

**H V A C**

C O G G E D V - B E L T F O R H V A C F A N , C O M M E R C I A L

SWHC026-02

C O N T E N T S

[MEASURE NAME 2](#_Toc57530050)

[STATEWIDE MEASURE ID 2](#_Toc57530051)

[TECHNOLOGY SUMMARY 2](#_Toc57530052)

[MEASURE CASE DESCRIPTION 3](#_Toc57530053)

[BASE CASE DESCRIPTION 3](#_Toc57530054)

[CODE REQUIREMENTS 3](#_Toc57530055)

[NORMALIZING UNIT 4](#_Toc57530056)

[PROGRAM REQUIREMENTS 4](#_Toc57530057)

[PROGRAM EXCLUSIONS 5](#_Toc57530058)

[DATA COLLECTION REQUIREMENTS 5](#_Toc57530059)

[USE CATEGORY 5](#_Toc57530060)

[ELECTRIC SAVINGS (KWH) 5](#_Toc57530061)

[PEAK ELECTRIC DEMAND REDUCTION (KW) 6](#_Toc57530062)

[GAS SAVINGS (THERMS) 6](#_Toc57530063)

[LIFE CYCLE 6](#_Toc57530064)

[BASE CASE MATERIAL COST ($/UNIT) 8](#_Toc57530065)

[MEASURE CASE MATERIAL COST ($/UNIT) 8](#_Toc57530066)

[BASE CASE LABOR COST ($/UNIT) 8](#_Toc57530067)

[MEASURE CASE LABOR COST ($/UNIT) 9](#_Toc57530068)

[NET-TO-GROSS (NTG) 9](#_Toc57530069)

[GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA) 9](#_Toc57530070)

[NON-ENERGY IMPACTS 9](#_Toc57530071)

[DEER DIFFERENCES ANALYSIS 10](#_Toc57530072)

[REVISION HISTORY 10](#_Toc57530073)

# MEASURE NAME

Cogged V-Belt for HVAC Fan, Commercial

# STATEWIDE MEASURE ID

SWHC026-02

# TECHNOLOGY SUMMARY

A V-belt typically connects the motor and the supply air fan of a rooftop unit (RTU) of an HVAC system. Larger unitary HVAC equipment may also have a V-belt between the return air motor and fan.

The typical smooth V-belts are usually referred to into five basic groups: Note that only the “A” and “B” V-belts are applicable for this measure.

* “L” belts are low end belts that are for small, fractional horsepower motors and are not used in RTUs.
* “A” and “B” belts are the two types typically used in RTUs. The “A” belt is ½ inch wide and 5/16 inch thick. The “B” belt is larger, 21/32 inches wide and 12/32 inches 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 used for industrial applications with high power transmission requirements.

*Note that only the “A” and “B” V-belts are applicable for this measure. (Belt types “A” and “B” should not be confused with the offering A and B, where Offering A is for NR and Offering B is NC)*

The cogged belts typically have an “X” added to the designation or model number. A typical “A” V-belt is replaced by a cogged “AX” V-belt, and a “B” is replaced by a “BX.”

In general, smooth V-belts have an efficiency of 90% to 98% while cogged V-belts have an efficiency of 95% to 98%. Because cogged V-belts are more flexible they are compatible with smaller diameter pulleys and 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.

In particular, four research papers show that a cogged V-belt efficiency ranges from 0.4% to 4.8% better than a typical smooth V-belt.1 A more recent publication 2012 by the U.S. Department of Energy (DOE)

1 [A] Cole, J. (University of California Berkeley). 1994. "Summary of Findings of CIEE Technology Assessment of Energy-Efficient Belt Transmission." Memorandum, August 17, 1994. Attached paper by Almeida, Anibal De, University of Coimbra, and Steve Greenberg, Lawrence Berkeley laboratory.

