### 8.3.2 V-Belts

**This guide follows Mott[14].*

1. **To start designing a V-Belt drive, you must know:**

   - $H_{nom}$ [hp], Nominal Transmitted Power
   - n [rpm], Input Rotational Speed
   - Velocity Ratio (or some way to find it, like output speed). Recall:

   $$VR = \frac{V_{driving}}{V_{driven}} = \frac{D}{d} = \frac{n_{driving}}{n_{driven}}$$

   *d is driving sheave's diameter, while D is driven sheave's diameter*

2. **From there, you must choose your belt type. To do so, first find your relative service factor ($K_s$ or SF) from the figure below**

**TABLE 7–1 V-Belt Service Factors[1]**

| Driven machine type | Driver type: AC motors: Normal torque[2] DC motors: Shunt-wound Engines: Multiple-cylinder | | | Driver type: AC motors: High torque[3] DC motors: Series-wound, or compound-wound Engines: 4-cylinder or less | | |
|---|---|---|---|---|---|---|
| | <6 h per day | 6–15 h per day | >15 h per day | <6 h per day | 6–15 h per day | >15 h per day |
| ***Smooth loading*** | 1.0 | 1.1 | 1.2 | 1.1 | 1.2 | 1.3 |
| Agitators, light conveyors, centrifugal pumps fans and blowers under 10 hp (7.5 kW) | | | | | | |
| ***Light shock loading*** | 1.1 | 1.2 | 1.3 | 1.2 | 1.3 | 1.4 |
| Generators, machine tools mixers, fans and blowers over 10 hp (7.5 kW) gravel conveyors | | | | | | |
| ***Moderate shock loading*** | 1.2 | 1.3 | 1.4 | 1.4 | 1.5 | 1.6 |
| Bucket elevators, piston pumps textile machinery, hammer mills heavy conveyors, pulverizers | | | | | | |
| ***Heavy shock loading*** | 1.3 | 1.4 | 1.5 | 1.5 | 1.6 | 1.8 |
| Crushers, ball mills, hoists rubber mills, and extruders | | | | | | |
| ***Machinery that can choke*** | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |

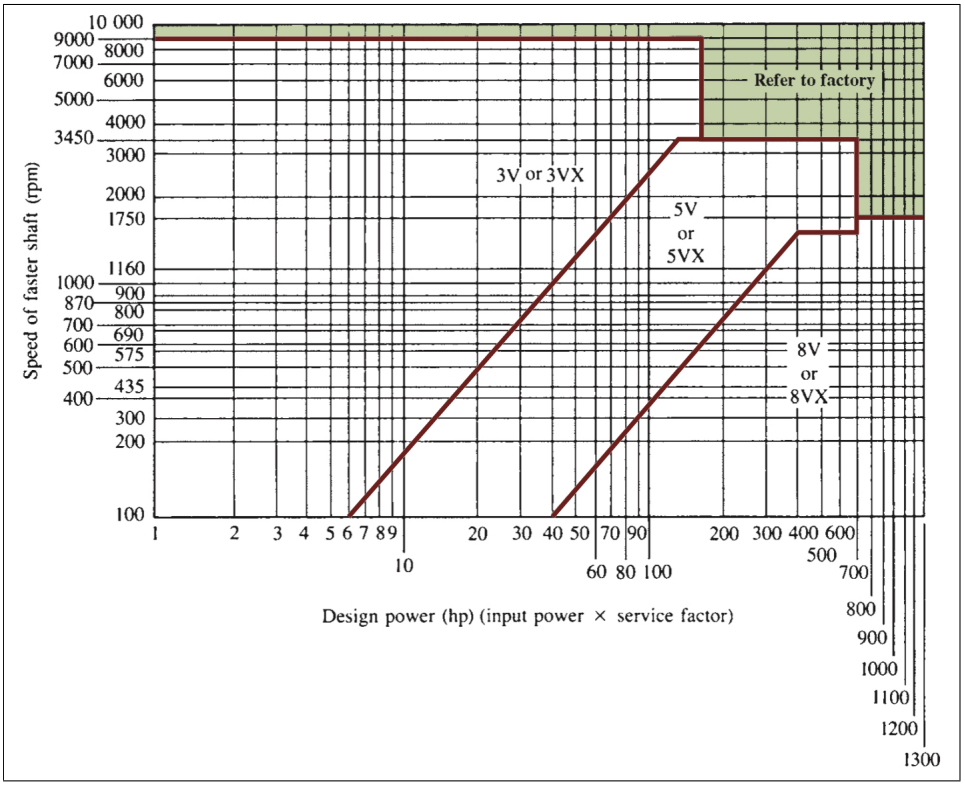
[1]Factors given are for speed reducers. For speed increases, multiply listed factors by 1.2.
[2]Synchronous, split-phase, three-phase with starting torque or breakdown torque less than 175% of full-load torque.
[3]Single-phase, three-phase with starting torque or breakdown torque greater than 175% of full-load torque.

