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.

Operating Speed

Design of expanding type elements allows them to behave as centrifugal clutches. To counteract the centrifugal effect and to permit them to idle or freewheel when disengaged, E and VE elements are furnished with release springs. Available springs and the resulting maximum element idle speeds are given in the following table.

E and VE Element Idle rpm

Size	Spring Force (lb)		
	30 lb	80 lb	150 lb
12E475	450	720	1010
14E475	400	640	900
16E475	390	620	870
19E475	300	480	690
21.5E475	280	450	640
24E475	300	480	680
27E475	280	450	640
30E600	N/A	350	N/A
34E600	N/A	340	N/A
40E700	N/A	230*	N/A
19VE475	390	620	N/A
24VE475	280	450	N/A
27VE475	300	480	N/A

*100 lb. spring

EB and ER elements rely upon the resiliency of their rubber actuating tube to counteract the centrifugal effect. Their idle speeds are given in the following table.

Size	Idle RPM
3ER125	1200
4EB125	1100
6EB&ER200	800
8EB&ER250	650
9EB325	600
10EB&ER300	520
12EB&ER350	420
14EB&ER400	340
16EB&ER475	270
19EB&ER475	200
21.5EB&ER475	120
24EB&ER475	100

ER elements utilize rubber friction couples. They are intended for use as holding brakes or shaft couplings and are only to be engaged at zero speed differential between element and drum.

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
E & VE	125	8,6
EB & ER	110	7,6

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 E and VE elements, the pressure to overcome friction shoe release springs. Parasitic pressures are given in the following tables and must be deducted from the operating pressure.

E and VE Parasitic Pressure p_p vs Spring Force

Spring Force (lb)	English	SI
	psi	bar
30	2	0,14
80	5	0,34
100	5	0,34
150	10	0,68

Parasitic Pressure p_p

Size	English	SI
	psi	bar
3ER125	20	1,38
4EB125	20	1,38
6 and 8 EB & ER	7	0,48
10 and 12 EB & ER	6	0,41

The listed torque ratings are for E and VE elements with slip linings. Torque ratings for elements with standard linings are 50% higher. Contact the factory for the possible requirement of reinforced housings if non-slip linings are used.

A rotating element must have its torque rating adjusted to include the additional torque resulting from centrifugal effects. The method used is to calculate a centrifugal pressure $\mathbf{p_c}$ and add its value to the applied pressure.

$p_c = C_s \cdot n^2$

where p_c = centrifugal 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:

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

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 $\mathbf{M_b}$.

Example 1 at the end of this section illustrates the use of the above formulas.

Continuous Thermal Capacity

Expanding elements, when used in combination with air agitating vaned drums, are ideally suited for continuous thermal dissipation. The air agitating vaned drum should be located on the driving side in a clutch application and on the shaft to be stopped in a brake application. Thermal ratings $\mathbf{P_t}$ vary with operating speed and are shown on the Thermal Power Graphs. Refer to Section X, Tensioning to determine the thermal requirements for an application. For good lining life, limit operating pressure to 20 psi (1,4 bar) and the friction couple slipping velocity to 1600 fpm (8 mps).

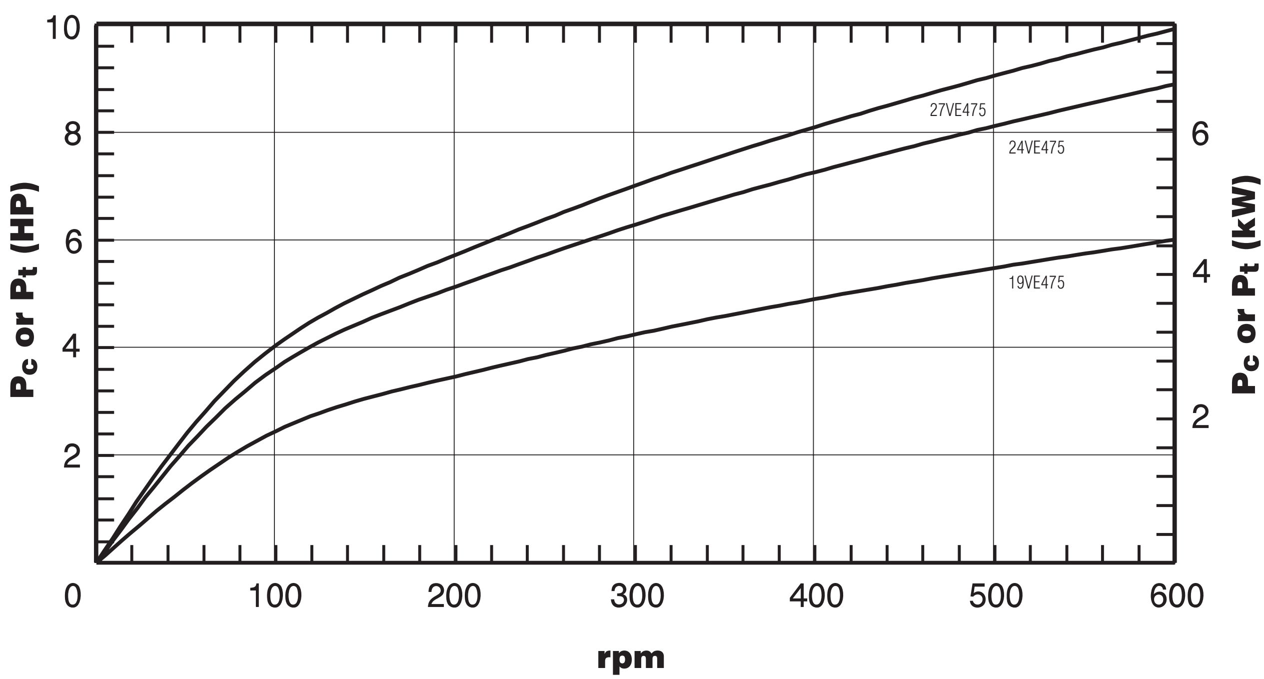
For the water-cooled brake application shown on Form E 610 use a friction lining thermal loading of 0.15 HP/in^2 (0,017 kW/cm^2). Dividing the application thermal requirement by the allowable thermal loading determines the friction area requirement of the brake element. Limit operating pressure to 30 psi (2 bar) and friction couple slipping velocity to 2000 fpm (10,1 mps).