1. "Gates Corporation Announces New EPDM Modeled Notch V-belts” [http://www.gates.com/news/index.cfm?id=11296$show=newsitem&location](http://www.gates.com/news/index.cfm?id=11296%24show%3Dnewsitem&location) \_id=753&view=Gates. Accessed on June 2010.
2. Ula, S., LE. Birnbaum, D. Jordan (Electrical Engineering Dept, University of Wyoming). Year. "Energy Efficient Drivepower: An Overview." Prepared for Bonneville Power Administration. Page 33.
3. "Energy Loss and Efficiency of Power Transmission Belts," Advanced Engineering Research, Belt Technical Center, Carlisle Power Transmission Products, Third Work Energy Engineering Congress, Association of Energy Engineers, 1977.

Energy Efficiency and Renewable Energy states that cogged V-belts “run cooler, last longer, and are about 2% more efficient than standard V-belts.”2The 2% estimate of fan system efficiency improvement is based on an engineering review of the literature summarized below.

|  |  |
| --- | --- |
| Efficiency Improvement  Estimate | Source |
| 3% | 1 [A] |
| 3% | 1 [B] |
| 1% to 2% | 1 [C] |
| 0.4% to 4.8% | 1 [D] |
| 2% | 2 |
| 2% | Consensus Median |

# MEASURE CASE DESCRIPTION

The measure case is defined as the replacement of smooth V-belts in nonresidential package rooftop HVAC systems with cogged (or notched) V-belts.

# BASE CASE DESCRIPTION

The base case is defined as a nonresidential package rooftop HVAC system with typical existing smooth fan belts.

# CODE REQUIREMENTS

This measure is not governed by federal or state standards. The 2019 California Building Energy Efficiency Standards (Title 24)3 and the California Appliance Efficiency Regulations (Title 20)4 address nonresidential package and split HVAC systems. However, these requirements do not directly affect the fan belt or its operating characteristics and thus do not impact the assumptions that quantify the demand reduction and energy savings methodologies for this measure. HVAC contractors should be licensed by the California State Licensing Board (CSLB) and the HVAC technicians should be EPA-certified. State code does not require a building and/or job permit for HVAC system maintenance and repairs.

2 U.S. Department of Energy (DOE) 2012. “Energy Efficiency and Renewable Energy, Advanced Manufacturing Office. Energy Tips

* Motor Systems. Motor System Tip Sheet #5.” DOE/GO-102012-3740. November.

3 California Energy Commission (CEC). 2018. *2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.* CEC-400-2018-020-CMF.

4 California Energy Commission (CEC). Title 20. Division 2. *Appliance Efficiency Regulations.* CEC-400-2019-002. January 2019. Section 1605.1(a)(5)(C)(2).

Applicable State and Federal Codes and Standards

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Date |
| CA Appliance Efficiency Regulations – Title 20 | None. | Jan 2019 |
| CA Building Energy Efficiency Standards – Title 24 | None. | 01/01/2020 |
| Federal Standards | None. | n/a |

# NORMALIZING UNIT

Per cooling ton.

# PROGRAM REQUIREMENTS

*Measure Implementation Eligibility*

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

*Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.*

Implementation Eligibility

|  |  |  |
| --- | --- | --- |
| Measure Application Type | Delivery Type | Sector |
| Normal replacement (NR) | DnDeemDI | Com |
| Normal replacement (NR) | DnDeemed | Com |
| Normal replacement (NR) | UpDeemed | Com |
| New construction (NC) | DnDeemDI | Com |
| New construction (NC) | DnDeemed | Com |
| New construction (NC)) | UpDeemed | Com |
| Normal replacement (NR) | DnDeemDI | Ind |
| Normal replacement (NR) | DnDeemed | Ind |
| Normal replacement (NR) | UpDeemed | Ind |
| New construction (NC) | DnDeemDI | Ind |
| New construction (NC) | DnDeemed | Ind |
| New construction (NC)) | UpDeemed | Ind |

*Eligible Products*

A cogged V-belt can be installed on supply air and return air fans in rooftop units that do not already have a cogged V-belt.

Only the “A” and “B” V-belts are applicable for this measure.

