Work Paper SCE17HC040

**Revision 0**

**Southern California Edison Company**

**Cogged V-Belt Non-Residential HVAC Fans**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Measure Codes:**** | AC-46275 - HVAC Fan Cogged V-Belt replacing Smooth V-Belt |
| **Measure Description:** | The replacement of smooth V-belts in non-residential package rooftop HVAC systems with cogged V-belts |
| **Base Case Description:** | Standard smooth fan belts |
| **Units:** | Per ton |
| **Energy Savings:** | Refer to Excel Calculation Attachment 1 |
| **Full Measure Cost ($/unit):** | Refer to Excel Calculation Attachment 1 and 3 |
| **Incremental Measure Cost ($/unit):** | Refer to Excel Calculation Attachment 1 and 3 |
| **Effective Useful Life:** | 2.7 to 5 years, depending on building type - EUL ID: HV-CoggedBelt (EUL for building types not available on READi Tool v2.4.7 are adopted from previous version of the workpaper - SCE13HC040.2 and described in corresponding Section 1.1 herein) |
| **Measure Application Type:** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratio:** | 0.60; NTG ID: Com-Default>2yrs |
| **Important Comments:** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Rev | Date | Author | Summary of Changes |
| 0 | 12/26/2017 | Arvind Subramanya/TRC | - This work paper is an update of SCE13HC040.2  - Updated with new 2017 calculation template  - Updated 2016 Title-24 code language.  - Updated cost from 2018 Grainger.com and 2010-2012 WO017 Cost Study Report  - All Climate Zones are included in this update. |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
|  |  |  |  |  |  |

Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

This work paper details the replacement of smooth v-belts in non-residential unitary (packaged) rooftop HVAC systems and split system HVAC units with cogged v-belts. The base case is a rooftop unit (RTU) that contains one or more smooth v-belts. The measure replaces them with new cogged (notched) v-belts. The savings are calculated for applicable commercial building types served by rooftop HVAC systems in all California climate zones. The savings are based on only the electric portion of the unitary system.

## 1.1 Measure Description & Background

**Measure Description:** This measure is the replacement of smooth v-belts with cogged v-belts in nonresidential package rooftop HVAC systems.

**Base Case Description:** Standard Smooth V-Belts in Non-Residential Package Rooftop HVAC Systems.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Cogged V-Belts in Non-Residential Package Rooftop HVAC Systems |
| Existing Condition | Smooth V-Belts in Non-Residential Package Rooftop HVAC Systems |
| Code/Standard | N/A |
| Industry Standard Practice | Smooth V-Belts in Non-Residential Package Rooftop HVAC Systems |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | AC-46275 |  | HVAC Fan Cogged V-Belt replacing Smooth V-Belt |

**Eligibility Requirements:** The participant must have electricity distributed by subject Utility to the installation service address. This measure does not apply if the RTU already has cogged V-belts.

**Implementation Requirements:** This measure can be applied to supply air and return air fans in RTUs that do not already have a cogged V-belt installed. As part of the CQM program design, measure implementation will be conducted by a trained contractor for systems participating in the CQM that are only equipped with Smooth V-Belt. HVAC systems served by non-Smooth V-Belt do not qualify for this incentive.

**Documentation Requirements:** The installer must certify that the existing unit does not have a cogged v-belt in place to qualify. Other requirements are set by each program that offers the measure.

**Standard Practice Baselines**

Methodology for adjusting standard practice baseline is focused on the “building vintages” in relation to the mechanical system’s expected useful life. Given that the EUL of HVAC systems receiving the energy efficiency measure is in the order of 15 years; it is expected to a degree that this offering is mostly applicable to HVAC systems that have not drastically exceeded its EUL; hence, measure savings on this version of the workpaper have been adjusted to exclude early building vintages, e.g., 1975 and 1985.