Slip (Lo-Co) friction material must be specified for elements intended for continuous slip service.

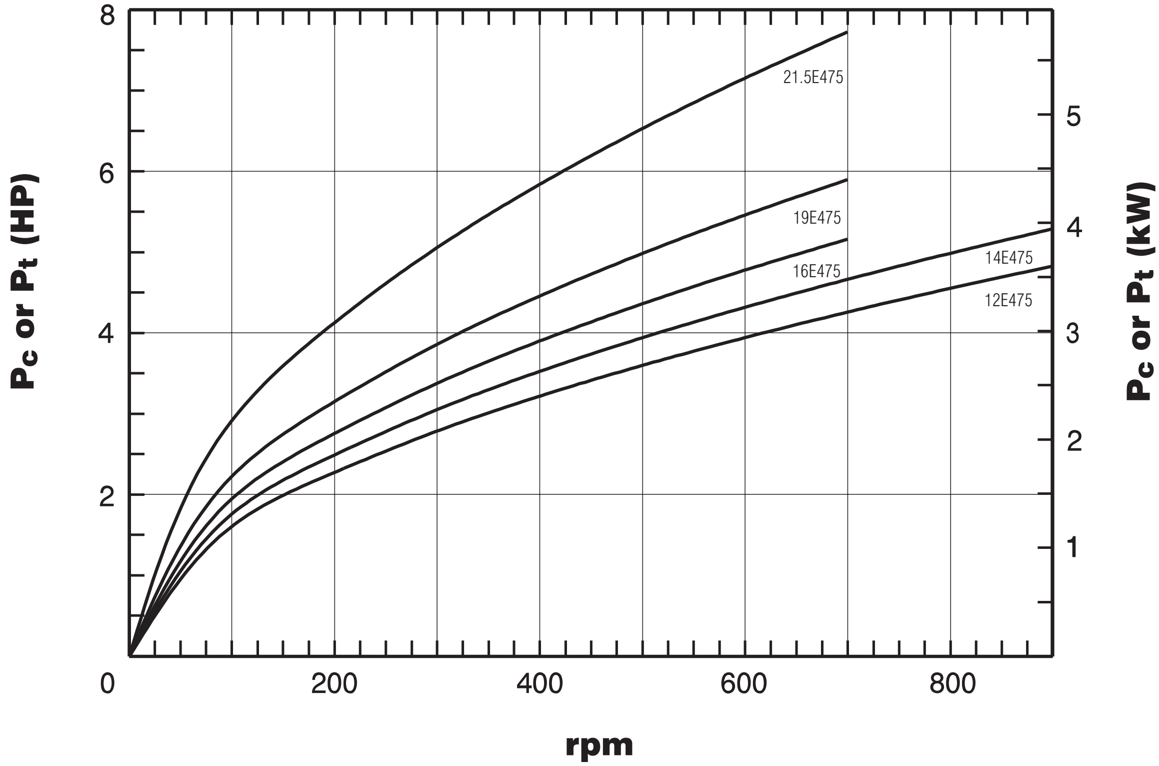
Examples 2 and 3 at the end of this section illustrates the above procedure and use of the graphs.