*Eligible Building Types and Vintages*

This measure is applicable for package rooftop HVAC systems in the following nonresidential building types. The measure is eligible for all vintages (old, existing, recent and new)

|  |  |  |
| --- | --- | --- |
|  | DEER Building Prototype | |
| Assembly | | Health/Medical – Nursing Home |
| Education – Community College | | Office – Large |
| Education – Primary School | | Office – Small |
| Education – Secondary School | | Restaurant - Fast-Food |
| Education – University | | Restaurant - Sit-Down |
| Education – Relocatable Classroom | | Retail - Multistory Large |
| Health/Medical – Hospital | | Retail - Single-Story Large |
| Lodging – Hotel | | Retail – Small |
| Lodging – Motel | | Storage – Conditioned |
| Manufacturing - Bio/Tech | | Grocery |
| Manufacturing – Light Industrial | |  |

*Eligible Climate Zones*

This measure is applicable in all California climate zones.

# PROGRAM EXCLUSIONS

This measure is not applicable if the rooftop unit already has cogged V-belts.

# DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

# USE CATEGORY

HVAC

# ELECTRIC SAVINGS (KWH)

The electric unit energy savings (UES) of the replacement of a smooth V-belt with a cogged V-belt of a gas pack system, and a heat pump system were derived from building energy use energy simulations.

MASControl3, released on 30 Sept 2018, an updated version of the measure analysis software for DEER2020 is used to generate UES values for the measures. MASControl3 uses the DOE-2.3/ eQuest 3.65

simulation engine and generates the energy usage and DEER2020 peak kW savings. The following is the step by step procedure for calculation methodology.

* + MASControl3 (MC3) does not have a measure for cogged V-Belt. Hence, the following existing measures are replicated and modified as follows:
    - MC3 Measure ID: NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-wPreEcono
    - MC3 Measure ID: NE-HVAC-airHP-SpltPkg-65to134kBtuh-11p5eer-3p4cop
    - The measure case supply fan power is reduced by 2% to account for the efficiency of cogged V-belt.
    - A global parameter names “BeltFactor” is created which is set to 1.0 for base case and

0.98 for measure case.

* + - The DOER2.3 keyword SUPPLY-KW/FLOW is multiplied with the “BeltFactor”
  + With the above modifications, batch processing is run in MC3 for all climate zones and vintages. The output file will include unit energy and demand values for baseline, measure and savings, and the total capacity in tons of the AC units.
  + While the measure is run for gas packs (airAC/cDXGF) and heat pumps (airHP/cDXHP), only the savings for airAC are considered since it is not easy to track the type of HVAC in downstream and upstream delivery channels, most of the HVAC systems in the industry are gas packs and the average savings of airHP are only 7% lower than airAC.
  + The UES from the above steps for year-style vintages are transformed into era-style vintages using weighted average approach with weights the DEER2020 building weights5. For ease of implementation, the old and recent vintages are dropped out. Only the UES for existing and new are considered.

Please refer to MC3 and eQuest support files6 and calculation file7 for details.

# PEAK ELECTRIC DEMAND REDUCTION (KW)

Peak demand reduction values were derived using the methodology presented in Electric Savings.

# GAS SAVINGS (THERMS)

Gas unit energy savings (UES) values were derived using the methodology presented in Electric Savings.

# LIFE CYCLE

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would

5 DEER2020-Building-Weights.xlsx from <http://www.deeresources.com/index.php/deer-versions/deer2020#PkPeriod>

6 SWHC026-02 MC3 and eQuest files

7 SWHC026-02 Energy ImpactAnalysis.xlsx

have remained in service and operational had the program intervention not caused the replacement or alteration.

The estimated lifetime of a V-belt is 24,000 hours8. The fan runtime varies by building type. This runtime is extracted from eQuest REPORT- SS-E Building HVAC Load Hours – Hours Fan ON. The fan runtime varies by climate zone but climate zone 9 selected to extract the runtime assuming it represents the median weather. The EUL is calculated as the belt life divided by the number of occupancy hours per year; the inputs are specified below.