## 1.2 Technical Description

A V-belt typically connects the motor and the supply air fan. Some of the larger unitary equipment may also have a v-belt between the return air motor and fan. According to NREL’s Energy Tips [E], about one-third of the electric motors in the industrial and commercial sectors use belt drives. Further, the majority of belt drives use V-belts. V-belts use a trapezoidal cross section to create a wedging action on the pulleys to increase friction and the belt’s power transfer capability.

This referenced study [E] suggests that vast majority of HVAC installations are expected to be equipped with Smooth V-belt technology; however, the study cannot be used (with a high level of certainty) to stablished Smooth V-belt technology as the Industry Standard Practice condition. Further, program offering is only applicable to HVAC systems that are (as the existing condition) equipped with Smooth V-belt technology.

The typical 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 ½ inch width by 5/16 inch thickness. 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 available from various vendors. The cogged version of these belts typically have an “X” added to the designation or model number. For this HVAC Fans Cogged V-Belt Replacement measure, only the “A” and “B” v-belts are considered. 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 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.

In particular, four research papers [A][B][C][D] show that the cogged v-belt efficiency is 0.4% to 4.8% better than a typical smooth v-belt. A fifth paper by USDOE’s Energy Efficiency and Renewable Energy [E] group reviewed most of the earlier literature and recommended using a conservative 2% overall efficiency improvement of the supply fan, motor and drive for energy savings for calculations.

## 1.3 Installation Types and Delivery Mechanisms

The installation type is:

* **Replace On Burn-out (ROB).**

The delivery method is:

* **Direct Install**
* **Down-Stream Incentive – Deemed**
* **Mid-Stream Incentive**

Currently the measure is offered by SCE in the Commercial Quality Maintenance and Commercial Quality Renovation programs, but may be added to other programs at the discretion of Program Administrators.

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Mid-Stream Programs | *See Mid-Stream Incentive in the Incentive Method Descriptions table.* |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The utility program performs an assessment of the customer’s facility, provides recommendations, and implements energy efficiency measures for free. |
| Down-Stream Incentive - Deemed | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. |
| Mid-Stream Incentive | The utility program offers buydowns and incentives to third parties (typically retailers, distributors, and contractors), who then stock, promote, lower prices on, and/or sell energy efficient equipment. Contractors install energy efficiency equipment, sometimes using specified quality procedures, at the customer’s property. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

This measure is currently not supported by DEER. The measure is evaluated using DEER2014 commercial prototypes generated by MASControl v3.00.19 using the Customer Average (CAv) case option for the following tech IDs:

* D08-NE-HVAC-airAC-SpltPkg-110to134kBtuh-11p0eer
* D08-NE-HVAC-airHP-SpltPkg-110to134kBtuh-11p5eer-3p4cop
* D08-NE-ILtg-Power-Exit-60pct (for “Lodging – Motel” building type only)

The first two tech IDs are able to create Customer Average prototypes for every building type except “Lodging – Motel” with a gas pack or heat pump system type. Selecting the tech IDs with the “110to134kBtuh” simulated system cooling capacity provides the greatest number of prototype models while staying close to the assumed cooling capacity range for units within the utility programs. The “Lodging – Motel” building type was created for both system types using the third tech ID.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | Yes |
| Scaled DEER measure | No |
| DEER Base Case | Yes |
| DEER Measure Case | Yes |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | yes |
| DEER Version | N/A |
| Reason for Deviation from DEER | Measure not available in DEER |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool v2.4.7. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR ID | Description | Sector | BldgType | ProgDelivID | NTG |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years; Customer Rebate | Com | Any | Any | 0.60 |

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI tool v2.4.7. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

However, the EUL does not apply to fan v-belt life. A v-belt has a life based on fan run hours which varies by building type based primarily on occupancy schedule because the fans have to run continuously during all occupied hours. The supply and return fans will also run a few hours during unoccupied hours for heating and cooling as needed. Unoccupied fan hours for cooling are essentially zero in southern California due to thermostat set up and the major reduction in internal cooling loads (appliances off, lighting reduced to emergency only, and no people). In spite of thermostat setbacks, unoccupied fan hours for heating can be significant in cold climates since internal heat gains are small. In most SCE climate zones the majority of non-residential buildings have a low heating requirement. Therefore, the fan belt life can be based on the occupancy schedule.