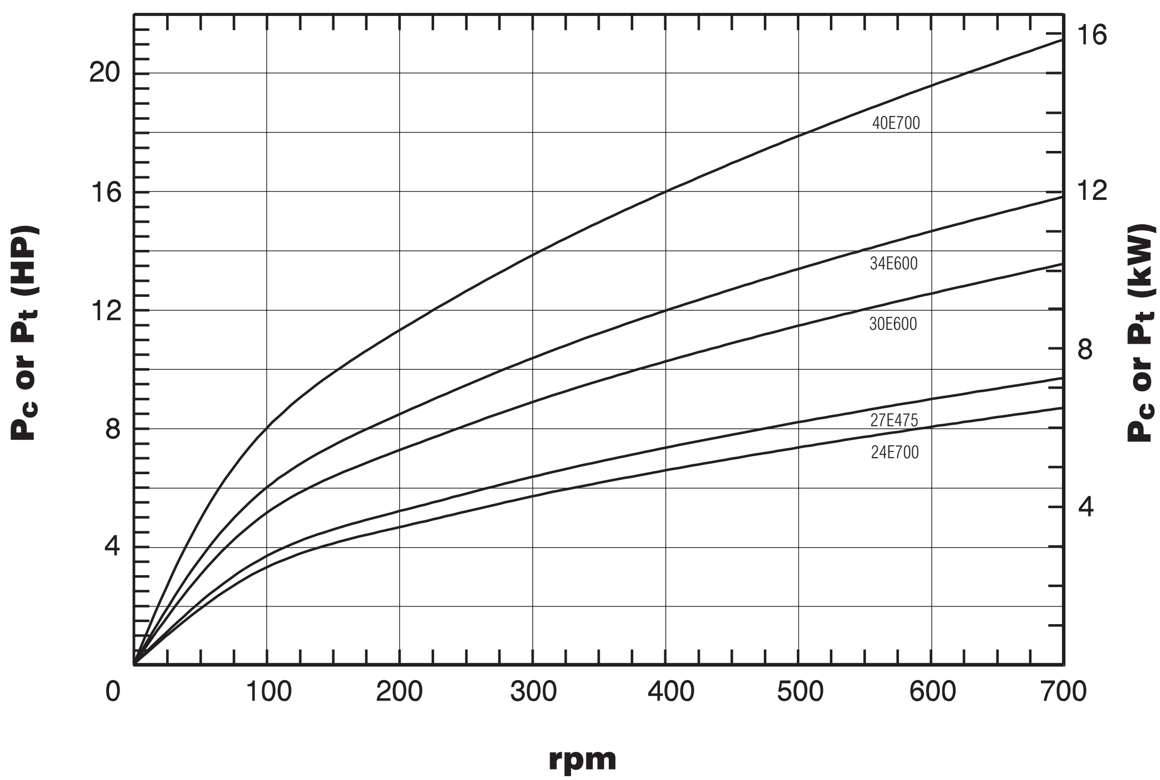
Cyclic Thermal Capacity

Because the expanding elements have only one tube inlet, the rate at which they can be cycled is limited. Allowable rates should be no greater than 10 times per minute. Use the Thermal Power graphs for determining cyclic capacity $\mathbf{P_c}$.

