### Notched V Belts for HVAC Systems

**Measure Description**

This measure is for replacement of smooth v-belts in non-residential package and split HVAC systems with notched v-belts. Typically there is a v-belt between the motor and the supply air fan and/or return air fan in larger package and split HVAC systems (RTU).

In general there are two styles of grooved v-belts, notched and synchronous. The DOE defines each as follows;

**Notched V-Belts** - A notched belt has grooves or notches that run perpendicular to the belt’s length, which reduces the bending resistance of the belt. Notched belts can use the same pulleys as cross-section standard V-belts. They run cooler, last longer, and are about 2% more efficient than standard V-belts.

**Synchronous Belts** - Synchronous belts (also called cogged, timing, positive-drive, or high-torque drive belts) are toothed and require the installation of mating grooved sprockets. These belts operate with a consistent efficiency of 98% and maintain their efficiency over a wide load range.

Smooth v-belts are usually referred to in five basic groups:

* “L” belts are low end belts that are for small, fractional horsepower motors and these are not used in RTUs.
* “A” and “B” belts are the two types typically used in RTUs. The “A” belt is a ½ inch width by 5/16 inch thickness and the “B” belt is larger, 21/32 inch wide and 12/32 inch thick so it can carry more power. V-belts come in a wide variety of lengths where 20 to 100 inches is typical.
* “C” and “D” belts are primarily for industrial applications with high power transmission requirements.
* V-belts are provided by various vendors. The notched version of these belts typically have an “X” added to the designation. For this HVAC fans notched v-belt Replacement measure, only the “A” and “B” v-belts are considered. A typical “A” v-belt is replaced by a notched “AX” v-belt and a “B” is replaced by a “BX.” In general, smooth v-belts have an efficiency of 90% to 98% while notched v-belts have an efficiency of 95% to 98%. Because notched v-belts are more flexible they work with smaller diameter pulleys and they have less resistance to bending. Lower bending resistance increases the power transmission efficiency, lowers the waste heat, and allows the belt to last longer than a smooth belt.

Three research papers[[1]](#footnote-2) [[2]](#footnote-3) [[3]](#footnote-4) show that the notched v-belt efficiency is 2% to 5% better than a typical smooth v-belt. A fourth paper by USDOE’s Energy Efficiency and Renewable Energy[[4]](#footnote-5) group reviewed most of the earlier literature and recommended using a conservative 2% efficiency improvement for energy savings for calculations.

For this measure it is assumed that upgrading a standard smooth v-belt with a new notched v-belt will result in a fan energy reduction of 2%.

**Definition of Efficient Equipment**

The Efficient Equipment is HVAC RTUs that have notched v-belts installed on the supply and/or return air fans.

**Definition of Baseline Equipment**

The Baseline Equipment is HVAC RTUs that have smooth v-belts installed on the supply and/or return air fans (i.e. RTU does not already have a notched v-belt installed).

**Deemed Lifetime of Efficient Equipment**

A v-belt has a life based on fan run hours which varies by building type based primarily on occupancy schedule because the fans are required by code to operate continuously during occupied hours. The supply and return fans will also run a few hours during unoccupied hours for heating and cooling as needed. For the notched v-belt EUL calculation, the default hours[[5]](#footnote-6) in the following table are used for a variety of building types and HVAC applications.

EUL = Belt Life / Occupancy Hours per year

Where:

Belt Life = 24,000 hours[[6]](#footnote-7)

Occupancy Hours per year = values from Table below

The notched v-belt measure EUL is summarized by building type in the following table.

