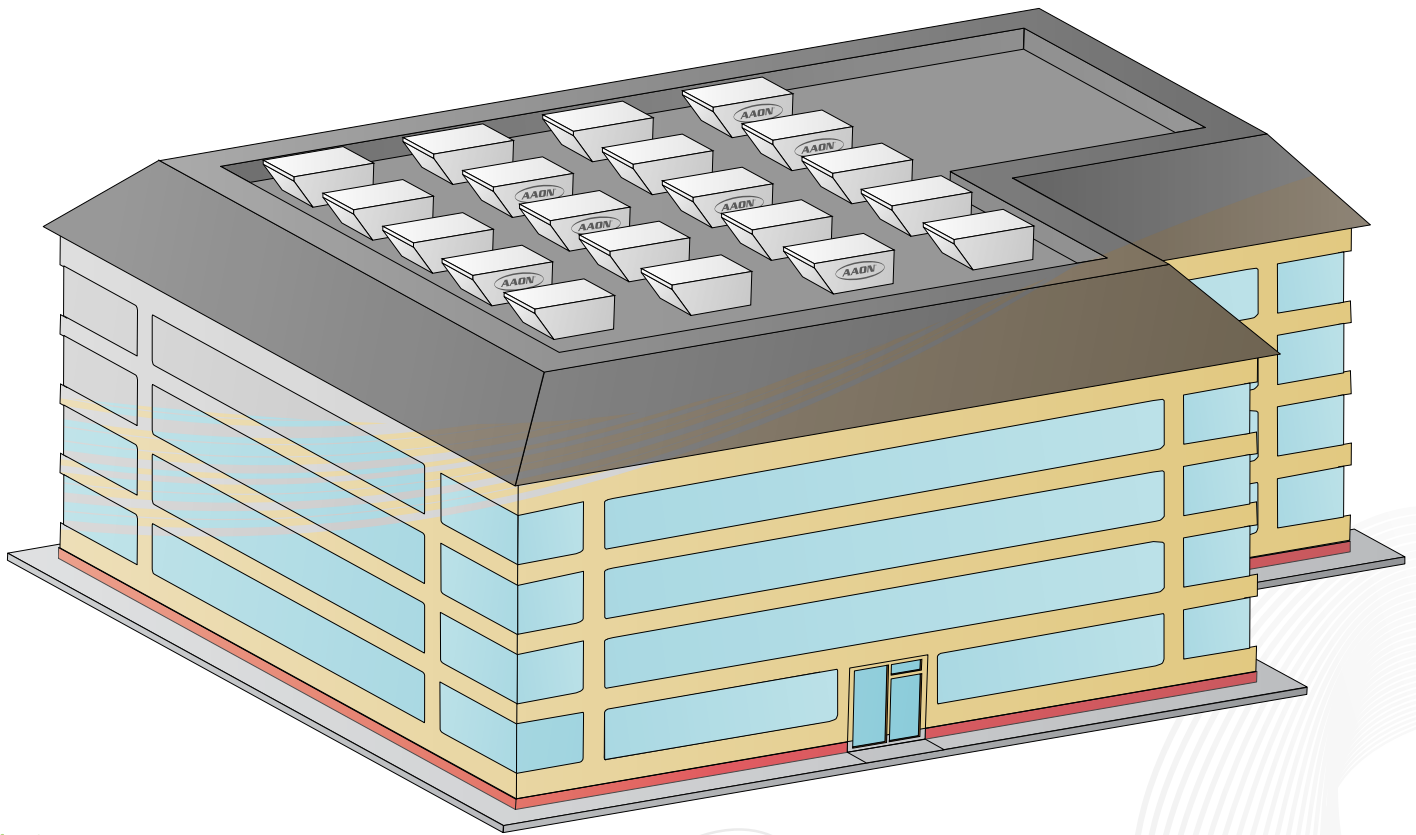




Defining Quality. Building Comfort.

# The Cost of Belt Drives



# Cost

## Belt Drive Losses

Belt drive systems transfer energy indirectly from the motor to the fan through a belt and pulley system causing power to be lost. However, the direct drive motors transfer the energy directly to the fan with no loss of power. A belt driven system can lose up to 15% of the applied power as heat due to belt slippage caused by the normal stretching and slipping of the belt.

Using Figure 1 from AMCA publication 203-90, the average 10-ton unit with a 3 horsepower motor loses about 7% of the applied power. Based on the average yearly energy usage of a 70,000 square foot office building with twenty 10-ton constant volume units and 90% occupancy from 8:00 am to 6:00 pm averaged amongst various cities across the United States and an average commercial electricity rate of \$0.12/KWh, the 10-ton belt driven units with 3 horsepower motors cost an average of \$2,850 more to operate per year than direct driven units because of belt drive losses. According to ASHRAE, the average lifespan of a packaged rooftop unit is 15 years. AAON units are engineered to be of higher than average quality resulting in a longer unit lifespan. Assuming an average AAON unit lifespan of 17 years, the 10 ton direct drive units would save about \$48,400 in electricity costs over the unit lifetime, or \$2,400 per unit.