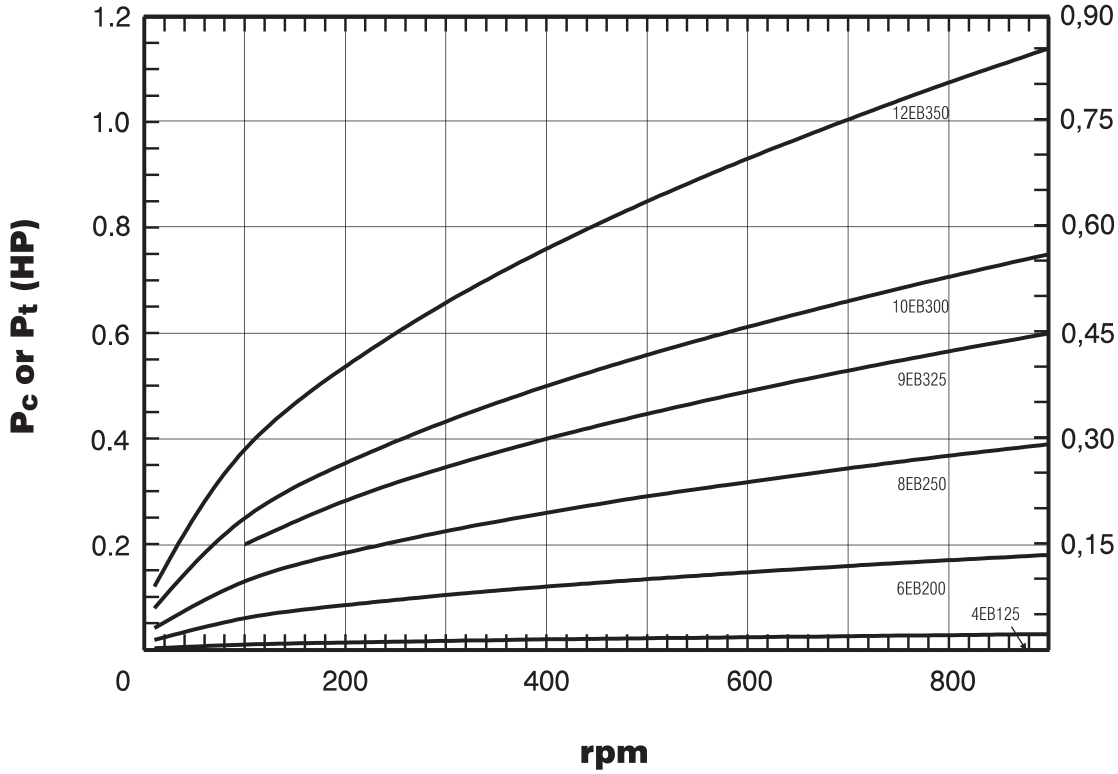


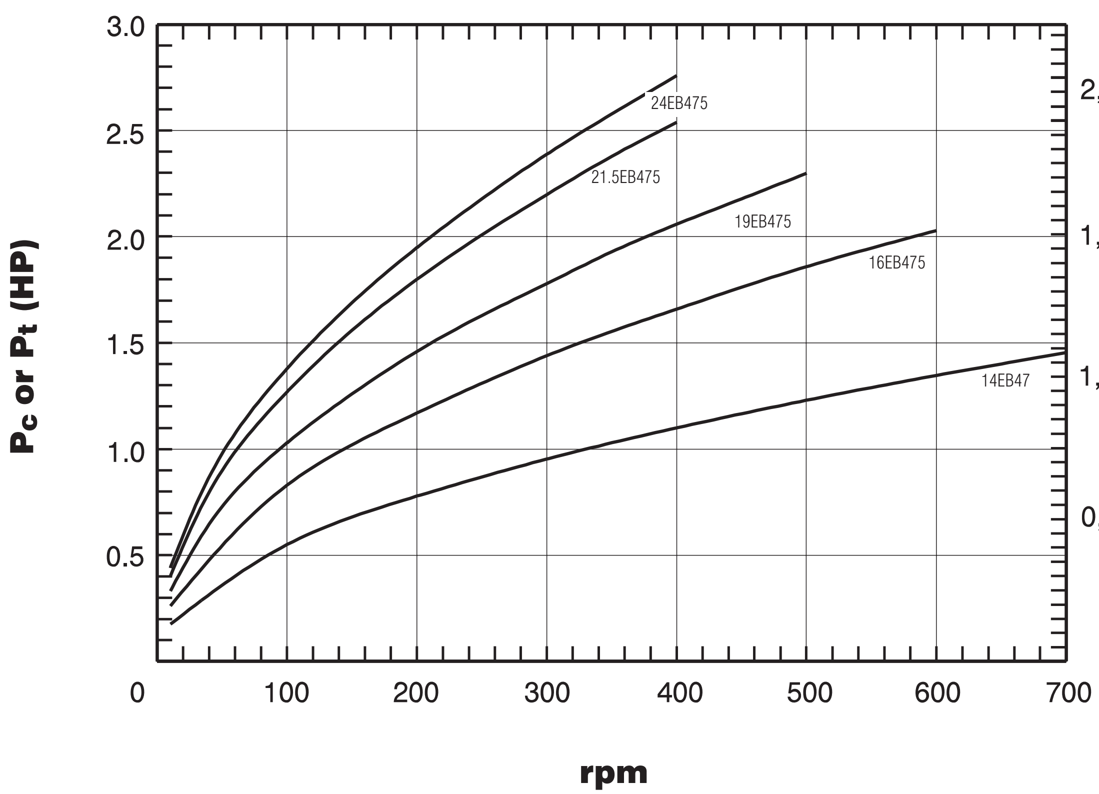
Thermal Capacitites





Thermal Capacitites





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 Thermal Capacity Graph. An explanation on the use of this graph follows.

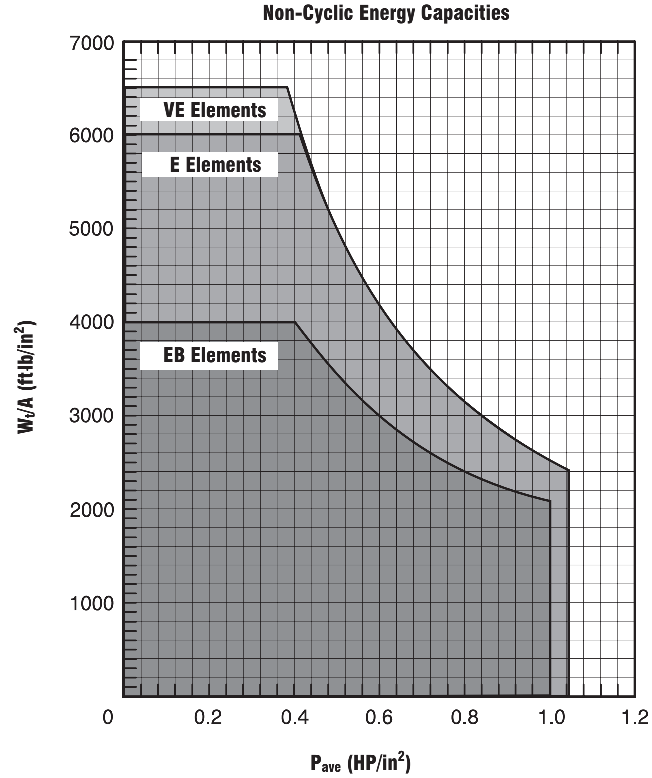
The thermal energy calculated for the load is adjusted to include the energy associated with accelerating or decelerating the components of the tentative clutch and/or brake selection. The adjusted thermal energy $\mathbf{W_t}$ is divided by the element's friction area **A**. Next, the average power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

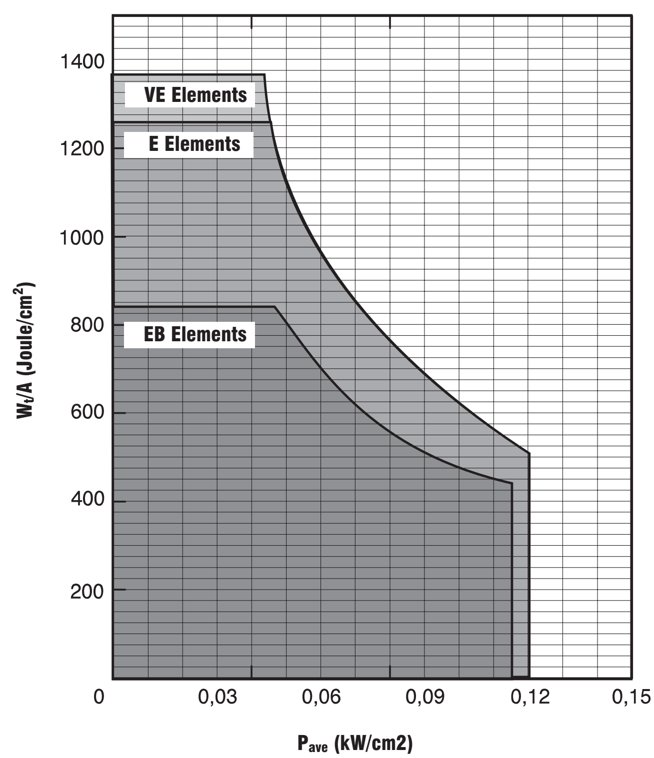
$$P_{ave} = \frac{P_t}{A}$$

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 Energy Capacities





Drum Velocity and Selection Methods

Drum Peripheral Velocity

Drum peripheral velocity should not exceed 8500 fpm (43 mps). In some applications, the drum may be required to freewheel at speeds faster than their engaged running speeds. This must be taken into consideration when calculating their velocities. Velocities are calculated by:

$$v\ (fpm) = 0.262 \cdot n \cdot D$$

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

D: outside drum diameter (in or mm)

Selection Methods

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. Determine the release spring force required to obtain shoe disengagement if an E or VE element was selected. A smaller diameter dual element may be required.