Then, find the design power:

$$H_d = H_{nom} K_s$$

[14]Shigley also provides a good V-belt guide, but you're better off to use Mott in exam. If the question asks for Tension per Strand ($T_{st}$), $F_{min}$ , or deflection, have a look in Shigley.

Finally, choose the belt based on which region your specs lie in the graph below:




3. **After figuring out your belt, you will have to find the Driven and Driver sheave diameters**. To do so, assume a belt speed of $V = 4000\ ft/min$[15], and solve for d:

$$d = \frac{12V}{\pi n}$$

Then choose a standard Sheave Diameter from the figures below (7-15, 7-16, 7-17) which is close to your d value (based on belt type), and use the VR to solve for D:

$$D = VR \times d$$

Once again, choose the closest standard sheave diameter from the figures below (7-15, 7-16, 7-17), based on your belt type. Finally, solve for your

[15]PLEASE NOTE: the velocity value is a place holder. I'm not exactly sure why 4000 ft/min is used, maybe ask Jon if you're curious!

new velocity ratio, and as a result, your final output rotational speed and belt speed. Make sure your final velocity is within 5% of 4000 ft/min.[16]

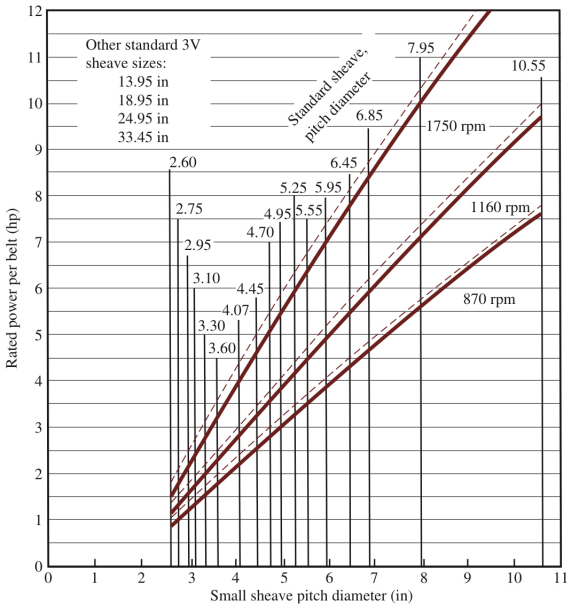



**FIGURE 7–14** Power rating: 3V belts

[16]In this step where you're finalizing your sheave diameters, you might have to perform a few "trials" where you choose different d values and calculate D. In some cases it will be easy, in some it might take a while. Be patient.