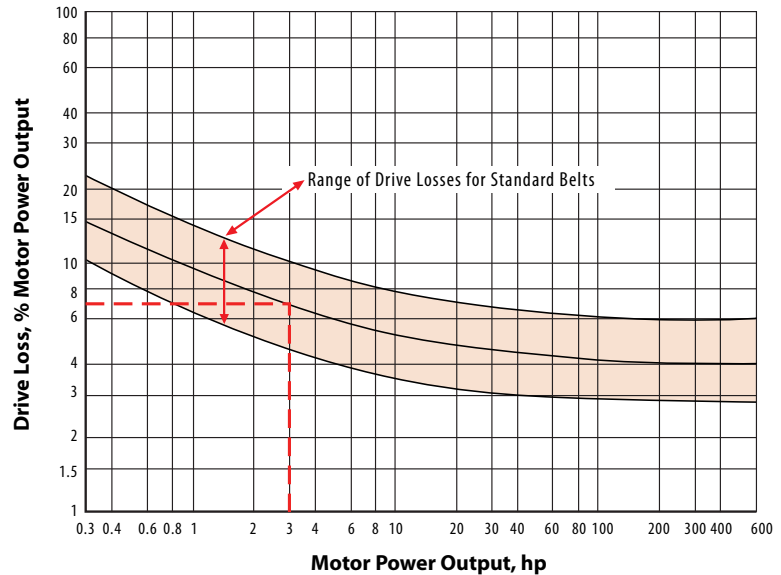


Figure 1: Average Belt Drive Losses vs. Motor Power Output (AMCA publication 203-90)

## Belt Maintenance

Belts should be inspected once a month to ensure that the belt is properly aligned and the belt shows no fraying or stretching. In addition, manufacturers suggest that belts be replaced once a year. Belt inspections and alignments will cost on average \$75 a month, assuming a \$75 maintenance service trip fee that covers the first 30 minutes of work and the cost of the trip to the facility, which adds up to \$825 a year, assuming 11 times a year the belt will be checked and the 12th month the belt will be replaced. This belt maintenance adds up to \$14,025 per unit over the lifetime of the unit. A belt replacement will cost approximately \$105 per year, assuming a \$75 service trip fee and half an hour of labor at \$60 per hour. Over a system lifespan of 17 years, regular belt replacements will cost an extra \$1,785 per unit.

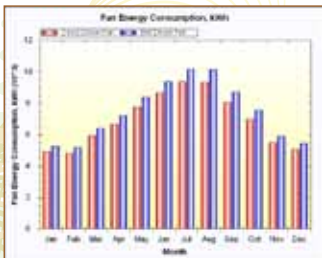


Figure 2: Monthly Fan Energy of direct drive vs. belt drive for Dallas, Texas

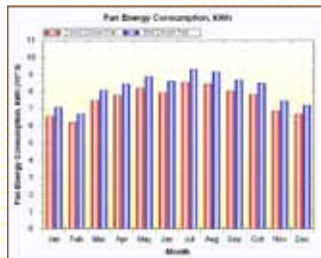


Figure 3: Monthly Fan Energy of direct drive vs. belt drive for Miami, Florida

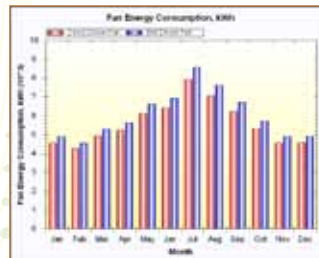


Figure 4: Monthly Fan Energy of direct drive vs. belt drive for Seattle, Washington

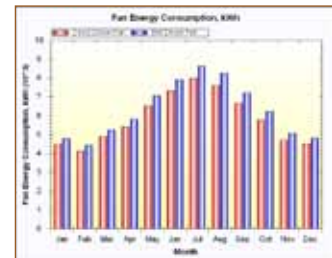


Figure 5: Monthly Fan Energy of direct drive vs. belt drive for New York, New York

## Bearing Maintenance

In addition to the bearings within the motor, belt driven systems have two additional bearings as shown in Figure 6. These bearings hold the impeller shaft and allow it to spin. A pulley on the end of the impeller shaft holds the belt that is connected to the motor. There are two main reasons why the bearings in the belt driven system are more likely to fail than the bearings in a direct driven system. First, there are more bearings in a belt driven system and therefore there is a statistically greater chance of part failure. Obviously, the more moving parts in a system, the greater the chance of something failing. Second, the load is much greater on the bearings in the belt driven system. In order to transfer energy from the motor to the impeller shaft, the tension in the belt must be large enough so that the belt does not slip. Belt tension varies based on the size and weight of the fan, with larger, heavier fans requiring more tension. For a 3 horsepower motor, this belt tension is usually around 140 pounds and the load on the bearings is 280 pounds of radial force, or twice the tension in the belt. The only radial load on the bearings in the direct driven system is the weight of the fan as shown in Figure 7. The average weight for an 18.5 inch aluminum fan used on a 10 ton unit is 18 pounds making the bearing load on a direct drive system more than 15 times less than the bearing load on a belt driven system. Because of the increased load on the bearings in the belt driven system, these bearings must be checked regularly to ensure they are properly lubricated and properly aligned.