*EUL = Belt Life / Hours Fan ON*

Estimated Useful Life Input Assumptions

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Source |
| Belt Life (hours) | 24,000 | [A] Jim Cole, "Summary of Findings of CIEE Technology Assessment of Energy- Efficient Belt Transmission," Cogged V-belts typical efficiency improvement of 3%... University of California Berkeley, Memorandum, August 17, 1994. Attached paper by Almeida, Anibal De, University of Coimbra, and Steve  Greenberg, Lawrence Berkeley laboratory. |
| Occupancy Hours  (hours/yr) | Varies by  building type, | derived from eQUEST SIM report “SS-E Building HVAC Load Hours”. |

EUL Based on DEER Prototype Occupancy Hours

|  |  |  |
| --- | --- | --- |
| DEER Building Prototype | Occupancy  Hours per Year | EUL (Years) 9 |
| Assembly | 5517 | 4.4 |
| Education-Community College | 4336 | 5.5 |
| Education-Primary School | 2998 | 8 |
| Education-Relocatable Classroom | 3374 | 7.1 |
| Education-Secondary School | 4165 | 5.8 |
| Education-University | 4684 | 5.1 |
| Grocery | 8760 | 2.7 |
| Health/Medical - Hospital | 8760 | 2.7 |
| Lodging - Hotel | 8760 | 2.7 |
| Manufacturing Biotech | 3664 | 6.6 |
| Manufacturing Light Industrial | 3946 | 6.1 |
| Lodging - Motel | 8760 | 2.7 |
| Health/Medical - Nursing Home | 8760 | 2.7 |
| Office - Large | 3547 | 6.8 |
| Office - Small | 3848 | 6.2 |
| Restaurant - Fast-Food | 6935 | 3.5 |
| Restaurant - Sit-Down | 5111 | 4.7 |
| Retail - Multistory Large | 5155 | 4.7 |

8 Jim Cole, "Summary of Findings of CIEE Technology Assessment of Energy-Efficient Belt Transmission," Cogged V-belts typical efficiency improvement of 3%... University of California Berkeley, Memorandum, August 17, 1994. Attached paper by Almeida, Anibal De, University of Coimbra, and Steve Greenberg, Lawrence Berkeley laboratory.

9 EUL Analysis tab in SWHC026-02 Energy Impact Analysis.xlsx

|  |  |  |
| --- | --- | --- |
| DEER Building Prototype | Occupancy  Hours per Year | EUL (Years) 9 |
| Retail - Single-Story Large | 5508 | 4.4 |
| Retail - Small | 4855 | 4.9 |
| Storage - Conditioned | 4985 | 4.8 |
| Warehouse - Refrigerated | 8760 | 2.7 |

# BASE CASE MATERIAL COST ($/UNIT)

Methodology outlined below was followed to calculate baseline equipment cost:

1. Costs of industry standard V-Belts of types A and B for sizes 20”, 40”, 60”, and 80” were obtained from the online cost database Grainger.com and Mcmaster.com as of Q4 of 2020.
2. Average cost per inch of standard belt was calculated from the above step.
3. Product data which includes belt length and existing belt type was gathered for 50 packaged units representing two manufacturers, 5 models, 15 different nominal capacities ranging from 2 ton to 50 tons. The cost of belt was calculated estimated for each unit by multiplying cost per inch from Step 2 and belt length.
4. From the above step, cost of standard belt per ton was then calculated by dividing cost per belt by system tonnage.

# MEASURE CASE MATERIAL COST ($/UNIT)

Methodology outlined below was followed to calculate measure case cost:

1. Costs of cogged V-Belt of types A and B for sizes 20”, 40”, 60”, and 80” were obtained from the online cost database Grainger.com and Mcmaster.com as of Q4 of 2020.
2. Average cost per inch of cogged belt was calculated from the above step.
3. Product data which includes belt length and existing belt type was gathered for 50 packaged units representing two manufacturers, 5 models, 15 different nominal capacities ranging from 2 ton to 50 tons. The cost of belt was calculated estimated for each unit by multiplying cost per inch from Step 2 and belt length.
4. From the above step, cost of cogged V-Belt per ton was then calculated by dividing cost per belt by system tonnage.

