BELT DRIVE SELECTION PROCEDURE

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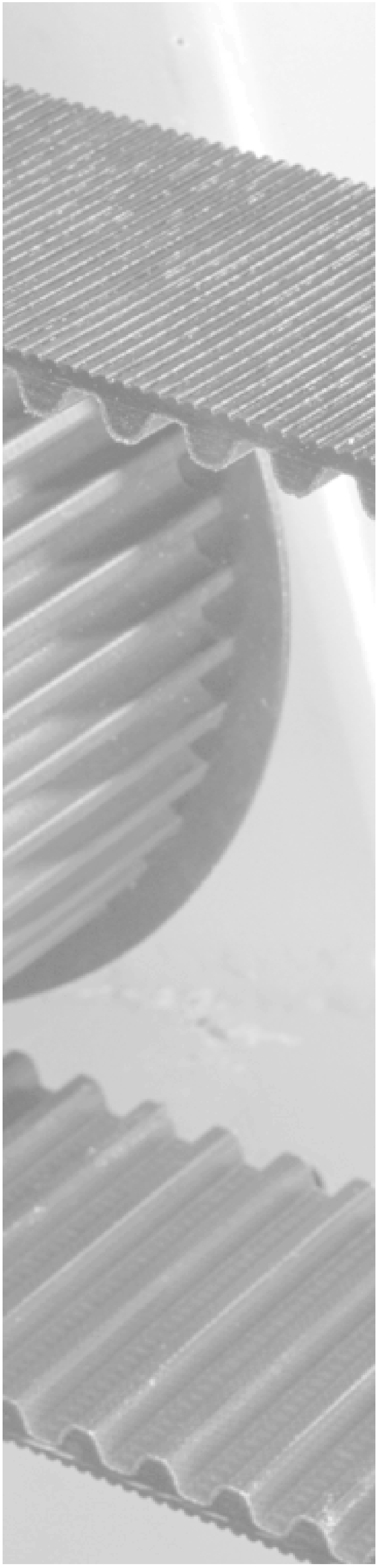

Before designing a Gates Poly Chain® GT2 synchronous belt drive, you need to determine following drive requirements:

1. power requirement and type of driveN machine
2. the rpm of the driveR machine
3. the rpm of the driveN machine
4. the approximate centre distance for the drive
5. hours per day operation

To select a Gates Poly Chain® GT2 belt drive, you need to complete the following steps:

STEP 1

CALCULATE THE DESIGN POWER

Design power = service factor x power requirement

A. To calculate the design power it is necessary to determine the service factor for the drive. Determine the type of the driveR machine using the service factor chart on page 9.

B. Using the service factor chart, determine the service factor for the driveN machine and the type of operational service.

C. Multiply the power requirement of the drive by the service factor you have selected. This gives you the design power for use in designing the drive.