*Equation 1 EUL = Belt Life / Occupancy Hours per year*

*Where:*

*Belt Life is 24,000 hours [A]*

*Occupancy Hours per year from table below.*

The EUL for the measure is 24,000 hours divided by the annual hours from the eQUEST run report “SS-L Fan Energy/Hours”. This analysis was applied to 21 DEER Building Prototypes as listed in table below. The eight building types marked by an asterisk (\*) are the large buildings and they have central supply air systems usually with variable volume. DEER2014 EUL ID values based on the previous revision of this work paper are also included in the table below. The previous revision had fewer building types, and therefore the DEER2014 EUL IDs are not available for the additional building types.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Building Type** | **EUL (Years)** | **RUL (Years)** | **Occupancy Hours per Year\*\*** | **EUL**  **Source** |
| HV-CoggedBelt | Assembly | 4.7 | 1.6 | 5,110 | READi Tool  2.4.7 |
| HV-CoggedBelt | Education – Community College\* | 5.0 | 1.7 | 3,828 | READi Tool  2.4.7 |
| HV-CoggedBelt | Education – Primary School | 5.0 | 1.7 | 2,616 | READi Tool  2.4.7 |
| HV-CoggedBelt | Education – Secondary School\* | 5.0 | 1.7 | 2,840 | READi Tool  2.4.7 |
| HV-CoggedBelt | Education – University\* | 2.7 | 0.9 | 4,671 | WP SCE13HC040.2 |
| HV-CoggedBelt | Education – Relocatable Classroom | 2.7 | 0.9 | 5,012 | WP SCE13HC040.2 |
| HV-CoggedBelt | Health/Medical – Hospital \* | 2.7 | 0.9 | 8,760 | WP SCE13HC040.2 |
| HV-CoggedBelt | Lodging – Hotel\* | 2.7 | 0.9 | 8,760 | WP SCE13HC040.2 |
| HV-CoggedBelt | Lodging – Motel\* | 2.7 | 0.9 | 8,760 | WP SCE13HC040.2 |
| HV-CoggedBelt | Manufacturing - Bio/Tech | 2.7 | 0.9 | 3,514 | WP SCE13HC040.2 |
| HV-CoggedBelt | Manufacturing – Light Industrial | 5.0 | 1.7 | 3,514 | READi Tool  2.4.7 |
| HV-CoggedBelt | Health/Medical – Nursing Home\* | 2.7 | 0.9 | 8,760 | READi Tool  2.4.7 |
| HV-CoggedBelt | Office – Large\* | 5.0 | 1.7 | 3,974 | READi Tool  2.4.7 |
| HV-CoggedBelt | Office – Small | 5.0 | 1.7 | 3,371 | READi Tool  2.4.7 |
| HV-CoggedBelt | Restaurant - Fast-Food | 3.5 | 1.2 | 6,935 | READi Tool  2.4.7 |
| HV-CoggedBelt | Restaurant - Sit-Down | 4.7 | 1.6 | 5,110 | READi Tool  2.4.7 |
| HV-CoggedBelt | Retail - Multistory Large\* | 5.0 | 1.7 | 4,482 | READi Tool  2.4.7 |
| HV-CoggedBelt | Retail - Single-Story Large | 4.4 | 1.5 | 5,475 | READi Tool  2.4.7 |
| HV-CoggedBelt | Retail – Small | 5.0 | 1.7 | 4,745 | READi Tool  2.4.7 |
| HV-CoggedBelt | Storage – Conditioned | 2.7 | 0.9 | 4,707 | WP SCE13HC040.2 |
| HV-CoggedBelt | Grocery | 2.7 | 0.9 | 6,570 | WP SCE13HC040.2 |
| \* DEER Building Prototypes marked with an asterisk do not have RTUs but have central HVAC systems with variable air flow and a combination of Single zone VAV, Fan Coil, and VAV Reheat.  \*\*Occupancy hours derived from eQUEST SIM report SS-L Fan Energy. | | | | | |