On average, the bearings should be inspected every 3 months for proper alignment and lubrication costing an average of \$75 per inspection, assuming less than 30 minutes of labor time and a \$75 service trip fee. Assuming only the bearing maintenance is done during the service trip, this routine bearing maintenance will cost an extra \$300 per year and an extra **\$5,100** over a system lifespan of 17 years. In addition to this increased routine maintenance cost, the bearings are also more likely to fail prematurely, even with regular maintenance. A bearing replacement takes between 1 to 4 hours.

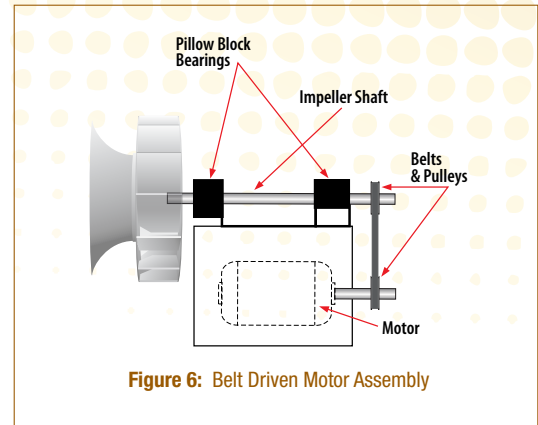


Figure 6: Belt Driven Motor Assembly

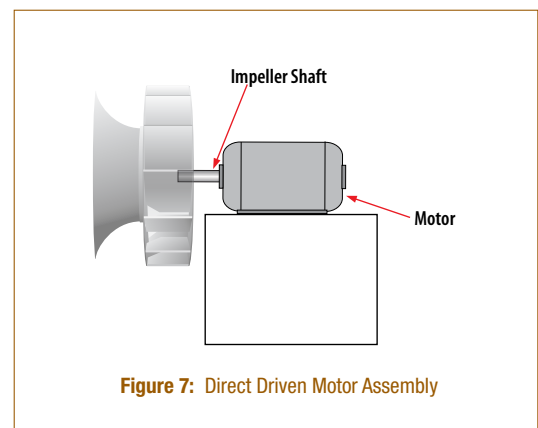


Figure 7: Direct Driven Motor Assembly

Assuming an estimate of \$60/hour for service, a \$75 service trip charge, and \$36 per bearing, this bearing replacement could cost as much as **\$357**, assuming both bearings are replaced at once.

## Filter Replacement

As belts endure normal workloads, the wearing of the belt causes the belt material to break down, releasing a dust/residue into the system. This residue is released as the air passes over the belt and is released through the diffuser into the indoor air. This dark belt residue can often be seen on diffusers in buildings with belt driven units. The air is then circulated back into the HVAC unit and collects in the filters causing the filters to become clogged faster than the filters in a direct driven system. Assuming, on average a belt driven system causes the filters to have to be replaced one extra time a year, then based on the average 10-ton unit with 4 filters each costing \$3.62 and a mainte-

# Comfort

nance service trip fee of \$75, the belt driven system could cost an extra \$89.48 per year. The decrease in filter life could cost on average an extra \$1,520 over the average 17 year life of the system.

## Air Quality

The dust and residue that is released by the belt in a belt-driven system is released into the indoor environment. Basic filters are often only 20 to 30 percent efficient at filtering debris so the belt dust and residue that isn't trapped by the filter is released into the air stream. The direct driven fan is a cleaner system allowing for healthier indoor air.

## Noise

The direct driven system is a quieter system. The belt driven fan creates vibrations that increase the noise pollution of the system. In addition to these vibrations, an improperly maintained belt driven fan will create additional noise from the belt slippage of a deteriorating belt. Even in a properly maintained and well operating belt driven system, the belt driven system will be noisier than an equivalent direct drive system due to the additional required fan speed needed to overcome the belt drive efficiency deficiencies. Noise is lost power. Any power lost to noise does no useful work to turn the fan.

## What's it all cost?

How much do these extra costs add up to over the average 17 year lifespan of a 10-ton belt driven unit with a 3 horsepower motor? Assuming the routine bearing maintenance can be completed at the same time as the routine belt maintenance, resulting in only one service trip fee for the combined maintenance, the average belt related costs for one rooftop unit over the estimated 17 year lifespan add up to:

Belt Drive Losses	\$2,400
Belt Replacement	\$1,785
Belt and Bearing Maintenance	\$14,025
Bearing Replacement	\$357
Filter Replacement	\$1,520
<b>Total Belt Related Costs Per Unit Lifetime:</b>	<b>\$20,087</b>

In addition to the reduced maintenance costs and energy consumption, the direct driven system provides a quieter, healthier, and more comfortable indoor environment. A direct driven system also provides the customer with the comfort of knowing that their HVAC unit is less likely to fail when needed. *Contact your local AAON representative to find out how a direct drive system will benefit you.*



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