BELT DRIVE SELECTION PROCEDURE

SERVICE FACTOR CHART

DRIVE N MACHINE	DRIVE R					
The driveN machines listed below are representative samples only. Select a driveN machine whose load characteristics most closely approximate those of the machine being considered.	AC motors: normal torque, squirrel cage, synchronous, split phase, inverter controlled. DC motors: shunt wound, stepper motors. Engines: multiple cylinder internal combustion.			AC motors: high torque, high slip, repulsion induction, single phase, series wound, slip ring. DC motors: series wound, compound wound, servomotors. Engines: single cylinder internal combustion. Line shafts. Clutches.		
	Intermittent service	**Normal service**	**Continuous service**	**Intermittent service**	**Normal service**	**Continuous service**
	3-8 hours daily or seasonal	**8-16 hours daily**	**16-24 hours daily**	**3-8 hours daily or seasonal**	**8-16 hours daily**	**16-24 hours daily**
Display equipment. Dispensing equipment. Instrumentation. Measuring equipment. Medical equipment. Office equipment. Projection equipment.	**1.0**	**1.2**	**1.4**	**1.2**	**1.4**	**1.6**
Appliances. Sweepers. Sewing machines. Screens: oven, drum, conical. Woodworking equipment (light): band saws, drills, lathes.	**1.1**	**1.3**	**1.5**	**1.3**	**1.5**	**1.7**
Agitators for liquids. Conveyors: belt, light package. Drill presses. Lathes. Saws. Laundry machinery. Woodworking equipment (heavy): circular saws, jointers, planers.	**1.2**	**1.4**	**1.6**	**1.6**	**1.8**	**2.0**
Agitators for semi-liquids. Centrifugal compressors. Conveyor belt: ore, coal, sand. Dough mixers. Line shafts. Machine tools: grinders, shapers, boring mills, milling machines. Paper machinery (except pulpers): presses, punches, shears. Printing machinery. Pumps: centrifugal, gear. Screens: revolving, vibratory.	**1.3**	**1.5**	**1.7**	**1.6**	**1.8**	**2.0**
Brick machinery (except pug mills). Conveyors: apron, pan, bucket, elevator. Extractors. Washers. Fans. Centrifugal blowers. Generators and exciters. Hoists. Rubber calender. Mills. Extruders.	**1.4**	**1.6**	**1.8**	**1.8**	**2.0**	**2.2**
Centrifuges. Screw conveyors. Hammer mills. Paper pulpers. Textile machinery.	**1.5**	**1.7**	**1.9**	**1.9**	**2.1**	**2.3**
Blowers: positive displacement. Mine fans. Pulverisers.	**1.6**	**1.8**	**2.0**	**2.0**	**2.2**	**2.4**
Reciprocating compressors. Crushers: gyratory, jaw, roll. Mills: ball, rod, pebble, etc. Pumps: reciprocating. Saw mill equipment.	**1.7**	**1.9**	**2.1**	**2.1**	**2.3**	**2.5**

These service factors are adequate for most belt drive applications. Note that service factors cannot be substituted for good engineering judgement. Service factors may be adjusted based upon an understanding of the severity of actual drive operating conditions.

BELT DRIVE SELECTION PROCEDURE

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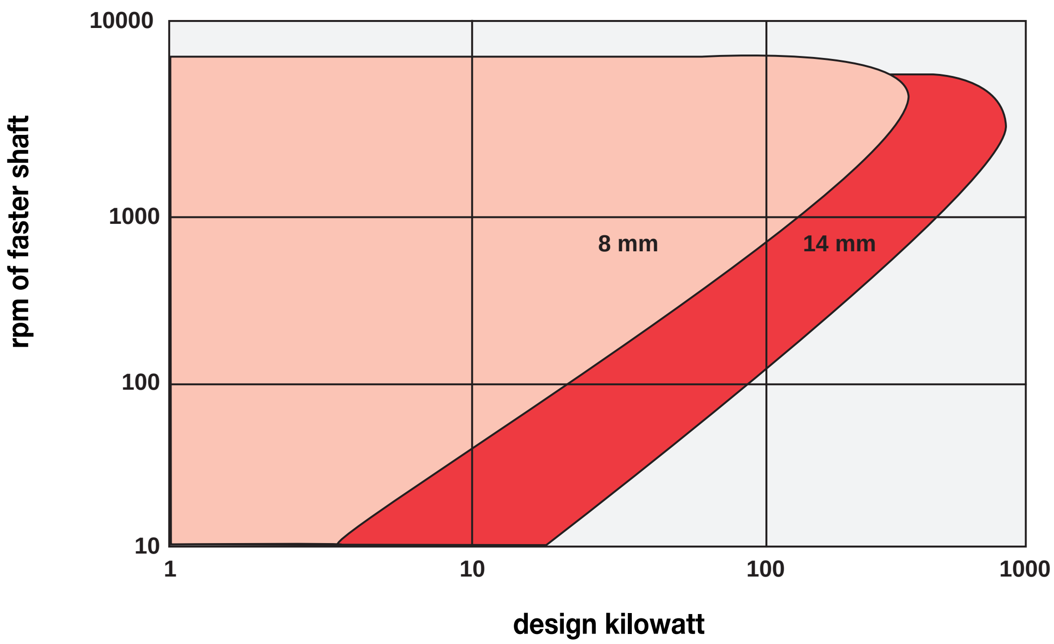
STEP 2

DETERMINE THE BELT PITCH

A. Locate the design power along the horizontal axis of the belt pitch selection guide below. Read up to the rpm of the faster shaft (smaller pulley). The belt pitch indicated in the area surrounding the point of intersection which you located is the one you should use for your design. If the point of intersection falls outside of any specific area, see your Gates representative. If the point falls very near the line between 8 mm and 14 mm, a good drive can likely be designed using either belt pitch.

