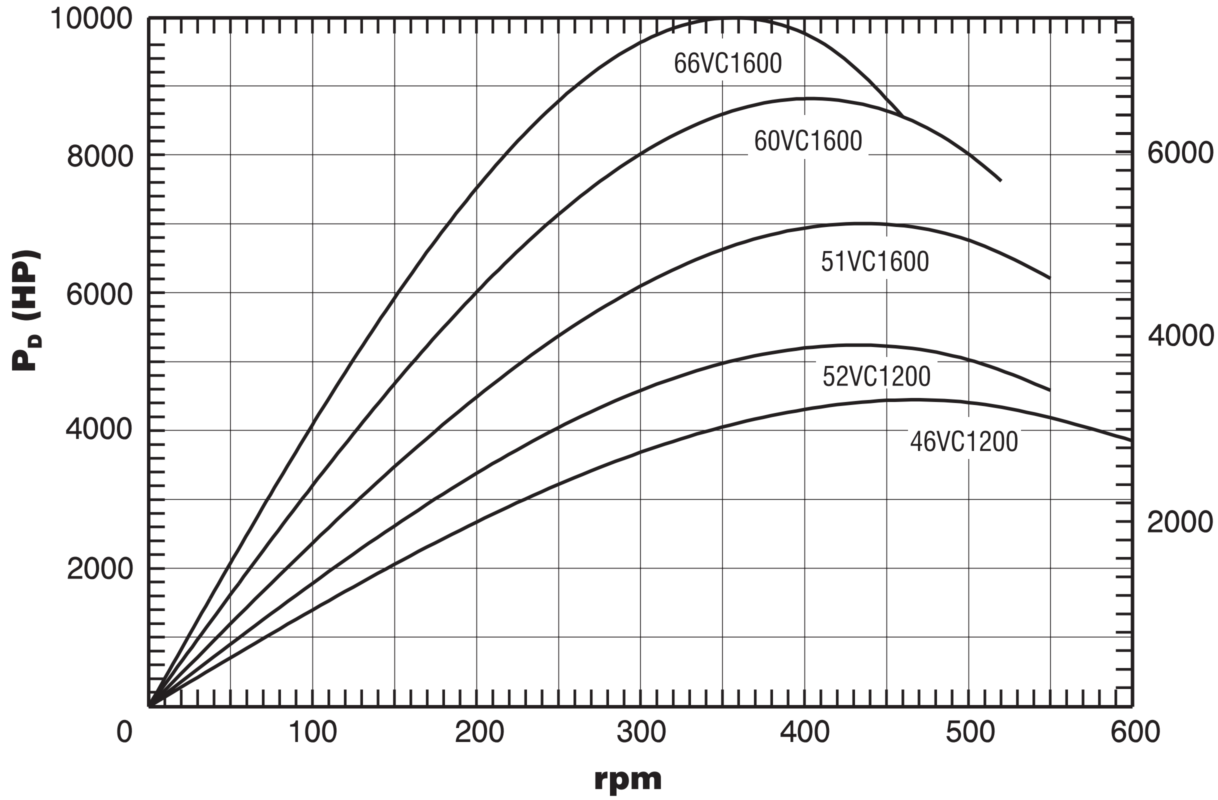

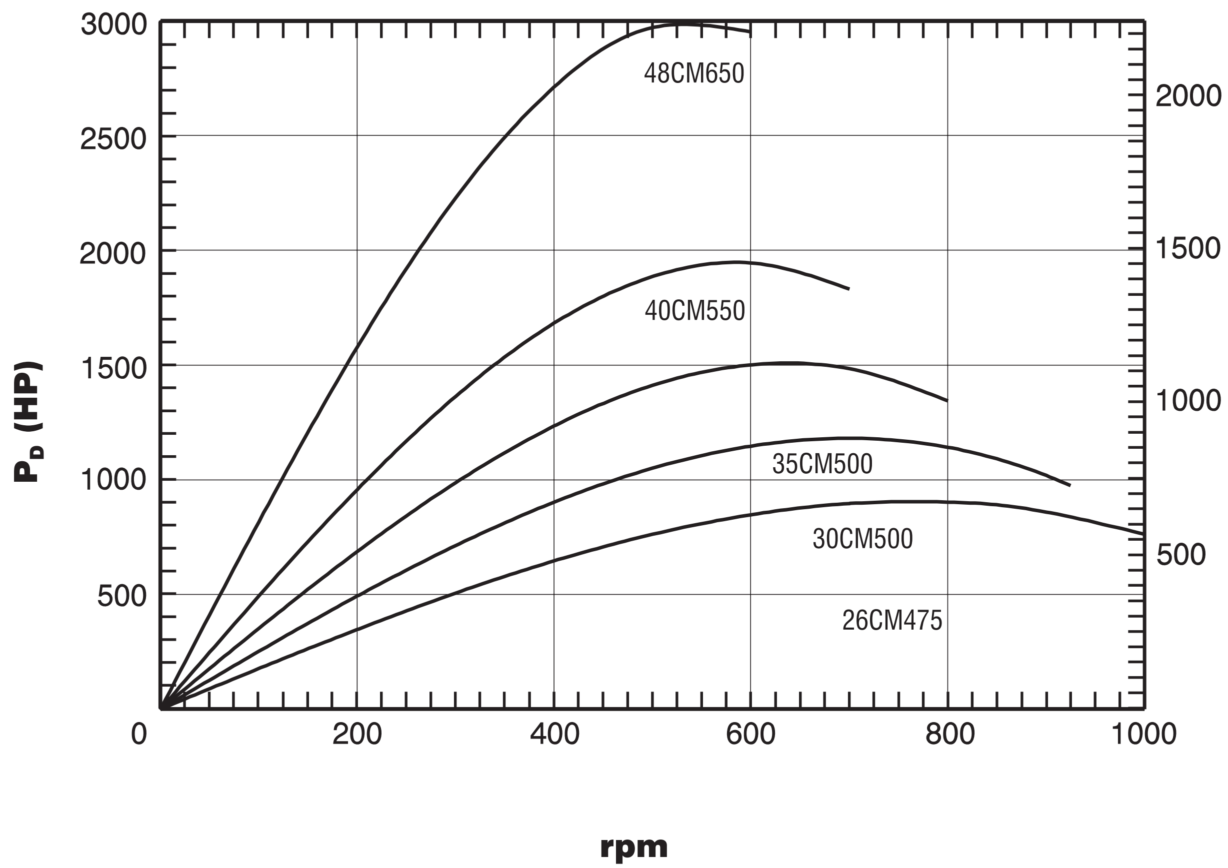

Example 1

Determine the dynamic torque of a 16CB500 element rotating at 1000 rpm with an applied pressure of 100 psi (6,9 bar).

$$Me = \frac{p_o - p_p - p_c}{75} \cdot M_r$$

$$p_p = 2 \text{ psi}$$

$$p_c = C_s \cdot n^2$$

$$= 20 \cdot E\text{-}06 \cdot 1000^2 = 20 \text{ psi}$$

$$Me = \frac{100 - 2 - 20}{75} \cdot 35200$$

$$= 36600 \text{ lb·in}$$

Example 2

What minimum pressure should be applied to a 12CB350 element rotating at 1200 rpm in order to transmit a dynamic torque of 10000 lb·in
(1130 N•m)?

$$Me = \frac{p_o - p_p - p_c}{75} \cdot M_r$$

$$p_o = 75 \cdot \frac{M_e}{M_r} + p_p + p_c$$

$$p_p = 2 \text{ psi}$$

$$p_c = C_s \cdot n^2$$

$$= 12 \cdot E\text{-}06 \cdot 1200^2 = 17 \text{ psi}$$

$$p_o = 75 \cdot \frac{10000}{13300} + 2 + 17$$

$$= 75 \text{ psi}$$

Example 3

What is the holding torque of a dual 20CB500 stationary element when pressurized to 50 psi (3,4 bar)?

The holding torque is equal to the element's static torque.

$$Me = \frac{p_o - p_p - p_c}{5{,}2} \cdot M_r \cdot 1{,}25$$

$$= \frac{3{,}4 - 0{,}14 - 0}{5{,}2} \cdot 12120 \cdot 1{,}25$$

$$= 9500 \text{ N·m}$$

Example 4

A 20VC600 element is tentatively selected to accelerate a load up to operating speed in 5 seconds. The thermal energy which must be absorbed is 1.7 E+06 ft·lb (2,3 E+06 J). Will the 20VC600 element handle the thermal load?

