Work Paper SCE17HC029

**Revision 1**

**Southern California Edison**

**Residential HVAC Quality Maintenance**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | AC-20329, AC-20326, AC-20327, AC-20328, AC-56069, AC-95345, AC-94699, AC-60036, AC-21964 |
| **Measure Description** | HVAC Quality Maintenance treatments: Refrigerant charge adjustment, condenser coil cleaning, evaporator coil cleaning, air flow adjustment, duct seal medium to low, and duct seal high to low |
| **Base Case Description** | Central air-cooled direct expansion cooling and gas heating without adequate Quality Maintenance |
| **Units** | Ton |
| **Energy Savings** | Refer to Excel Calculation Attachment 1 |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment 1 |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment 1 |
| **Effective Useful Life** | 10 years (HV-RefChrg)  3 years (HV-ResAC-CleanCoil)  5 years (HV-ResRCx)  18 years (HV-DuctSeal) |
| **Measure Installation Type** | Retrofit Add-On (REA) |
| **Net-to-Gross Ratio** | Res-Default>2 (0.55)  Res-sAll-mDuctSeal (0.78)  Res-sAll-mHVAC-RCA (0.78) |
| **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 | 05/30/2017 | Arvind Subramanya/TRC; Andres Fergadiotti/SCE | * This work paper is an update of SCE13HC029.4 * New calculation template update for 2017 program year * Work paper is updated with 2016 Title-24 code requirement and 2016 California Building Code language. * Measure impacts have been updated to DEER 2018 and DEER 2017 values from READI v2.4.7 tool. * Measure cost has been updated with costs from WO017 Cost Study Report and 2016 RSMeans as indicated in the costs section of the workpaper. * The measure AC-16390 Design Capacity Sizing was removed from the measure list. * EUL values have been updated to match DEER 2017/2018. * All the 16 California Climate Zones have been added. |
| 1 | 05/22/2018 | Stephen Brett Reno/TRC | * Updated RCA per latest DEER2018 update * Updated Measure Costs (RSMeans and WO017 cost sources) to 2018 values * Updated GSIA values * Removed Hard to Reach language |

# 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

## 1.1 Measure Description & Background

This work paper details the Residential HVAC Quality Maintenance (QM) measures for packaged and split system HVAC units. These treatments are related to ductwork and HVAC unit optimization.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Residential HVAC Quality Maintenance (QM) |
| Existing Condition | Residential HVAC – Standard Non-QM System |
| Industry Standard Practice | (ACCA) Standard 4 for “Maintenance of Residential HVAC Systems” |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| N/A | N/A | AC-20329 | N/A | Decrease Refrigerant Charge - System with No thermal expansion valve (TXV) - Typical (8% rated charge) |
| N/A | N/A | AC-20326 | N/A | Decrease Refrigerant Charge - System with thermal expansion valve (TXV) - Typical (8% rated charge) |
| N/A | N/A | AC-20327 | N/A | Increase Refrigerant Charge - System with No thermal expansion valve (TXV) - Typical (8% rated charge) |
| N/A | N/A | AC-20328 | N/A | Increase Refrigerant Charge - System with thermal expansion valve (TXV) - Typical (8% rated charge) |
| N/A | N/A | AC-56069 | N/A | Condenser Coil Cleaning |
| N/A | N/A | AC-95345 | N/A | Evaporator Coil Cleaning |
| N/A | N/A | AC-94699 | N/A | Air Flow Adjustment |
| N/A | N/A | AC-60036 | N/A | Duct Seal Med to Low |
| N/A | N/A | AC-21964 | N/A | Duct Seal High to Low |

Residential Single Family, Multifamily, and Double-wide Mobile Homes in all California climate zones that use central air-cooled direct expansion cooling and gas heating are eligible. The participant must have electricity distributed by Southern California Edison (SCE) and/or applicable IOU to the installation service address. Additionally, the following prerequisites must be met before the Quality Maintenance measures can be implemented:

* Unit and system must be capable of delivering a supply air flow rate of at least 350 cfm/ton after treatments related to airflow are completed and before refrigerant charge is tested and/or adjusted.
* Unit must be drawing power.
* Unit must have a condenser over ambient temperature (COAT) of at least 3 degrees.
* Customer must agree to QM Service Agreement.