B. Design the drives using both belt pitches and select the drive best meeting your size requirements or the most economical drive.

POLY CHAIN® GT2 BELT PITCH SELECTION GUIDE



STEP 3

SELECT THE PULLEY COMBINATION, BELT LENGTH AND CENTRE DISTANCE

Locate the appropriate centre distance table for the belt pitch you selected (pages 18 - 39).

For standard and non-standard motor speeds:

A. Calculate the speed ratio by dividing the rpm of the faster shaft by the rpm of the slower shaft. If you are replacing a chain or gear drive, divide the number of teeth on the larger pulley or gear by the number of teeth on the smaller pulley or gear. In the centre distance tables, refer to the column headed speed ratio. Locate the speed ratio nearest to your requirements.

B. For the speed ratio selected, record the number of grooves and pitch diameter of each pulley. If there are several combinations close to your requirements, you may want to consider more than one combination in your drive selection.

C. Reading further to the right on the same line, locate and record the centre distance nearest to your requirements. The belt pitch length designation is given at the top of that column in terms of pitch length. Note these values.

BELT DRIVE SELECTION PROCEDURE

Alternative method to establish the belt length/ centre distance

If you do not know a tentative centre distance, a good estimate is to use the large pulley diameter, or 1/2 (D + 3d), whichever is the larger. You can then find a tentative belt length by solving the following formula:

Formula 1

Tentative belt length =
1.57 (D + d) + (tentative centre distance x 2)

Where: D = diameter of large pulley
d = diameter of small pulley

The approximate relationship between a centre distance and belt pitch length is given by the following formula:

Formula 2

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

Where: L_p = belt length
D = diameter of large pulley
d = diameter of small pulley
C = centre distance

A more precise formula is given below:

Formula 3

$$L_p = 2C\cos Ø + \frac{\pi\,(D + d)}{2} + \frac{\pi\,Ø\,(D - d)}{180}$$

Where: L_p = pitch length of belt
C = centre distance
D = pitch diameter of large pulley
d = pitch diameter of small pulley
$Ø = \sin^{-1}\left(\frac{D - d}{2C}\right)$ distance

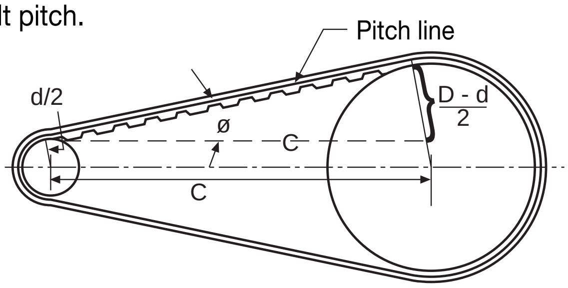
The approximate centre distance can be found by this formula:

Formula 4

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

Where: $K = 4L_p - 6.28\,(D + d)$

The exact centre distance can then be determined by trial using the belt pitch length formula. The pitch length increment of a positive belt is equal to a multiple of the belt pitch.



STEP 4

SELECT THE BELT WIDTH

For all reduction and speed-up drives

A. Power rating tables on pages 40 to 57 show the ratings covered by each stock width. Each table represents one stock belt width for a specific pitch belt. The left-hand column lists the rpm of the smaller pulley, while the stock pulleys are listed across the top of the columns and are designated by the number of grooves and pitch diameter. By reading down the first column to the speed of your faster shaft and across the line to the column headed by your smaller pulley, the power rating can be determined for any stock belt width.

For reduction drives only, read across to the add-on power for speed ratio. Select the value from the appropriate column headed by speed ratio range. Add this value to the basic power rating.

IMPORTANT

Power ratings listed in this catalogue are based on a minimum of six teeth in mesh between the belt and the pulley. The ratings must be corrected for excessive tooth loading if there are less than six teeth in mesh. For non-stock drives not listed in the centre distance tables, the teeth in mesh may be calculated by using this formula:

Formula 5

$$\text{Teeth in mesh (T.I.M.)} = \left[0.5 - \left(\frac{D - d}{6C}\right)\right] Ng$$

Where: D = pitch circle diameter of large pulley (mm)
d = pitch circle diameter of small pulley (mm)
C = centre distance between shafts (mm)
Ng = number of grooves in small pulley

In cases where fewer than six teeth are in full contact, 20% of the power rating must be subtracted for each tooth less than six not in full contact. After computing the teeth in mesh, the belt rating should be multiplied by the appropriate K_{tm} factor shown in the following table.