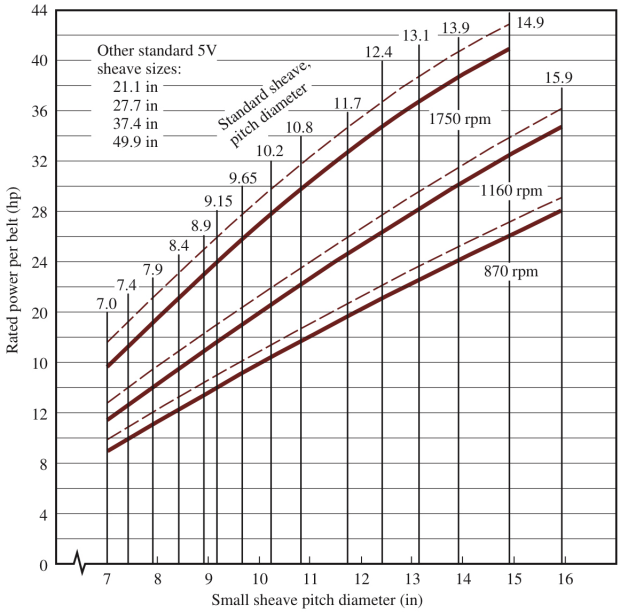



**FIGURE 7–15** Power rating: 5V belts

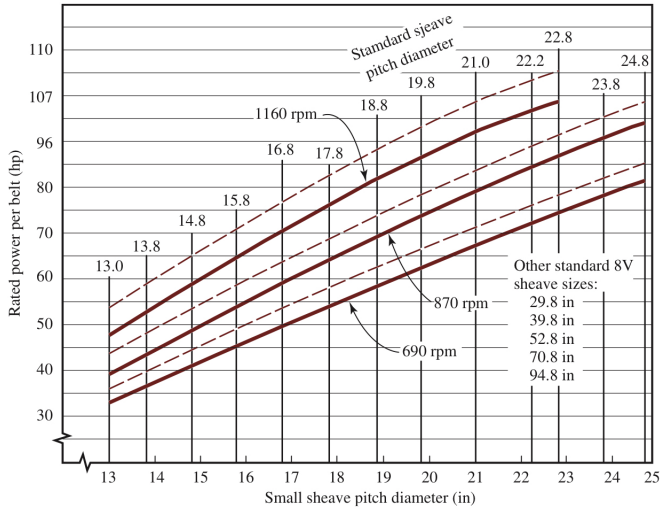



**FIGURE 7–16** Power rating: 8V belts

4. **Once you've finalised your diameters, you can use the same figures above to get the rated power of your belt** (use your d value). Looking at the figures, the red curves represents the power rating at a VR

of 1 and the dashed curves are for a VR of 3.38[17]. The dashed line shows the "added power" amount that gives you your true power rating. For 5V belts, the figure below shows the amount you have to add. However, for 3V and 8V belts, you'll need to interpolate for the "true" rating using the figures. Since this is probably a bit hard to understand, I will give a simple rundown:

- **If you choose a 3V or 8V belt**, read off the solid and dashed curve power values ($P_1$ and $P_2$), then use the following equation to find your rated Power:

$$H_r = P_2 + \frac{VR - 3.38}{3.38 - 1}(P_2 - P_1)$$

- **If you choose a 5V belt**, read off the value of the solid line ($H_s$), then use the figure below to get the "added power" ($H_{added}$) based on your VR. Then:

$$H_r = H_s + H_{added}$$

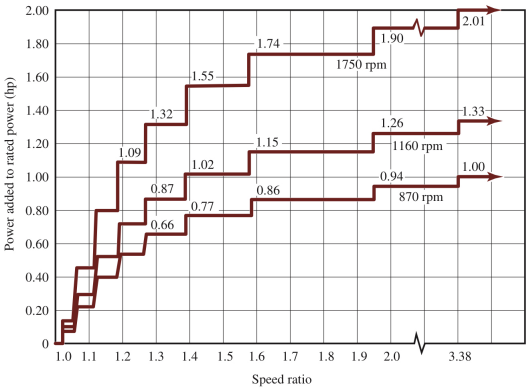



FIGURE 7–17 Power added versus speed ratio: 5V belts

5. **Now you need to finalize your belt length (L, in.) and Centre Distance (CD, in.)**. Begin by specifying a trial centre distance using the following range:

$$D < CD < 3(D + d)$$

Try being closer to D. After that, compute the belt length using the equation below, then find the closest standard length for your belt type from the figure below.

$$L_p = 2CD + 1.57(D + d) + \frac{(D - d)^2}{4CD}$$

[17]For a VR greater than 3.38, assume the dashed line doesn't increase further, and your rated power doesn't change much.

**TABLE 7–2 Standard Belt Lengths for 3V, 5V, and 8V Belts (in)**

| 3V only | 3V and 5V | 3V, 5V, and 8V | 5V and 8V | 8V only |
|---|---|---|---|---|
| 25 | 50 | 100 | 150 | 375 |
| 26.5 | 53 | 106 | 160 | 400 |
| 28 | 56 | 112 | 170 | 425 |
| 30 | 60 | 118 | 180 | 450 |
| 31.5 | 63 | 125 | 190 | 475 |
| 33.5 | 67 | 132 | 200 | 500 |
| 35.5 | 71 | 140 | 212 | |
| 37.5 | 75 | | 224 | |
| 40 | 80 | | 236 | |
| 42.5 | 85 | | 250 | |
| 45 | 90 | | 265 | |
| 47.5 | 95 | | 280 | |
| | | | 300 | |
| 165 | | | 315 | |
| | | | 335 | |
| | | | 355 | |