The 350 cfm/ton airflow requirement ensures that the refrigerant system can be properly diagnosed and charged. If the system is not delivering 350 cfm/ton upon initial inspection, an assessment should be made to determine if the system will be able to deliver 350 cfm/ton by implementing some or all of the QM treatments related to airflow. If it is determined that the supply fan and duct system in place do not have the capability to deliver 350 cfm/ton after the airflow treatments have been performed, refrigerant charge cannot be properly diagnosed, rendering the QM process incomplete and the savings in this work paper invalid.

If some or all of the existing ductwork is beyond repair and sections must be replaced, the sections that must be replaced must be less than 40 linear feet in total per 2016 Title 24 Section 150.2(b), or the replaced ductwork must be installed and tested in accordance with the applicable requirements in 2016 Title 24 Section 150.2(b)1D [496].

The level of maintenance by technicians on a typical air conditioner or Heat Pump equipment is minimal with service being performed at an unacceptable level. This may eventually lead to unit failure and/or poor performance, forcing premature equipment replacement. In response to this problem, Air Conditioner Contractors of America (ACCA) developed Standard 4 for “Maintenance of Residential HVAC Systems” [1]. For the measures contained in this work paper, an assessment and report is required in accordance with ACCA Standard 4 prior to any treatments being applied to determine the baseline conditions and to develop treatment recommendations.

## 1.2 Technical Description

Proper maintenance of the unit enables an Air Conditioner or Heat Pump HVAC equipment to operate at or near its optimal efficiency. The Quality Maintenance measures are treatments designed to increase the unit’s ability to deliver heating and cooling efficiently and to provide increased thermal comfort. An example of a performance/parameter improvement is: Refrigerant Charge Adjustment improves EER and Cooling Capacity. Treatments are further detailed in the report.

## 1.3 Installation Types and Delivery Mechanisms

The delivery methods are:

* Financial Support – Downstream Incentive – Deemed

The install types are:

* Retrofit Add-on (REA)

|  |  |
| --- | --- |
| **Measure Code** | **Measure Name** |
| AC-20329 | Decrease Refrigerant Charge - System with No thermal expansion valve (TXV) - Typical (8% rated charge) |
| AC-20326 | Decrease Refrigerant Charge - System with thermal expansion valve (TXV) - Typical (8% rated charge) |
| AC-20327 | Increase Refrigerant Charge - System with No thermal expansion valve (TXV) - Typical (8% rated charge) |
| AC-20328 | Increase Refrigerant Charge - System with thermal expansion valve (TXV) - Typical (8% rated charge) |
| AC-56069 | Condenser Coil Cleaning |
| AC-95345 | Evaporator Coil Cleaning |
| AC-94699 | Air Flow Adjustment |
| AC-60036 | Duct Seal Med to Low |
| AC-21964 | Duct Seal High to Low |

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Retrofit Add-on (REA) | Above Customer Existing | 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. |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Down-Stream Incentive | 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. Such an incentive may be deemed or customized. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

DEER 2018 contains some of the QM treatments as standalone measures, with the assumption that all other features of the prototype are held constant at an energy efficient baseline; the standalone measures are: refrigerant charge and adjustment, duct sealing, refrigerant charge with duct sealing, and commercial condenser coil cleaning. All measure impacts are adopted directly from referenced DEER version or derived from DEER and/or CPUC disposition (e.g., Coil cleaning treatments).