### 1.4.2 Codes and Standards Analysis

2016 Title 24 [501] 2016 Title 20 [508] include some content related to non-residential package and split HVAC systems, which are the target system types for this measure. 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 the measure. Title 24 does not deal with maintenance issues. HVAC contractors should be licensed by the California State Licensing Board (CSLB) and the HVAC technicians should be EPA certified. Under state code, performance of maintenance and repairs does not require a building and/or job permit.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | N/A | 1/1/2017 |
| Title 20 (2016) | N/A | 11/1/2016 |

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

### 1.5.1 Non-DEER Study Review

The efficiency improvement is a conservative estimate based on an engineering review of research literature as shown in the below table. This is in agreement with USDOE’s assessment of the same literature as shown in their Motor Systems Tips #5 [E] where they suggest 2% as a median value for fan system efficiency improvement in HVAC systems with Type A and Type B cogged v-belts only.

Fan System Efficiency Improvement

|  |  |
| --- | --- |
| **Reference Source** | **Range of Efficiency Improvement** |
| [A] | 3% |
| [B] | 3% |
| [C] | 1% to 2% |
| [D] | 0.4% to 4.8% |
| [E] | 2% |
| Consensus Median | 2% |

## 1.6 Data Quality and Future Data Needs

N/A

# Section 2: Calculation Methodology

Energy savings and demand reduction were estimated by performing eQUEST [F] simulations. This is because these are non-DEER measures. The simulations used the DEER prototypes described in Section 1.4.1 as the baseline case. Keyword changes were then completed to simulate an improvement in fan system efficiency, and corresponding reduction in fan heat added to the airstream.

## 2.1 Energy Simulation with eQUEST

eQUEST is a DOE2[[1]](#footnote-1) based simulation software package used to produce estimates of energy and demand in buildings. The DEER non-residential building prototypes were simulated using eQUEST-3.64, consisting of 21 different building types. The 21 DEER non-residential building types were simulated with three different HVAC unit types: AC Only, Gas Packs, and Heat Pumps. The only building type that does not have all three HVAC unit types available through MASControl is the “Education – Relocatable Classroom” which can only be produced with a gas pack. All 21 DEER non-residential building types are in table below with an “X” indicating when the building type was simulated with the corresponding HVAC unit type. The AC Only unit type was not simulated, instead using the results from the Gas Pack simulations and ignoring the therm energy use.

DEER Prototype Non-residential Building Types Simulated per HVAC Type

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Building  Type** | **Abbreviated Building Types** | **AC Only** | **Gas Pack** | **Heat Pump** |
| Assembly | Asm | **X** | **X** | **X** |
| Education - Community College | ECC | **X** | **X** | **X** |
| Education - Primary School | EPr | **X** | **X** | **X** |
| Education - Relocatable Classroom | ERC | **X** | **X** |  |
| Education - Secondary School | Ese | **X** | **X** | **X** |
| Education - University | EUn | **X** | **X** | **X** |
| Grocery | Gro | **X** | **X** | **X** |
| Health/Medical - Hospital | Hsp | **X** | **X** | **X** |
| Health/Medical - Nursing Home | Nrs | **X** | **X** | **X** |
| Lodging - Hotel | Htl | **X** | **X** | **X** |
| Lodging - Motel | Mtl | **X** | **X** | **X** |
| Manufacturing - Bio/Tech | MBT | **X** | **X** | **X** |
| Manufacturing - Light Industrial | MLI | **X** | **X** | **X** |
| Office - Large | OfL | **X** | **X** | **X** |
| Office - Small | OfS | **X** | **X** | **X** |
| Restaurant - Fast-Food | RFF | **X** | **X** | **X** |
| Restaurant - Sit-Down | RSD | **X** | **X** | **X** |
| Retail - Multistory Large | Rt3 | **X** | **X** | **X** |
| Retail - Single-Story Large | RtL | **X** | **X** | **X** |
| Retail - Small | RtS | **X** | **X** | **X** |
| Storage - Conditioned | SCn | **X** | **X** | **X** |