Once you have your standard length, re-solve for your CD (in.):

$$CD = \frac{B + \sqrt{B^2 - 32(D-d)^2}}{16}$$

where,

$$B = 4L_p - 6.28(D+d)$$

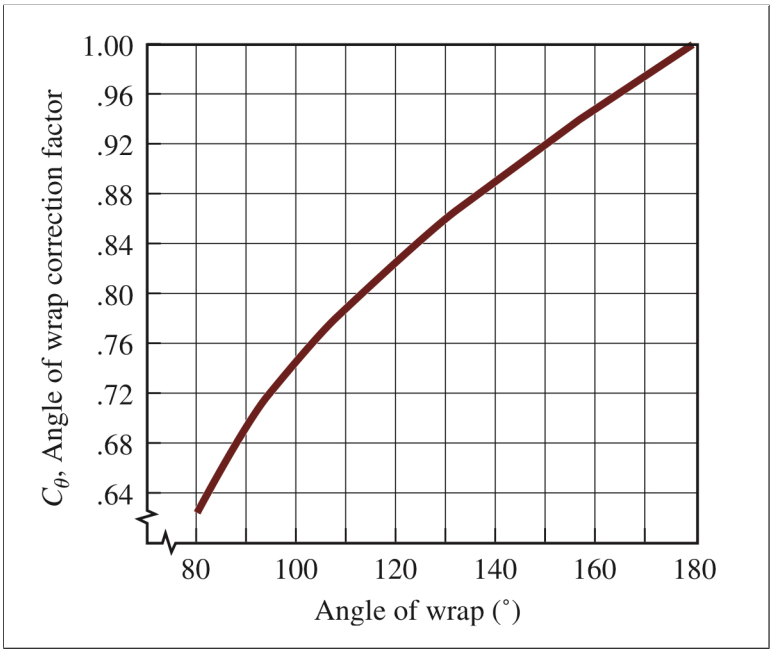
6. **Next, you need to find the corrected rated power** ($H_c$, hp). First compute the angle of wraps for both sheaves:

$$\theta_d = \pi - 2sin^{-1}(\frac{D-d}{2CD})$$

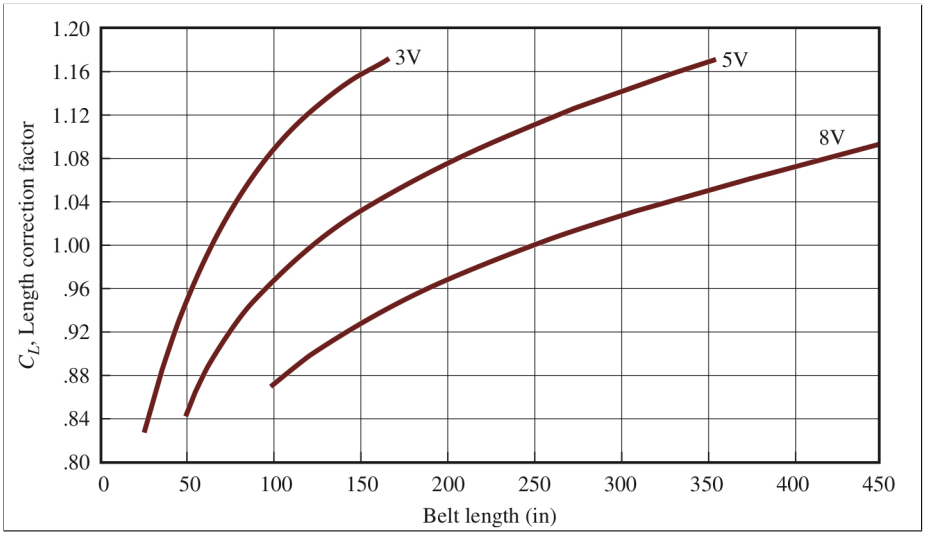
$$\theta_D = \pi + 2sin^{-1}(\frac{D-d}{2CD})$$

Then, find from the figures below:

- **Angle of wrap correction factor,** $C_\theta$




- **Belt Length Correction Factor,** $C_L$




Then, calculate the corrected power rating:

$$H_c = H_r C_\theta C_L$$

7. **Finally, calculate how many belts you need**, using:

$$Minimum\ No.\ of\ Belts = \frac{H_d}{H_c}$$

Always round up to the next whole number![18]

**You're done!**

**EXTRA:** For this section, there is no calculator since V-belts require quite a bit of table lookup. However, these might help

- for wrap angles, you can use the flat belt code
- for finalizing length and CD, use the designated code at the end of the Matlab live script.[19]
- For the rated power of a 3V or 5V belt, you can use the interpolator on excel.

[18] For example, if you get 2.01, you'll need 3 belts.

[19] I tried making this part automated so just give it d and D and it will do its thing. You can adjust the CD yourself if you need a desired value