6. Adjust the torque rating of the tentative selection to reflect the operating pressure and speed and determine if it still meets the requirement.

7. 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.

8. Check drum peripheral velocity.

Refer to catalog Sections X and Y to determine the requirements for Step 1 and 2. Step 3 requires some measurement 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, 7 and 8, a larger element or a smaller dual element should be considered. Steps 4 thru 8 should then be repeated for the new selection. If the new selection still does not meet the requirements of steps 6 and 7, a different product line should be considered. If the selection does not meet the requirements of Step 8, 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 power capacity graphs to select an element which has the power capacity at the element's operating speed. These graphs are for single clutch elements. Dual clutch elements have twice the capacity shown.

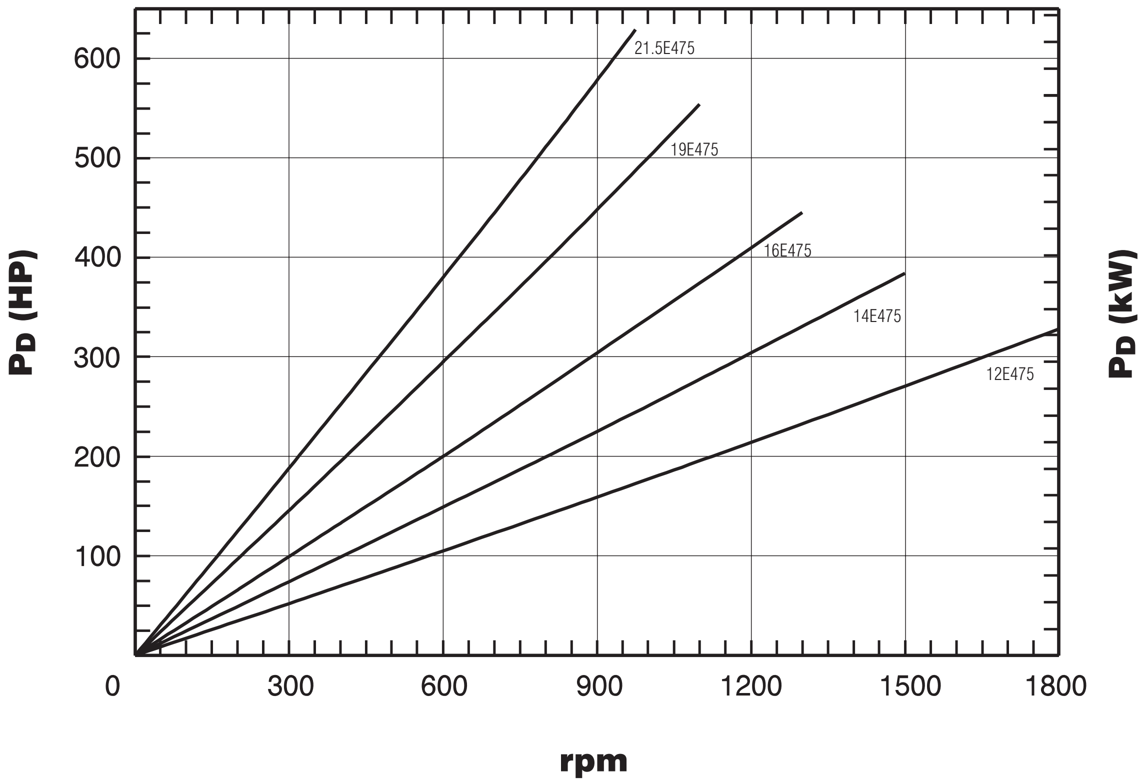
Graphs for the E and VE are for elements having 30 lb. release springs.