These commercial prototypes were simulated for each of the four non-residential vintages shown in table below. Each vintage has a different cooling load and may have different building and system component properties based either on code or standard practice at the time.

DEER Prototype Non-residential Vintages

|  |  |
| --- | --- |
| **Vintage** | **Years Represented** |
| Vintage 96 | 1993 to 2001 |
| Vintage 3 | 2002 to 2005 |
| Vintage 7 | 2006 to 2011 |
| Vintage 11 | After 2011 |

Each of the building prototypes were run through eQUEST with the 16 CZ2010 weather data.

To simulate the HVAC Fans Cogged V-Belt Replacement measure in eQUEST, (DOE2) keyword values were changed to represent an improvement in fan efficiency and the corresponding reduction of fan heat entering the air stream. Table below indicates the required keyword(s) values to change per each HVAC system in the prototype model:

List of Modified eQUEST Keywords

|  |  |
| --- | --- |
| **HVAC Unit Type** | **Keyword** |
| Gas Pack | SYSTEM:SUPPLY-KW/FLOW |
| Gas Pack | SYSTEM:SUPPLY-DELTA-T |
| Heat Pump | SYSTEM:SUPPLY-EFF |

The base case for each DEER non-residential prototype model requires no changes to the existing keyword values. The modifications required for simulating the HVAC Fans Cogged V-Belt Replacement measure case depend on the eQUEST keywords being utilized by default within each DEER prototype. The HVAC Fans Cogged V-Belt Replacement measure case for prototypes with Gas Pack units required modifying the supply fan energy per air flow and using that value to update any dependent keywords, as shown in the following calculations:

*Measure Case SYSTEM:SUPPLY-KW/FLOW = Base Case SYSTEM:SUPPLY-KW/FLOW \* 0.98*

*Measure Case SYSTEM:SUPPLY-DELTA-T = Measure Case SYSTEM:SUPPLY-KW/FLOW \* 3090*

*Where 3090 is the default factor to approximate temperature rise as a function of supply fan energy according to the eQUEST DOE-2 Dictionary.*

The HVAC Fans Cogged V-Belt Replacement measure case for prototypes with Heat Pump units required directly modifying the supply fan efficiency, as shown in the following calculation:

*Measure Case SYSTEM:SUPPLY-EFF = Base Case SYSTEM: SUPPLY-EFF \* 1.02*

## 2.2 Electric Energy Savings Estimation Methodologies

The calculation of electric energy use for the base case and measure case followed the methodology discussed in Section 2.0. The savings for the HVAC Fans Cogged V-Belt Replacement measure are estimated as follows.

*Fan System Energy Savings [kWh/ton-year] = Base Case Annual Fan System Energy Use – Measure Case Annual Fan System Energy Use*

*Where:*

*Base Case Annual Fan System Energy Use = Output from eQUEST runs*

*Measure Case Annual Fan System Energy Use = Output from eQUEST runs*

### Base Case

The base case is the existing system as described by the unmodified DEER prototype models as described in Sections 1.4.1. The electric demand reduction for the HVAC Fans Cogged V-Belt Replacement measure is estimated according to the DEER2014 peak demand period definitions. The DEER peak demand period methodology requires taking the average hourly peak demand during a defined time period for both the baseline and measure case.