Table 1

Teeth in mesh factor

Teeth in mesh	> 6	5	4	3	2
Factor K_{tm}	1	0.8	0.6	0.4	0.2

B. Select a stock belt width and determine the power rating as outlined in Step 1. If the power rating is equal to or exceeds the design power found in Step 2, that belt width can be used. If not, move on to the next wider stock belt width and repeat this step. If the widest stock belt width for the pitch selected is still not acceptable, you may want to consider larger pulley diameters or a larger pitch belt if possible.

C. Where there are several pulley combinations which meet your drive requirements, the following rules of thumb may influence your choice.

a. The larger the pulley diameter, typically the less belt width required.

b. Larger diameter pulleys typically reduce bearing and shaft loads.

STEP 5

INSTALLATION AND TAKE-UP

Because of its high resistance to elongation (stretch), there is no need to take up a Poly Chain® GT2 belt drive. However, some adjustment must be provided when installing synchronous belt drives to accomodate manufacturing and assembly tolerances and initial tensioning requirements.

Installation and tensioning allowances

Since fixed centre drives are not recommended, centre distance allowances for a Gates Poly Chain® GT2 belt drive are necessary to ensure that the belt can be installed without damage and then tensioned correctly. The standard installation allowance is the minimum decrease in centre distance required to install a belt when flanged pulleys are removed from their shafts for belt installation. This is shown in the first column of table 2. The table also lists the minimum increase in centre distance required to ensure that a belt can be properly tensioned.

If a belt is to be installed over flanged pulleys without removing the pulleys, the additional centre distance allowance for installation shown in table 3 must be added to the allowance shown in table 2.

Table 2

Poly Chain® GT2 installation & tensioning allowances

Centre distance allowance for installation and tensioning

Belt	Standard installation allowance in mm (flanged pulleys removed for installation)	Tensioning allowance in mm (any drive)
<1000 mm	1.8	0.8
>1000 mm to 1780 mm	2.8	0.8
>1780 mm to 2540 mm	3.3	1.0
>2540 mm to 3300 mm	4.1	1.0
>3300 mm to 4600 mm	5.3	1.3

Table 3

Additional centre distance allowance for installation over flanged pulley*

(Add to installation allowance in table 2)

Pitch	One pulley flanged (mm)	Both pulleys flanged (mm)
8 mm	21.8	33.3
14 mm	31.2	50.0

** For drives that require installation of the belt over one pulley at a time, use the value for both pulleys flanged, even if only one pulley is flanged.*

STEP 6

CALCULATE BELT TENSIONING REQUIREMENTS - STANDARD PROCEDURE

When you install a Gates Poly Chain® GT2 belt, you will want to:

- Be sure it is tensioned sufficiently to prevent jumping of teeth (ratcheting) under the most severe load conditions which the drive will encounter during operation.
- Avoid extremely high tension which can reduce belt life and possibly damage bearings, shafts and other drive components.

When you wish to use a numerical method for tensioning the belt drive, the following procedure consists of measuring the force required to deflect one span of the belt a given amount, as shown in the sketch.

2

A. Calculate the required minimum installation tension

Using the following formula, calculate the required minimum installation tension:

Formula 6

$$T_{st} = 425 \frac{P}{v} + mv^2$$

where: T_{st} = static tension (N)
P = power (kW)
v = belt speed (m/s)
m = belt unit mass per meter length (kg/m); value in table 4

Table 4

Pitch (mm)	Belt width (mm)	m (kg/m)	Y (N)
8	12	0.057	80
	21	0.098	140
	36	0.167	240
	62	0.290	413
14	20	0.158	245
	37	0.291	454
	68	0.536	834
	90	0.711	1103
	125	0.986	1530

Because of the high performance capabilities of Poly Chain® GT2, it is possible to design drives that have significantly greater load ratings than are necessary to carry the actual design load. Consequently, formula 6 can provide T_{st} values less than necessary for the belt to operate properly, resulting in poor belt performance and reduced service life. If a more appropriately sized drive cannot be designed, minimum recommended T_{st} values are provided in table 5 to ensure that the Poly Chain® GT2 belts are tensioned properly when lightly loaded.