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | Yes (as noted) |
| 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 | DEER 2017 and 2018 per READI v2.4.8 |
| Reason for Deviation from DEER | N/A |
| DEER Measure IDs Used | RE-HV-RefChrg-Inc-NoTXV-typ (sample measure ID) |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI v2.4.8 tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Solution Code** | **NTGR ID** | **Description** | **Sector** | **Bldg Type** | **Measure Delivery** | **NTGR** |
| AC-94699 | Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Res | Any | All | 0.55 |
| AC-60036,  AC-21964 | Res-sAll-mDuctSeal | Duct Sealing | Res | Any | PreReb | 0.78 |
| AC-20329,  AC-20326,  AC-20327,  AC-20328,  AC-56069,  AC-95345 | Res-sAll-mHVAC-RCA | HVAC Maintenance: Refrigerant Charge Adjustment (RCA) | Res | Any | PreReb | 0.78 |

**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 v2.4.8 tool. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Solution Code** | **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| AC-20329,  AC-20326 AC-20327,  AC-20328, AC-94699 | Res-RCA-All | Residential Refrigerant Charge & Airflow Adjustment | Res | Any | Any | 0.568 |
| AC-56069,  AC-95345 | Def-GSIA | Default GSIA values | Any | Any | Any | 1 |
| AC-60036,  AC-21964 | Res-DuctSeal-All | Residential Duct Sealing, Annual Installation Rate | Res | Any | Any | 0.463 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI v2.4.8 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.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Solution Code** | **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| AC-20329,  AC-20326,  AC-20327,  AC-20328 | HV-RefChrg | Refrigerant Charge - Residential | Res | HVAC | N/A | 3.3 |
| AC-56069,  AC-95345 | HV-ResAC-CleanCoil | Clean Condenser Coils – Residential | Res | HVAC | N/A | 1.0 |
| AC-94699 | HV-ResRCx | Residential HVAC assessment report & maintenance contract | Res | HVAC | N/A | 1.7 |
| AC-60036,  AC-21964 | HV-DuctSeal | Duct Sealing | Res | HVAC | N/A | 6.0 |

### 1.4.2 Codes and Standards Analysis

The measure contained in this work paper is generally not governed by either state or federal codes and standards.

However, in the event that ducts are found to be so badly damaged that some or all of the ductwork must be replaced, the total length of the replaced ducts shall be less than 40 linear feet in total per 2016 Title 24 Section 150.2(b) 1D, or the replaced ductwork must be installed and tested in accordance with the applicable requirements in 2016 Title 24 Section 150.2(b) 1D Altered Duct Systems - Duct Sealing –

*“The altered duct system, regardless of location, shall be sealed as confirmed through field verification and diagnostic testing in accordance with all applicable procedures for duct sealing of altered existing duct systems as specified in the Reference Residential Appendix RA3.1, utilizing the leakage compliance criteria specified in Reference Residential Appendix TABLE RA3.1-2, and conforming to either Subsection a or b below:*

1. *Entirely New or Complete Replacement Duct System. If the new ducts form an entirely new or replacement duct system directly connected to the air handler, the measured duct leakage shall be equal to or less than 5 percent of the system air handler airflow as confirmed by field verification and diagnostic testing utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1. Entirely new or complete replacement duct systems installed as part of an alteration shall be constructed of at least 75 percent new duct material, and up to 25 percent may consist of reused parts from the dwelling unit's existing duct system, including but not limited to registers, grilles, boots, air handler, coil, plenums, duct material; if the reused parts are accessible and can be sealed to prevent leakage. Entirely new or complete replacement duct systems shall also conform to the requirements of Section 150.0(m)12 and 150.0(m)13.” [496].*

Title 24 does not deal with quality maintenance; however, the program requires the HVAC contractor to be licensed by the California State Licensing Board (CSLB) and the HVAC technicians to be EPA certified. Under state mechanical code, changes, alterations, or repairs of a minor nature not affecting structural features, egress, sanitation, safety, or accessibility as determined by the enforcing agency are exempt from the requirement to obtain a mechanical permit.

