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HVAC

COGGED V-BELT FOR HVAC FAN, COMMERCIAL

SWHC026-01

CONTENTS

MEASURE NAME

Cogged V-Belt for HVAC Fan, Commercial

STATEWIDE MEASURE ID

SWHC026-01

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)

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[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.
[B] "Gates Corporation Announces New EPDM Modeled Notch V-belts” http://www.gates.com/news/index.cfm?id=11296$show=newsitem&location _id=753&view=Gates. Accessed on June 2010.
[C] 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.
[D] "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.”[2]

The fan system efficiency improvement estimate of 2% is based on an engineering review of the literature summarized below.

Estimates of Fan System Efficiency Improvement

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.

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[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).

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

Applicable State and Federal Codes and Standards

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 weights[5]. 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 files[6] and calculation file[7] 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] SWHC024-01 MC3 and eQuest files

[7] SWHC024-01 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 hours[8]. 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”.

DEER

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 SWHC024-01 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 is 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 taken from the 2018 online cost database Grainger.com.
2. Average cost per inch of standard belt was calculated from the above step.
3. Given program participation data for 2010 – 2017, package units of sizes 7.5-ton and 10-ton with various belt lengths were considered and cost per belt was estimated for each unit by multiplying cost per inch from Step 2 and belt length. The unit capacities were based on SCE provided mean and standard deviation estimates of systems capacities per program participation.
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 is followed to calculate measure case cost:

1. 2018 costs of cogged V-Belt of types A and B for sizes 20”, 40”, 60”, and 80” were taken from the online cost database Grainger.com.
2. Average cost per inch of cogged belt was calculated from the above step.
3. Given program participation data for 2010 – 2017, package units of sizes 7.5 tons and 10 tons with various belt lengths and counts were considered and cost per belt was estimated for each unit. The unit capacities were based on SCE provided mean and standard deviation estimates of systems capacities per program participation.
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 $70.69 for HVAC Package unit was taken from 2010-2012 WO017 Cost Study Report[10] from *Table 4-3: Installation Cost Estimates for Split-System and Packaged DX and HP* for Small and Large Package Unit DX systems. Using the Historical Cost Index from RSMeans 2018[11], an escalation factor for California average is calculated for 2018 compared to 2013 which is the RSMeans reference year for WO017. Assumed that it would take around 20 minutes to replace the belt and using the escalation factor, labor cost per belt is estimated at $26.62 Labor cost per ton was calculated by dividing cost per belt determined in step 3 in material cost section.

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[10] 2010-2012 WO017 Ex Ante Measure Cost Study Final Report, May 27,2014

[11] RSMeans Engineering Department. 2018. *RSMeans Electrical Cost Data 2018*

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 file[12] 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.

[12] SWHC024-01 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