Always use the greater T_{st} values; i.e. from formula 6 or table 5.

Table 5

Pitch (mm)	Belt width (mm)	Min. recomm. T_{st} (N)
8	12	125
	21	220
	36	375
	62	645
14	20	530
	37	980
	68	1800
	90	2380
	125	3310

B. Calculate pretension parameters

To calculate the optimum pretension values you will need to calculate the static tension (formula 6) and either measure or calculate the span length (formula 7).

Formula 7

$$S = \sqrt{a^2 - \frac{(D_p - d_p)^2}{4}}$$

where:
S = span length (mm)
a = centre distance (mm)
D_p = large pitch diameter (mm)
d_p = small pitch diameter (mm)

I. For the most precise determination of pretension the Gates sonic tension tester is recommended. This device uses the belt's natural frequency to determine tension.

Calculate the natural frequency of the belt.

When an impulse is applied to a belt span, the frequency of span is related to the static belt tension. This is calculated as follows:

Formula 8

$$f = \sqrt{\frac{T_{st}}{4 \times S^2 \times m \times 10^{-6}}}$$

where: f = frequency (Hz)
T_{st} = static tension (N)
S = span length (mm)
m = belt unit mass (kg/m) per meter length; value in table 4

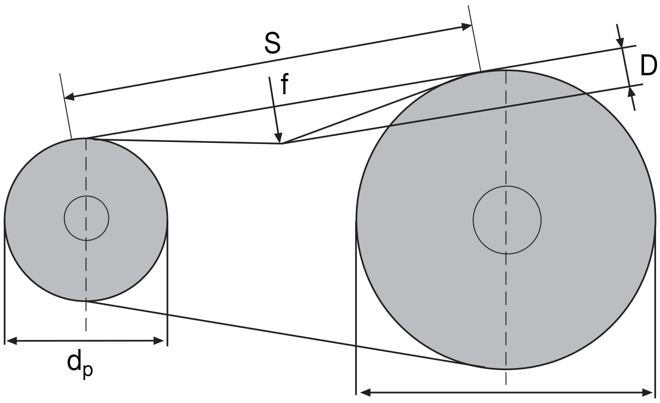
2

Note:

It is critical for the exact calculation of the frequency that the correct span length is used. An error of 10% in span length will result in an error of about 20% as the span length value is squared in the formula.

If a Gates Sonic tension tester is not available a load/deflection method may be used.

II. Calculate the minimum recommended deflection forces



Formula 9

$$\text{Deflection force, Min.} = \frac{T_{st} + \left(\frac{S}{L}\right) Y}{25}$$

where: T_{st} = static tension (N)
S = span length (mm)
L = belt pitch length (mm)
Y = constant from table 4

Deflection is 1/100 per mm of span length

$$\text{Deflection } D = \frac{S}{100}$$

Note: For unusual, shock or pulsating loads consult Gates Application Engineering Department for guidance.

Important

If belts need to be removed and replaced, the tension prior to removal has to be measured and applied for re-installation.

STEP 7

CHECK BELT TENSION

A. By use of the Gates Sonic tension meter

The best procedure to check belt tension is measuring the frequency by means of Gates' sonic tension meter. This sonic tension meter measures tension by analysing the sound waves, which the belt produces when strummed. A belt vibrates at a particular frequency based on its static tension, the belt mass and the free-swinging span. The tension tester transforms this frequency in a tension value.

1. Enter belt unit weight (provided with operating instructions), width and span on the keypad. These data remain in the meter even after shut-off.
2. Hold the small sensor up to the belt span and strum the belt slightly to make it vibrate.
3. Press the "measure" button. The computer processes the variations in sound pressure emanating from the belt span. The belt tension values are displayed on the panel in Newtons (N). If desired, the belt span frequencies can be displayed directly in Hertz (Hz).

For more detailed information, e.g. suitability of the tension meter for different belt product lines, please contact your Gates representative.

Warning

Gates sonic tension meter is not certified for use in explosion risk areas.