In the 2016 California Building Code [505], regarding Section 1.8.4 Permits, Fees, Applications, and Inspections, a written construction permit shall be obtained from the enforcing agency prior to the erection, construction, reconstruction, installation, relocation, or alteration of any mechanical system.

Exceptions:

1. Work exempt from permits as specified in Chapter 1, Administration, Division II, Sections 112.2 through 112.2.3 of this code.
2. Changes, alterations, or repairs of a minor nature not affecting structural features, egress, sanitation, safety, or accessibility as determined by the enforcing agency.

Code Summary

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Names** | **Code** | **Reference** | **Effective Dates** |
| Duct Seal Med to Low  Duct Seal High to Low | Title 24 Part 6 (2016) | Section 150.2(b) 1D Altered Duct Systems - Duct Sealing | January 1, 2017 |
| All | Title 24 Part 2 (2016) | Section 1.8.4 Permits, Fees, Applications, and Inspections | January 1, 2017 |

## 

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

**Impact Evaluation of 2015 Commercial Quality Maintenance Programs (HVAC3)**

This report presents the impact evaluation of the 2015 HVAC Quality Maintenance (QM) programs. The specific programs evaluated were Residential QM (PG&E, SDG&E), Commercial QM (PG&E), AirCare Plus (PG&E), QM (SCE and SoCalGas), Deemed (SDG&E), and Direct Install (SDG&E). The evaluation focused on the impacts of three residential measures implemented through the QM programs (coil cleaning, supply fan, and refrigerant charge adjustment (RCA)) and the five commercial measures with the highest claimed savings across the QM programs

## 1.6 Data Quality and Future Data Needs

SCE is currently collecting data on the prevalence of thermal expansion valves within their customer base. This information is expected to be used in future workpaper updates for adjusting as applicable other RQM measures – e.g., Condenser Coil Cleaning, Evaporator Coil Cleaning, and Air Flow Adjustment measures.

# Section 2. Calculation Methodology

Energy savings and demand reductions for all RQM treatments in previous revision of the workpaper were based primarily on the May 2, 2013 Energy Division Workpaper Disposition for Residential Quality Maintenance – See Attachment 4 [367].

In this revision, energy savings and demand reductions are adopted (as applicable) from DEER2017 and/or DEER2018 documentation specifically DEER READI v2.4.8 tool. Measure impacts for Adjusted Refrigerant Charge and Duct Sealing treatments are taken directly from DEER. Coil Cleaning measures are derived using Disposition’s recommended contributions as a function of the Adjusted Refrigerant Charge measure (DEER2018).

The following measure IDs with associated calculation methods are overviewed below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Solution Code** | **MeasureID** | **Description** | **Methodology** | **Source** |
| AC-20329 | RE-HV-RefChrg-Dec-NoTXV-typ | Decrease Refrigerant Charge - System with No thermal expansion valve (TXV) - Typical (8% rated charge) | DEER | DEER2018 |
| AC-20326 | RE-HV-RefChrg-Dec-TXV-typ | Decrease Refrigerant Charge - System with thermal expansion valve (TXV) - Typical (8% rated charge) | DEER | DEER2018 |
| AC-20327 | RE-HV-RefChrg-Inc-NoTXV-typ | Increase Refrigerant Charge - System with No thermal expansion valve (TXV) - Typical (8% rated charge) | DEER | DEER2018 |
| AC-20328 | RE-HV-RefChrg-Inc-TXV-typ | Increase Refrigerant Charge - System with thermal expansion valve (TXV) - Typical (8% rated charge) | DEER | DEER2018 |
| AC-60036 | Res-DuctSeal-HighToLow-wtd | Residential: Duct Sealing (Total Leakage Reduced from High (40/35%) to Low (15/12%) | DEER | DEER2017 |
| AC-21964 | Res-DuctSeal-MedToLow-wtd | Residential: Duct Sealing (Total Leakage Reduced from Medium (25/24%) to Low (15/12%) | DEER | DEER2017 |
| AC-56069 | Non-DEER | Condenser Coil Cleaning | Savings = 0.1250 \* (Res-RefrigCharge-Wtd) | Disposition/DEER2018 |
| AC-95345 | Non-DEER | Evaporator Coil Cleaning | Savings = 0.0625 \* (Res-RefrigCharge-Wtd) | Disposition/DEER2018 |
| AC-94699 | Non-DEER | Air Flow Adjustment | (Res-RCA-wtd) –  (Res-RefrigCharge-wtd) | Non-DEER (as a function of DEER2018) |