# BASE CASE LABOR COST ($/UNIT)

Labor cost per hour of $85.90 was taken from RSMeans 2021 Standard Labor Rate10 for skilled workers averaged over 35 trades. Assuming that it would take around 20 minutes to replace the belt, labor cost per belt was estimated at $28.63. Labor cost per ton was calculated by dividing cost per belt by product capacity determined in step 3 in material cost section.

10 RSMeans Engineering Department. 2020. *RSMeans 2021 Standard Union Labor Rates*

# MEASURE CASE LABOR COST ($/UNIT)

It is assumed that the labor cost for cogged V-Belt will be same as the cost of installing a smooth fan belt. Please refer to the cost calculations file11 for base and measure material and labor cost.

# NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. The NTG value based upon the average of all NTG ratios for all evaluated 2006 – 2008 commercial, programs, as documented in the 2011 DEER Update

Study conducted by Itron, Inc. This sector average NTG (“default NTG”) is applicable to all energy efficiency measures that have been offered through commercial sector programs for more than two years and for which impact evaluation results are not available.

Net-to-Gross Ratios

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Source |
| NTG – Commercial | 0.60 | Itron, Inc. 2011. *DEER Database 2011 Update Documentation.* Prepared  for the California Public Utilities Commission. Page 15-4 Table 15-3. |
| NTG - Industrial | 0.60 | Itron, Inc. 2011. *DEER Database 2011 Update Documentation.* Prepared  for the California Public Utilities Commission. Page 15-4 Table 15-3. |

# GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. The GSIA rate for this measure is the current “default” rate specified for measures for which an alternative GSIA has not been estimated and approved.

Gross Savings Installation Adjustment Rates

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Source |
| GSIA | 1.0 | California Public Utilities Commission (CPUC), Energy Division.  2013. *Energy Efficiency Policy Manual Version 5*. Page 31. |

# NON-ENERGY IMPACTS

Non-energy benefits for this measure have not been quantified.

11 SWHC026-02 Cost Calculation.xlsx

# DEER DIFFERENCES ANALYSIS

This section provides a summary of DEER-based inputs and methods, and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

|  |  |
| --- | --- |
| DEER Item | Comment / Used for Workpaper |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | Yes |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes |
| DEER Version | DEER2020 |
| Reason for Deviation from DEER | Measure not available in DEER. DEER2020 prototypes are used to model the measure. |
| DEER Measure IDs Used | n/a |
| NTG | Source: DEER. The NTG of 0.60 is associated with NTG ID: *Com- Default>2yrs; Ind-Default>2yrs* |
| GSIA | Source: DEER. The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA* |
| EUL/RUL | Source: Calculated using DEER Building Prototype occupancy hours and assumed total V-belt lifetime. The EUL years varies by building type for EUL ID: *HV-CoggedBelt*. |

# REVISION HISTORY

Measure Characterization Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision Number | Revision Complete Date | Primary Author, Title, Organization | Revision Summary and Rationale for Revision |
| 01 | 09/30/2018 | Jennifer Holmes Cal TF Staff | Draft of consolidated text for this statewide measure is based upon:  PGECOHVC144, Revision 2 (March 16, 2016)  SCE13HC040, Revision 2 (February 9, 2015)  SCE13HC040, Revision 1 (April 14, 2014) Consensus reached among Cal TF members. |
| 01 | 06/11/2019 | Akhilesh Endurthy Solaris-Technical | DEER2020 and E-4952 updates New prototypes from DEER2020  Included “NC” Measure Application Type |
| 02 | 11/11/2020 | Jenna Moon Solaris-Technical | Updated the costs using recent database |