Sonic tension meter

B. By use of the conventional tension tester

The deflection of the span creates an elongation of the belt and increase of the span tension. The required deflection force at a defined deflection will be measured.

Gates' conventional tension testers measure deflection force. The single tension tester measures up to ± 120 N and the double tension tester up to ± 300 N. Both testers consist of a calibrated spring with two scales: one to measure the deflection and another to measure the applied force.

The reading of these scales can be done as follows.

1. Measure the span length (S).
2. The calculated deflection (span/100) should be positioned with the lower ring on the distance scale. The upper ring should be on the zero position of the deflection force scale.
3. Put the tension tester perpendicular to the span and in the middle of the span. Exercise enough pressure to the tension tester to deflect the belt by the amount indicated by the lower ring. A straight edge, laid across pulleys, can help accuracy of reading.
4. The upper ring will slide up the upper scale and indicates the deflection force. Read at the bottom edge of the ring. When you use the double tension tester you can read the values just underneath the rings and calculate the sum of both values. This value has to be compared with the calculated min./max. force as per formula 9, page 14.

STEP 8

CHECK AND SPECIFY STOCK DRIVE COMPONENTS

A. Check the pulleys selected against any special design requirements using the dimensions given in the pulley specification tables on pages 59 - 63.

B. Using the pulley specification tables, determine the type of bushing to be used with each pulley. Check the bore range against the design requirements.

BELT DRIVE SELECTION EXAMPLE

Given

Standard motor speed - reduction

A 5 kW, 1800 rpm high torque AC motor will be used to drive a wood lathe at a nominal 1485 rpm. The required nominal centre distance is 510 mm ± 20 mm. Duty will be 10 to 12 hours per day.

2

Comments

STEP 1

Calculate the design power

A. From the service factor chart on page 9, the driveR would be found in the second group.

B. From the chart the **service factor** = 1.5

C. **Design power** = 5 x 1.5 = 7.5 kW

Results: Service factor = 1.5
Design power = 7.5 kW

STEP 2

Determine the belt pitch

From the belt pitch selection guide on page 10, a 7.5 kW power and 1800 rpm faster shaft requires an 8 mm pitch Gates Poly Chain® GT2 belt.

Results: Belt pitch = 8 mm

STEP 3

Select the pulley combination, belt length and centre distance

A. Calculate the speed ratio by dividing the faster rpm by the slower rpm.

Speed ratio $= \frac{1800}{1485} = 1.212$

Results: Speed ratio = 1.212

B. In the centre distance tables, refer to the column headed by speed ratio. Locate the speed ratio nearest to your requirements. For this example let's select 1.21.
Actual driveN speed = 1800 : 1.21 = 1487 rpm

C. For the speed ratio selected, record these pulleys:
DriveR = 8M-28S (28 grooves), 71.3 mm pitch diameter;
DriveN = 8M-34S (34 grooves), 86.6 mm pitch diameter.

Reading to the right, the nearest to required centre distance 515.94 mm. Reading up that column record the belt which is an **8MGT-1280, 1280 mm pitch length, 160 teeth.**

Results: DriveR = 28 grooves, 71.3 mm P.D.
DriveN = 34 grooves, 86.6 mm P.D.
Nearest centre distance = 515.94 mm
Required belt = 8MGT-1280 P.L.
160 teeth

STEP 4

Select the belt width

In the 8MGT power rating table on page 40, the basic power rating = 8.17 kW for a 28-groove pulley at 1800 rpm, 12 mm width.

Service rating = (basic power rating + additional factor) x length correction factor = (8.17 + 0.35) x 1.05 = 8.95 kW

This exceeds the 7.5 kW design power, so it is an acceptable drive.

Results: Belt width = 12 mm
Service rating = 8.95 kW

BELT DRIVE SELECTION EXAMPLE

STEP 5

Find the required installation and take-up allowances
From tables 2 and 3 on page 12 **the minimum centre distance allowance to install and tension the belt is** 2.8 mm/+0.8 mm. Additional allowance from table 3 is required when installing over flanged pulleys not removed from the shafts.

Minimum centre distance allowance for installation and tensioning = -2.8 mm/+0.8 mm

STEP 6

Calculate the belt tensioning requirements
Using formulae 6 and 7 on page 13.

Deflection force = 14 to 16 N
Deflection = 5.2 mm