Calculation methodology supporting the workpaper update is further described below.

1. The DEER2018 measure ID “Res-RCA-wtd” is a market-weighted average of refrigerant charge adjustments. DEER2018 D17v1 updated the Refrigerant Charge Adjustment measure to differentiate between an increase or decrease in refrigerant charge, and systems with and without a thermal expansion valve (TXV). The RCA only measures (AC-20329, AC-20326, AC-20327, AC-20328) use the more specific DEER2018 D17v1 measures, while the coil cleaning (AC-56069 and AC-95345) and air flow adjustment (AC-94699) measures base their savings on the market-weighted average DEER measures. SCE is currently evaluating the prevalence of TXVs in their customer participation, and may update future measure savings based on new data.
2. The DEER2018 measure ID “Res-RCA-wtd” consists of both Refrigerant Charge Adjustment and Air Flow Adjustment measures. The DEER measure ID “Res-RefrigCharge-wtd” consists of only Refrigerant Charge Adjustment measure. Air Flow Adjustment measure impacts are calculated by subtracting the impacts of “Res-RCA-wtd” from “Res-RefrigCharge-wtd”. Refer to Attachment 2 for Impacts calculation sheet.
3. Condenser cleaning measure impacts were calculated as a fraction of the Refrigerant Charge Adjustment (Res-RefrigCharge-wtd) measure impacts. Fraction value of 0.125 was used based on referenced CPUC’s disposition (Attachment 2).
4. Evaporator cleaning measure savings impacts were calculated as a fraction of the Refrigerant Charge Adjustment (Res-RefrigCharge-wtd). Fraction value of 0.0625 was used based on referenced CPUC’s disposition (Attachment 2).
5. Duct Sealing (High-low and Medium-Low) measure savings were taken from READI v2.4.8 tool based on DEER2017 version using MeasureIDs Res-DuctSeal-HighToLow-wtd and Res-DuctSeal-MedToLow-wtd respectively. See Attachment 2.

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Residential Single Family | DEER:HVAC\_Eff\_AC | RES |
| Residential Multifamily | DEER:HVAC\_Eff\_AC | RES |
| Residential Mobile Home - Double-Wide | DEER:HVAC\_Eff\_AC | RES |

# Section 4. Costs

Costs for measures in this version of the workpaper have been updated to scale WO017 [475] costs to 2018 using RS Means Historical Cost Index (15.9% increase) and 2018 RS Means Mechanical Cost Data [514] documentation (See Attachment 5 and Attachment 6).

## 4.1 Base Case Cost

The base case is the customer’s existing equipment; therefore the base case cost is $0 for all the measures.

## 4.2 Measure Case Cost

### In this revision of the workpaper, both material and labor costs have been updated to scale WO017 [475] costs to 2018 costs using RS Means Historical Cost Index and 2018 RS Means Mechanical Cost Data [514].

### The RSMeans Historical Cost Index can be used to compare costs of projects between different cities and years. The ratio of cost indexes provides the percent change expected in the price between the specified years. As WO017 was completed in 2012, the 2018 cost index for Los Angeles was compared with 2012 to find an increased cost of 15.9%. This value was applied to the WO017 costs calculated below to scale them to reflect 2018 costs.