The electric demand reduction for the HVAC Fans Cogged V-Belt Replacement measure is then estimated as follows:

*Fan System Demand Reduction [kW/ton-year] = Base Case Peak Demand – Measure Case Peak Demand*

*Where:*

*Base Case Peak Demand = Average Hourly DEER-defined Peak Demand from eQUEST Hourly Output*

*Measure Case Peak Demand = Average Hourly DEER-defined Peak Demand from eQUEST Hourly Output*

## 2.3 Gas Energy Savings Estimation Methodologies

The SCE measure does not distinguish between system type and therefore does not estimate gas savings.

# Section 3: Load Shapes

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, the closest load shape chosen for this measure is the DEER: HVAC\_Split-Package\_AC load shape. See table below for a list of all Building Types and Load Shapes. A more thorough discussion regarding the load shapes for this measure is available [31]. The closest load shape chosen is indicated below:

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | Load Shape | E3 Alternate Building Type |
| All | DEER: HVAC\_Split-Package\_AC | NON\_RES |

# Section 4. Costs

## 4.1 Base Case Cost

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.
5. Labor cost per hour of $70.69 for HVAC Package unit was taken from 2010-2012 WO017 Cost Study Report [475] from *Table 4-3: Installation Cost Estimates for Split-System and Packaged DX and HP* for Small and Large Package Unit DX systems. It was assumed that it would take around 20 minutes to replace the belt. Cost per belt was estimated based on this assumption at $23.56 per belt.
6. Labor cost per ton was calculated by dividing cost per belt calculated in step 5 by unit size in tons.
7. Base case total cost was calculated by adding material and labor costs from the above steps.

Below table shows the standard V-Belt costs:

|  |  |  |
| --- | --- | --- |
| **Standard V-Belt Cost** | | |
| **Material Cost ($/Ton)** | **Labor Cost ($/Ton)** | **Base Case Cost ($/Ton)** |
| $1.90 | $2.75 | $4.65 |

Please refer to Attachment #2 for belt cost calculation.

## 4.2 Measure Case Cost

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, material cost of cogged V-Belt per ton was then calculated by dividing cost per belt by system tonnage.
5. Labor cost per hour of $70.69 for HVAC Package unit was taken from 2010-2012 WO017 Cost Study Report [475] from *Table 4-3: Installation Cost Estimates for Split-System and Packaged DX and HP* for Small and Large Package Unit DX systems. It was assumed that it would take around 20 minutes to replace the belt. Cost per belt was estimated based on this assumption at $23.56 per belt.
6. Labor cost per ton was calculated by dividing cost per belt calculated in step 5 by unit size in tons.
7. Measure case cost was calculated by adding material and labor costs from the above steps.

Below table shows the cogged V-Belt costs:

|  |  |  |
| --- | --- | --- |
| **Cogged V-Belt Cost** | | |
| **Material Cost ($/Ton)** | **Labor Cost ($/Ton)** | **Base Case Cost ($/Ton)** |
| $2.36 | $2.75 | $1.90 |

Please refer to Attachment #2 for belt cost calculation.

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| AC-91987 | ROB | $0.46 | $0.46 | N/A |

# Attachments

1. SCE17HC040.0 - Calculation Template
2. SCE17HC040.0 - CVB\_PostProcessing\_ReWeighed 12\_04\_2017
3. SCE17HC040.0 – Belt Cost Calculation

# References

References in this version of the work paper is based on the references file *“[References\_11152017\_131456]”*.

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5. Motor System Tip Sheet #5, Replace V-belts with Cogged or Synchronous Belt Drives,” USDOE-EERE, September 2005. (Specified 2% based on review of same references) <http://www1.eere.energy.gov/industry/bestpractices/pdfs/replace_vbelts_motor_systemts5.pdf>
6. eQUEST – building energy use and cost analysis software, developed by James J. Hirsch & Associates, version 3.64.

1. www.doe2.com [↑](#footnote-ref-1)