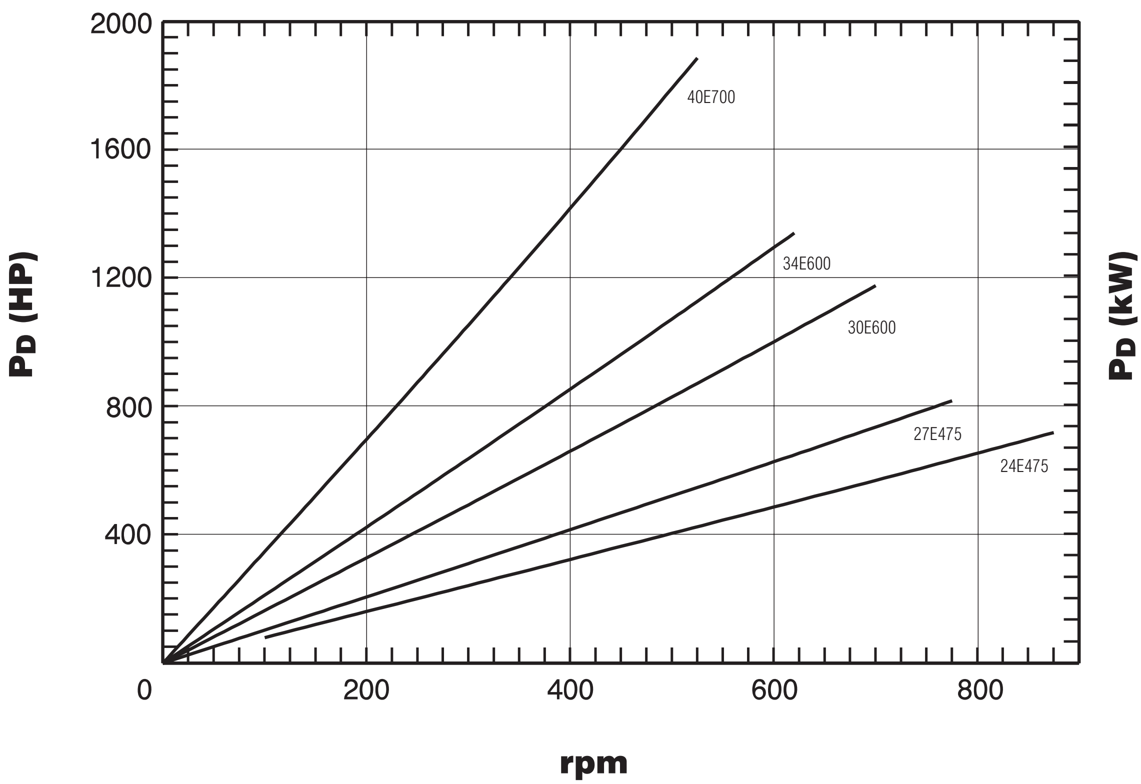
Example 5 at the end of this section illustrates the use of these graphs.

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.

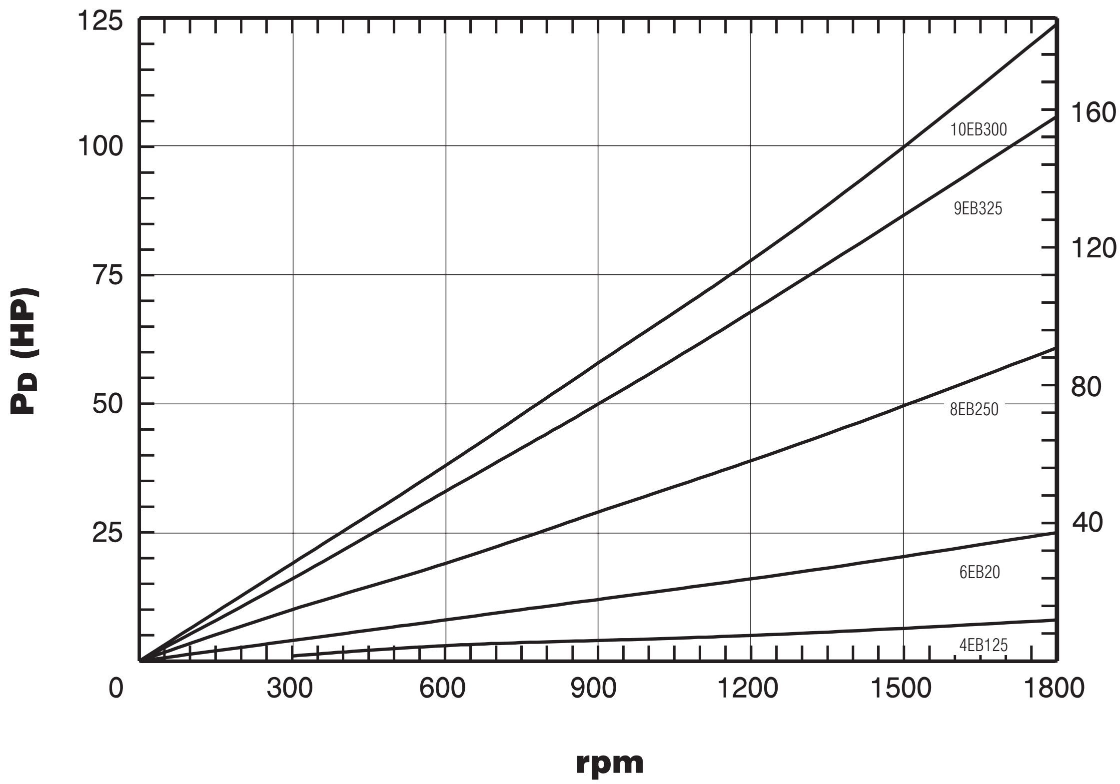
The required clutch torque $\mathbf{M_c}$ or the required brake torque $\mathbf{M_b}$ is used to make a tentative element selection. The element torque rating $\mathbf{M_r}$ is adjusted for operating speed and pressure as explained earlier. The adjusted element torque $\mathbf{M_e}$ must be equal to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