*2012 Los Angeles Cost Index: 207.2*

*2018 Los Angeles Cost Index: 240.2*

Percent Increase = [(2018 Index -2012 Cost Index)/ 2012 Cost Index] x 100%

Percent Increase = [(240.2-207.2)/207.2] x 100%= 15.9%

Cost calculation methodology for each measure is as described below.

### 4.2a Refrigerant Charge Adjustments

Measure cost for these measures was not available in 2018 RS Means, hence, it is based on WO017 and scaled to 2018 costs using RS Means Historical Cost Index.

Note that the costing is for commercial applications, however, it is expected (to a great extent) to be consistent with residential application considering the similarity in the scope of work.

The material and labor costs use costs from WO017 Section F.2 Simple Average and Built-Up Estimates – HVAC Maintenance Category. The table below shows the RCA costs from WO017 [475].



WO017 costs were scaled from 2012 to 2018 using RS Means Historical Cost Index (15.9% increase). The table below shows the updated 2018 costs. The costs are assumed to be the same for all RCA measures.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure** | **WO017 Material Cost/Ton** | **WO017 Labor Cost/Ton** | **2012 to 2018 Cost Increase** | **2018 Material Cost/Ton** | **2018 Labor Cost/Ton** | **Total Cost/Ton** |
|
| Refrigerant Charge Adjustment  (AC-20329, AC-20326, AC-20327, AC-20328) | $9.92 | $26.78 | 15.9% | $11.50 | $31.04 | $42.54 |

### 4.2b Duct Sealing

### The material and labor costs are based on WO017 [475] and are scaled from 2012 to 2018 using RS Means Historical Cost Index.

Cost calculation methodology for Duct Sealing measure is described below:

1. The work paper has (2) categories under the duct sealing measure:
2. Duct Sealing (Total Leakage Reduced from 24% of AHU flow to 12%)
3. Duct Sealing (Total Leakage Reduced from 40% of AHU flow to 12%)
4. Cost sources such as 2018 RS Means Cost data and 2010-2012 Work Order 017 - Ex\_Ante Measure Cost Study were researched. 2010-2012 Work Order 017 - Ex\_Ante Measure Cost Study provides costs very specific to this measure and has been considered as the primary source.
5. WO017 provides costs for a typical Duct Sealing measure and does not involve additional categories as mentioned in the Step 1 above. Therefore, material and labor cost for both the categories are assumed to be the same in the workpaper.
6. Material and labor costs for the duct sealing measure taken from WO017 study report are $71.45 per Dwelling and $181.24 per Dwelling respectively. Costs are taken from *Section F.2 Simple Average and Built-Up Estimates – HVAC Maintenance Category*.
7. The WO017 study has been scaled from 2012 to 2018 using the RS Means Historical Cost Index (15.9% increase); therefore, the material and labor costs have been updated to $82.81 per Dwelling and $210.06 per Dwelling respectively.
8. Average tonnage for a single family, climate zone and vintage weighted is considered as 3.27 tons/dwelling. Duct sealing cost per ton is calculated in the table below. Costs for both duct seal measures are assumed to be the same.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Measure** | **WO017 Material Cost  ($ per Dwelling)** | **WO017 Labor Cost  ($ per Dwelling)** | **2012 to 2018 Cost Increase** | **2018 Material Cost  ($ per Dwelling)** | **2018 Labor Cost  ($ per Dwelling)** | **Material Cost  ($ Per Ton)** | **Labor Cost  ($ Per Ton)** | **Total Cost  ($ Per Ton)** |
| Duct Seal  (AC-60036  AC-21964) | $71.45 | $181.24 | 15.9% | $82.81 | $210.06 | $25.32 | $64.24 | $89.56 |