**Notched v-belt Effective Useful Life (EUL)**

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Total Fan Run Hours** | **EUL (Years)** |
| Assembly | 7235 | 3.3 |
| Assisted Living | 8760 | 2.7 |
| College | 6103 | 3.9 |
| Convenience Store | 7004 | 3.4 |
| Elementary School | 7522 | 3.2 |
| Garage | 7357 | 3.3 |
| Grocery | 7403 | 3.2 |
| Healthcare Clinic | 6345 | 3.8 |
| High School | 7879 | 3.0 |
| Hospital - VAV econ | 8760 | 2.7 |
| Hospital - CAV econ | 8760 | 2.7 |
| Hospital - CAV no econ | 8760 | 2.7 |
| Hospital - FCU | 8760 | 2.7 |
| Manufacturing Facility | 8706 | 2.8 |
| MF - High Rise | 8760 | 2.7 |
| MF - Mid Rise | 8760 | 2.7 |
| Hotel/Motel - Guest | 8760 | 2.7 |
| Hotel/Motel - Common | 8760 | 2.7 |
| Movie Theater | 7505 | 3.2 |
| Office - High Rise - VAV econ | 6064 | 4.0 |
| Office - High Rise - CAV econ | 5697 | 4.2 |
| Office - High Rise - CAV no econ | 5682 | 4.2 |
| Office - High Rise - FCU | 6163 | 3.9 |
| Office - Low Rise | 6288 | 3.8 |
| Office - Mid Rise | 6125 | 3.9 |
| Religious Building | 7380 | 3.3 |
| Restaurant | 7809 | 3.1 |
| Retail - Department Store | 6890 | 3.5 |
| Retail - Strip Mall | 6846 | 3.5 |
| Warehouse | 6786 | 3.5 |
| Unknown | 7100 | 3.4 |

**Deemed Measure Cost**

A review of the Grainger online[[7]](#footnote-8) pricing for “A,” “B,” “AX,” and “BX” v-belts showed the incremental cost to upgrade to notched v-belts would result in a 28% price increase. The notched v-belt incremental cost is summarized in the table below:

**Notched V-belt Incremental Cost Summary**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Smooth V-Belt Industry Number** | **Outside Length (Inches)** | **Dayton Smooth V-Belt\*** | **Notched V-belt Industry Number** | **Dayton Notched v-belt\*** | **Price Increase** | **% Increase** |
| A30 (Item # 1A095) | 32 | $12.70 | AX29 (Item # 3GWU4) | $17.65 | $4.95 | 28% |
| B29 (Item # 6L208) | 32 | $16.75 | BX29 (Item # 5TXL4) | $23.23 | $6.48 | 28% |
| \* Pricing based on Dayton Belts as found on Grainger Website 10/30/14 | | | | | | |

**Deemed O&M Cost Adjustments**

N/A

**Loadshape**

Loadshape C05 - Commercial Electric Heating and Cooling

**Coincidence Factor**

N/A

**Algorithm**

**Calculation of Energy Savings**

**Electric Energy Savings**

ΔkWh = kWconnected\* Hours \* ESF

Where:

kWConnected =kW of equipment is calculated using motor efficiency[[8]](#footnote-9).

= (HP \* 0.746 kW/HP\* Load Factor)/Motor Efficiency

Load Factor =Motors are assumed to have a load factor of 80% for calculating KW if actual values cannot be determined[[9]](#footnote-10). Custom load factor may be applied if known.

Motor Efficiency = Actual motor efficiency shall be used to calculate KW. If not known a value from the motor efficiency refrence tables below should be used**[[10]](#footnote-11)**

| **Baseline Motor Efficiencies (EPACT)** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Size HP** | **Open Drip Proof (ODP)** | | | **Totally Enclosed Fan-Cooled (TEFC)** | | |
| **# of Poles** | | | | | |
| ***6*** | ***4*** | ***2*** | ***6*** | ***4*** | ***2*** |
| **Speed (RPM)** | | | | | |
| ***1200*** | ***1800*** | ***3600*** | ***1200*** | ***1800*** | ***3600*** |
| 1/8 | - | 44.00% | - | - | - | - |
| 1/6 | 57.50% | 62.00% | - | - | - | - |
| 1/4 | 68.00% | 68.00% | - | 68.00% | 64.00% | - |
| 1/3 | 70.00% | 70.00% | 72.00% | 70.00% | 68.00% | 72.00% |
| 1/2 | 78.50% | 80.00% | 68.00% | 72.00% | 74.00% | 68.00% |
| 3/4 | 77.00% | 78.50% | 74.00% | 77.00% | 75.50% | 74.00% |
| 1 | 80.00% | 82.50% | 75.50% | 80.00% | 82.50% | 75.50% |
| 1.5 | 84.00% | 84.00% | 82.50% | 85.50% | 84.00% | 82.50% |
| 2 | 85.50% | 84.00% | 84.00% | 86.50% | 84.00% | 84.00% |
| 3 | 86.50% | 86.50% | 84.00% | 87.50% | 87.50% | 85.50% |
| 5 | 87.50% | 87.50% | 85.50% | 87.50% | 87.50% | 87.50% |
| 7.5 | 88.50% | 88.50% | 87.50% | 89.50% | 89.50% | 88.50% |
| 10 | 90.20% | 89.50% | 88.50% | 89.50% | 89.50% | 89.50% |
| 15 | 90.20% | 91.00% | 89.50% | 90.20% | 91.00% | 90.20% |
| 20 | 91.00% | 91.00% | 90.20% | 90.20% | 91.00% | 90.20% |
| 25 | 91.70% | 91.70% | 91.00% | 91.70% | 92.40% | 91.00% |