$$\frac{W_t}{A} = \frac{1.7E+06}{380} = 4500 \frac{ft \cdot lb}{in^2}$$

$$P_t = \frac{W_t}{550 \cdot t} = \frac{1.7E+06}{550 \cdot 5} = 618 \text{ HP}$$

$$P_{ave} = \frac{P_t}{A} = \frac{618}{380}$$

$$= 1.63 \frac{HP}{in^2}$$

The point (W_t/A, P_{ave}) falls outside of the VC line on the non-cyclic energy capacity chart. Therefore, the 20VC600 element is not capable of handling the thermal load. Either a larger diameter single element or a smaller diameter dual element having greater friction lining area is required.

The 24VC1000 element

$$\left[\frac{W_t}{A} = 2360 \frac{ft \cdot lb}{in^2}, P_{ave} = 0.86 \frac{HP}{in^2}\right]$$

or dual 20VC600

$$\left[\frac{W_t}{A} = 2240 \frac{ft \cdot lb}{in^2}, P_{ave} = 0.81 \frac{HP}{in^2}\right]$$

will handle the thermal requirement.

Example 5

For a given application the cyclic thermal power P_c is 3 HP (2,2 KW). What size clutch operating at 500 rpm will handle this requirement?

$$P_c = P_g \cdot K_t \,;\; P_g = \frac{P_c}{K_t}$$

P_g is determined by dividing the cyclic thermal power by the arrangement factor. Using the P_g value and the cyclic thermal graphs the following clutch sizes and arrangement could be used:

In a clutch spider arrangement -

20VC600 or 20VC1000 single element
20CB500, 16VC600 or 16VC1000 dual element

In a ventilated adapter arrangement -

16VC600 single element
11.5VC500 dual element