### 4.2c Condenser and Evaporator Coil Cleaning

1. Costs sources such as 2018 RS Means Cost data and WO017 [475] were researched. WO017 [475], *Section F.2 Simple Average and Built-Up Estimates – HVAC Maintenance Category*, provides costs specific to this measure and has been considered as the primary source.
2. Coil cleaning costs for a residential unit was not available in WO017 [475], therefore, costs for a non-residential unit is taken, as the coil cleaning will involve similar steps irrespective of the type of facility
3. The WO017 [475] per-Ton cost for cleaning condenser coils is $6.73 for material and $25.66 for labor. Similarly per-Ton cost for cleaning evaporator coils is $7.98 for material and $33.70 for labor.
4. The WO017 study has been scaled from 2012 to 2018 using the RS Means Historical Cost Index (15.9% increase); therefore, the per-Ton cost for cleaning condenser coils is $7.80 for material and $29.74 for labor. Similarly per-Ton cost for cleaning evaporator coils is $9.25 for material and $39.06 for labor.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure** | **WO017 Material Cost/Ton** | **WO017 Labor Cost/Ton** | **2012 to 2018 Cost Increase** | **2018 Material Cost/Ton** | **2018 Labor Cost/Ton** | **Total Cost/Ton** |
|
| Condenser Coil Cleaning  (AC-56069) | $6.73 | $25.66 | 15.9% | $7.80 | $29.74 | $37.54 |
| Evaporator Coil Cleaning  (AC-95345) | $7.98 | $33.70 | 15.9% | $9.25 | $39.06 | $48.31 |

### 4.2d Air Flow Adjustment

1. In this revision of the workpaper, material and labor costs for the air flow adjustment measure were updated based on 2018 RS Means Mechanical Cost Data [514] – Section: *Rooftop heating and cooling unit – Air Balance*.
2. The cost provided is on a per unit basis, however, size of the unit in tons is not provided.
3. It is assumed that the per-household cost for an air flow adjustment is the labor cost of an air balance on a Package AC Unit, which is $350.00 from 2018 RS Means Mechanical Cost Data [514].





1. There is no material cost involved as the measure involves only labor work for adjusting the airflow in the equipment.

Labor Cost: $350.00/3.27 = $107.03 per Ton **= Total Airflow Adjustment Cost = $107.03 per Ton**

Where average tonnage for a single family, climate zone and vintage weighted is 3.27 tons/household.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure** | **Material Cost  ($ per Household)** | **Labor Cost  ($ per Household)** | **Material Cost  ($ per Ton)** | **Labor Cost  ($ Per Ton)** | **Total Cost  ($ Per Ton)** |
| Airflow Adjustment  (AC-94699) | $0.00 | $350.00 | $0.00 | $107.03 | $107.03 |

## 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** |
| REA | (MEC + MLC) | (MEC + MLC) | 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-20329 | REA | $42.54 | $42.54 | N/A |
| AC-20326 | REA | $42.54 | $42.54 | N/A |
| AC-20327 | REA | $42.54 | $42.54 | N/A |
| AC-20328 | REA | $42.54 | $42.54 | N/A |
| AC-56069 | REA | $37.54 | $37.54 | N/A |
| AC-95345 | REA | $48.31 | $48.31 | N/A |
| AC-94699 | REA | $107.03 | $107.03 | N/A |
| AC-60036 | REA | $89.56 | $89.56 | N/A |
| AC-21964 | REA | $89.56 | $89.56 | N/A |

# Attachments

1. SCE17HC029.1 A1 - Calculation Template\_Final
2. SCE17HC029.1 A2 - Impacts Calculation
3. SCE17HC029.1 A3 - Measure Definitions and Impacts
4. SCE17HC029.1 A4 - RQM Savings Disposition
5. SCE17HC029.1 A5 - Costs Update
6. SCE17HC029.1 A6 - RSMeans Cost Index

# References

# References in this version of the work paper is based on the references file *“[References\_05092018\_135230]”*.

# References used in this work paper are listed below:

[367]

[475]

[496]

[505]

[514]

[1] ACCA, “Maintenance of Residential HVAC Systems” - ANSI/ACCA Standard 4, 2008. <https://www.acca.org/industry/ansi-standards>