| **Efficient Motor Efficiencies (NEMA Premium)** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Size HP** | **Open Drip Proof (ODP)** | | | **Totally Enclosed Fan-Cooled (TEFC)** | | |
| **# of Poles** | | | **# of Poles** | | |
| **2** | **4** | **6** | **2** | **4** | **6** |
| **Speed (RPM)** | | | **Speed (RPM)** | | |
| **1200** | **1800** | **3600** | **1200** | **1800** | **3600** |
| 0.125 \* | - | 44.00% | - | - | - | - |
| 1/6 | 57.50% | 62.00% | - | - | - | - |
| 1/4 | 68.00% | 68.00% | - | 68.00% | 64.00% | - |
| 1/3 | 70.00% | 70.00% | 72.00% | 70.00% | 68.00% | 72.00% |
| 1/2 | 78.50% | 80.00% | 68.00% | 72.00% | 74.00% | 68.00% |
| 3/4 | 77.00% | 78.50% | 74.00% | 77.00% | 75.50% | 74.00% |
| 1 | 82.50% | 85.50% | 77.00% | 82.50% | 85.50% | 77.00% |
| 1.5 | 86.50% | 86.50% | 84.00% | 87.50% | 86.50% | 84.00% |
| 2 | 87.50% | 86.50% | 85.50% | 88.50% | 86.50% | 85.50% |
| 3 | 88.50% | 89.50% | 85.50% | 89.50% | 89.50% | 86.50% |
| 5 | 89.50% | 89.50% | 86.50% | 89.50% | 89.50% | 88.50% |
| 7.5 | 90.20% | 91.00% | 88.50% | 91.00% | 91.70% | 89.50% |
| 10 | 91.70% | 91.70% | 89.50% | 91.00% | 91.70% | 90.20% |
| 15 | 91.70% | 93.00% | 90.20% | 91.70% | 92.40% | 91.00% |
| 20 | 92.40% | 93.00% | 91.00% | 91.70% | 93.00% | 91.00% |
| 25 | 93.00% | 93.60% | 91.70% | 93.00% | 93.60% | 91.70% |

Hours = When available, actual hours should be used. If actual hours are not available default hours[[11]](#footnote-12) are provided in table below for HVAC fan operation which varies by building type:

|  |  |
| --- | --- |
| **Building Type** | **Total Fan Run Hours** |
| Assembly | 7235 |
| Assisted Living | 8760 |
| College | 6103 |
| Convenience Store | 7004 |
| Elementary School | 7522 |
| Garage | 7357 |
| Grocery | 7403 |
| Healthcare Clinic | 6345 |
| High School | 7879 |
| Hospital - VAV econ | 8760 |
| Hospital - CAV econ | 8760 |
| Hospital - CAV no econ | 8760 |
| Hospital - FCU | 8760 |
| Manufacturing Facility | 8706 |
| MF - High Rise | 8760 |
| MF - Mid Rise | 8760 |
| Hotel/Motel - Guest | 8760 |
| Hotel/Motel - Common | 8760 |
| Movie Theater | 7505 |
| Office - High Rise - VAV econ | 6064 |
| Office - High Rise - CAV econ | 5697 |
| Office - High Rise - CAV no econ | 5682 |
| Office - High Rise - FCU | 6163 |
| Office - Low Rise | 6288 |
| Office - Mid Rise | 6125 |
| Religious Building | 7380 |
| Restaurant | 7809 |
| Retail - Department Store | 6890 |
| Retail - Strip Mall | 6846 |
| Warehouse | 6786 |
| Unknown | 7100 |