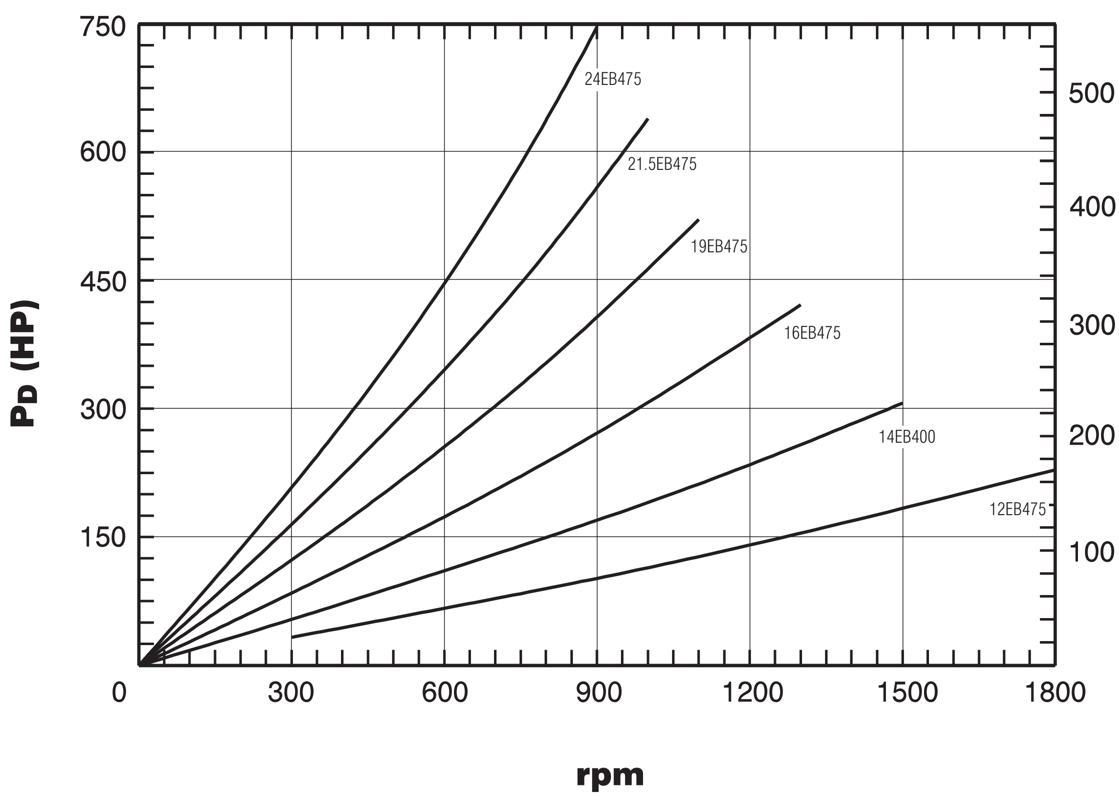
Power Capacities



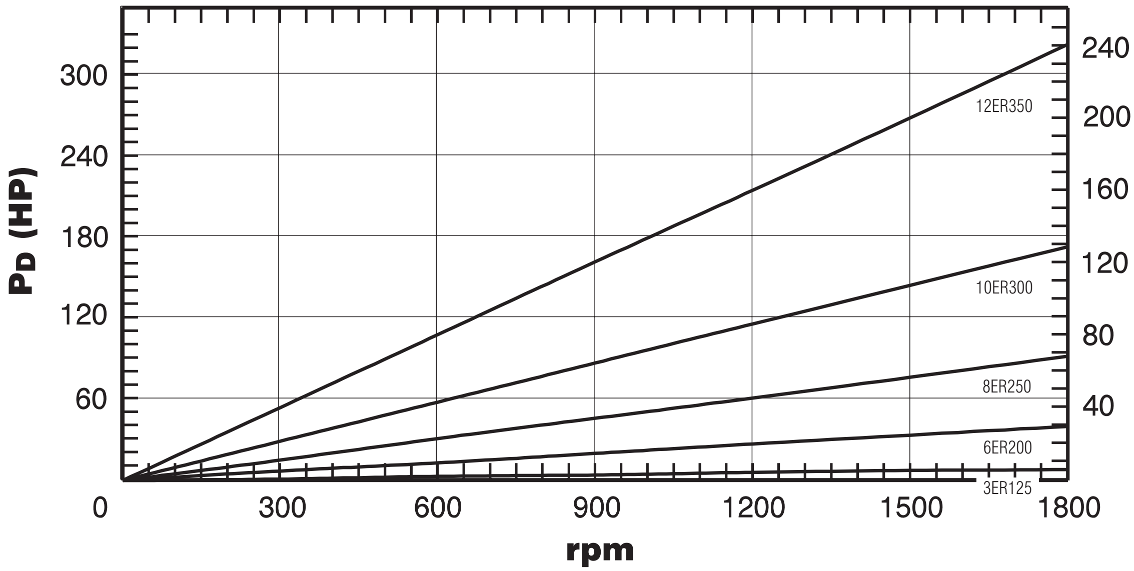


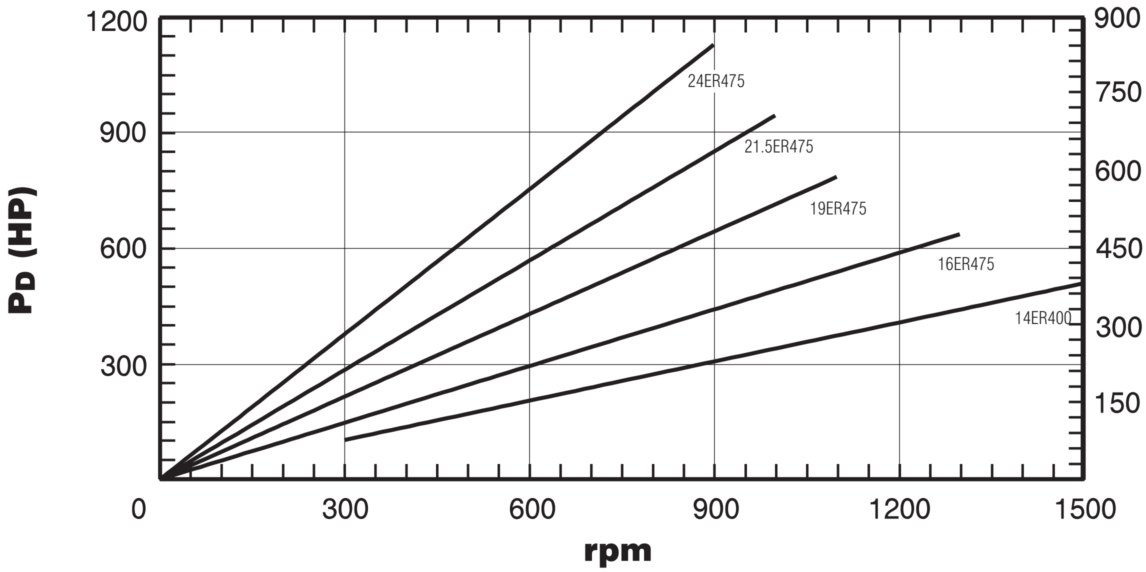
Power Capacities

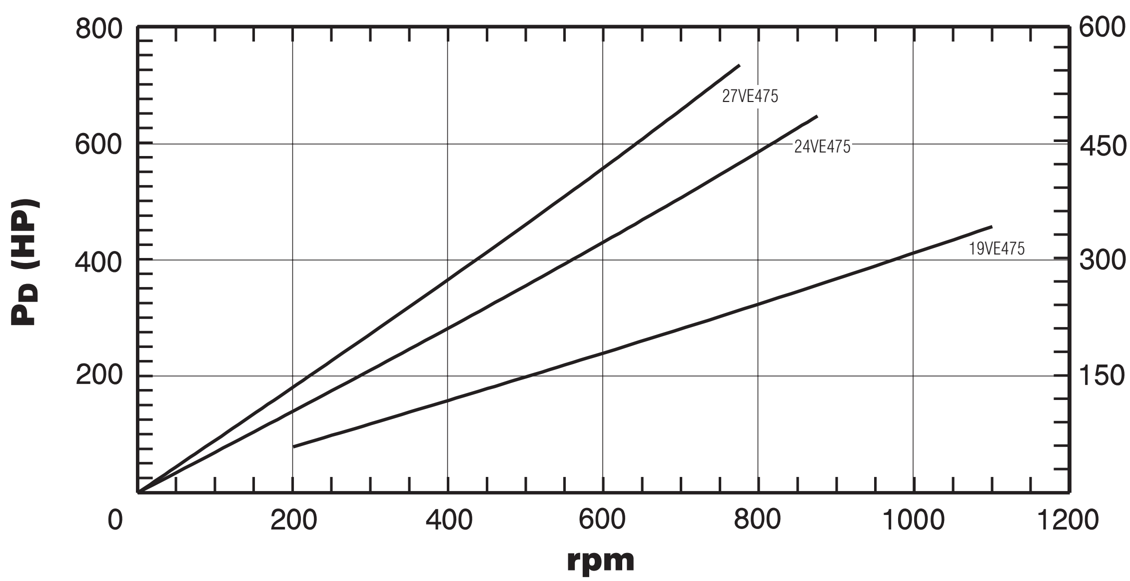




Power Capacities







Examples

Example 1

Determine the dynamic torque of a 16E475 element having 80 lb springs and rotating at 1000 rpm with an applied pressure of 100 psi (6,9 bar).

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

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

$$= 1.3 \cdot E\text{-}06 \cdot 1000^2$$

$$= 1.3 \text{ psi}$$

$$M_e = \frac{100 - 5 + 1.3}{75} \cdot 21500$$

$$= 27600 \text{ lb} \cdot \text{in}$$

Example 2

What size E element is capable of dissipating 6 HP continuously at 500 rpm?

From the Continuous Thermal Power graphs select size 21.5E475.

Example 3

A tension brake application requires continuous dissipation of 30 HP at 200 rpm. What size E element can be used?

The thermal requirement exceeds the capacity of either a single or dual element; therefore, a water-cooled application is required.