ESF = Energy Savings Factor, the ESF for notched v-belt Installation is assumed to be 2%

**EXAMPLE**

For example, an low rise office building RTU with a 5 HP NEMA premium efficiency motor using the default hours of operation, motor load and 89.5% motor efficiency;

ΔkWh = kWconnected\* Hours \* ESF

= ((HP \* 0.746 kW/HP\* Load Factor)/Motor Efficiency) \* Hours \* ESF

= ((5 HP \* 0.746 kW/HP\* 80%) / 89.5%) \* 6288 \* 2%

= 419 kWh Savings

**Summer Coincident Peak Demand Savings**

ΔkW = kWconnected\* ESF

Where:

kWConnected = kW of equipment is calculated using motor efficiency.

= (HP \*0 .746 kW/HP\* Load Factor)/Motor Efficiency

Variables as provided above

**EXAMPLE**

For example, an office building RTU with a 5 HP NEMA premium efficiency motor using the default motor load and 89.5% motor efficiency;

ΔkW = kWconnected\* ESF

= ((HP \* 0.746 kW/HP\* Load Factor)/Motor Efficiency) \* ESF

= ((5 HP \* 0.746 kW/HP\* 80%) / 89.5%) \* 2%

= 0.0667 kW Savings

**Natural Gas Savings**

N/A

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**Measure Code: CI-MSC-NVBE-V02-160601**

1. "Gates Corporation Announces New EPDM Molded Notch V-Belts,” The Gates Rubber Co., June 2010 (Assumed 3% efficiency improvement) <https://ww2.gates.com/news/index.cfm?id=11296&show=newsitem&location_id=753&view=Gates> [↑](#footnote-ref-2)
2. “[Synchronous Belt Drives Offer Low Cost Energy Savings](#3.5 Synchronous Belt Drives Offer Low Cost Energy Savings),” Baldor., February 2009. (attached in Reference Documents) [↑](#footnote-ref-3)
3. "Energy Savings from Synchronous Belts," The Gates Rubber Co., February 2014. (Assumed 5% efficiency improvement) <http://www.gates.com/~/media/Files/Gates/Industrial/Power%20Transmission/White%20Papers/Energy%20Savings%20from%20Synchronous%20Belt%20Drives.pdf> [↑](#footnote-ref-4)
4. “Motor System Tip Sheet #5, Replace V-Belts with Cogged or Synchronous Belt Drives,” USDOE-EERE, September 2005. (Assumed 2% efficiency improvement) <http://www1.eere.energy.gov/industry/bestpractices/pdfs/replace_vbelts_motor_systemts5.pdf> [↑](#footnote-ref-5)
5. ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low. [↑](#footnote-ref-6)
6. “[DEER2014-EUL-table-update\_2014-02-05.xlsx](#3.4 DEER2014-EUL-table-update_2014-02-05.xlsx),” Database for Energy Efficiency Resources (DEER), Deer 2014. [www.deerresources.com](file:///\\peci.org\files\Secure\Programs\14984%20-%20ComEd%20AirCare%20Plus\Engineering\Cogged%20v-belt\Work%20Paper\www.deerresources.com) (attached in Reference Documents) [↑](#footnote-ref-7)
7. Grainger catalog on-line web-site for Dayton v-belt pricing

   <http://www.grainger.com/Grainger/ecatalog/N-1z0r596/Ntt-v-belts> [↑](#footnote-ref-8)
8. Note that kWConnected may be determined using various methodologies. The examples provided use rated HP and assumed load factor. Other methodologies include rated voltage and full load current with assumed load factor, or actual measured voltage and current. [↑](#footnote-ref-9)
9. Com Ed TRM June 1, 2010 [↑](#footnote-ref-10)
10. Efficiency values for motors less than one HP taken from Baldor Electric Catalog 501: <http://www.baldor.com/pdf/501_Catalog/CA501.pdf> [↑](#footnote-ref-11)
11. Hours per year are estimated using the eQuest models as the total number of hours the fans are operating for heating, cooling and ventilation for each building type. [↑](#footnote-ref-12)