Area required = 30/0.15 = 200 in^2

Selected either a single 19E475 or a dual 12E475 element for use in the Form E610 arrangement.

Example 4

A 14E475 element is tentatively selected to accelerate a load up to operating speed in 8 seconds. The thermal energy which must be absorbed is 600,000 ft\cdot \lb. Is the 14E475 element capable of handling the thermal load?

$$\frac{W_t}{A} = \frac{600000}{139} = 4320 \, \frac{ft \bullet lb}{in^2}$$

$$P_t = \frac{W_t}{550 \bullet t} = \frac{600000}{550 \bullet 8} = 136 \text{ HP}$$

$$P_{ave} = \frac{P_t}{A} = \frac{136}{139} = 0.978 \, \frac{HP}{in^2}$$

The point (W_t/A, P_{avc}) falls outside the acceptable area of the Non-Cyclic Energy Chart; therefore, the 14E475 element is not capable of handling the thermal load. Either a dual 12E475 or a single 21.5E475 element should be used.

Example 5

A shaft coupling is required to transmit 50 HP at 900 rpm. The type of service indicates that a 2 service factor is required.

$$P_D = P_p \cdot SF$$

$$P_D = 50 \cdot 2 = 100 \text{ HP}$$

From Power Capacity graphs select the 12ER350 element.