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## HVAC

# SWSV006-01 REFRIGERANT CHARGE, RESIDENTIAL

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## MEASURE NAME

Refrigerant Charge Adjustment, Residential

## STATEWIDE MEASURE ID

SWSV006-01

## TECHNOLOGY SUMMARY

Proper maintenance of an air conditioner (AC) or heat pump HVAC equipment will enable the equipment to operate at or near its optimal efficiency. Quality maintenance (QM) measures are treatments designed to increase the effectiveness of HVAC equipment to deliver heating and cooling and increased thermal comfort.

The level of maintenance by technicians on a typical AC or heat pump unit 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”.<sup>1</sup>

The impact evaluation of 2015 commercial quality maintenance programs (HVAC3) conducted by DNV GL<sup>2</sup> analyzed the impacts of three residential measures implemented through the QM programs: coil cleaning, supply fan, and refrigerant charge adjustment – RCA (as well the five commercial measures with the highest claimed savings across the 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).

## MEASURE CASE DESCRIPTION

This measure is defined as a performance/parameter improvement which improves the EER and cooling capacity of a unit by applying treatment that either increases or decreases refrigerant charge with or without thermal expansion. The different charge states associated with each measure represent either the undercharged state for the system or overcharged state of the system.

Overcharge measures address systems experiencing higher than manufacturer rated flows of refrigerant through the evaporator, which results in system inefficiencies due to the refrigerant not entirely transitioning to saturated vapor and subsequently superheated vapor, thus having a low superheat. Undercharge measures address systems with high superheat, where lower than manufacture rated refrigerant volumes pass through the evaporator too slow resulting in all the refrigerant being converted to saturated vapor and reaching a superheated state prematurely. Both scenarios reduce capacity and

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<sup>1</sup> Air Conditioning Contractors of America (ACCA). 2019. *Maintenance of Residential HVAC Systems*. ANSI/ACCA Standard 4 QM – 2019.

<sup>2</sup> DNV GL. 2017. *Impact Evaluation of 2015 Commercial Quality Maintenance Programs (HVAC3)*. Prepared for the California Public Utilities Commission. April 7.

efficiency, through undercharge typically reduces both performance measures more severely, thus yielding more energy savings when an undercharge measure is applied.<sup>3</sup>

Measure offerings are defined by the type of refrigerant charge (increase or decrease) and if the system has or does not have a thermal expansion valve (TXV). The 4%, 8%, and 16% indicate the amount of recharge, or reduction (in the case of over-charged units) required to meet the manufacturer specified refrigerant volume for each unit; typically, the larger the percentage, the greater energy savings are yielded. Provided below is a list of the eight measures:

- Decrease Refrigerant Charge - System with No TXV - Typical (8% rated charge)
- Decrease Refrigerant Charge - System with TXV - Typical (8% rated charge)
- Increase Refrigerant Charge - System with No TXV - Typical (8% rated charge)
- Increase Refrigerant Charge - System with TXV - Typical (8% rated charge)
- Increase Refrigerant Charge – System with No TXV (16% rated charge)
- Increase Refrigerant Charge – System with TXV (16% rated charge)
- Increase Refrigerant Charge – System with No TXV (4% rated charge)
- Increase Refrigerant Charge – System with TXV (4% rated charge)

## BASE CASE DESCRIPTION

The base case for this measure is defined as a non-treated HVAC system.

## CODE REQUIREMENTS

This measure is not governed by federal or state appliance or building standards. The California Building Energy Efficiency Standards (Title 24) does not deal with quality maintenance (QM) treatments. Notably, the California mechanical code states that changes, alterations, or repairs of a minor nature that do *not* affect structural features, egress, sanitation, safety, or accessibility as determined by the enforcing agency are exempt from the requirement to obtain a mechanical permit.

Note, however, the program requires the HVAC contractor to be licensed by the California State Licensing Board (CSLB) and that HVAC technicians are certified by the U.S. Environmental Protection Agency (EPA).

### Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20 (2019)	None	1/1/2019
CA Building Energy Efficiency Standards – Title 24 (2019)	None	1/1/2019
Federal Standards	None	n/a

<sup>3</sup> More information on refrigerant levels and their impact on energy efficiency available here:

<https://www.buildingscience.com/documents/information-sheets/refrigerant-charge>

## NORMALIZING UNIT

Tons of cooling capacity (Cap-Tons)

## PROGRAM REQUIREMENTS

### *Measure Implementation Eligibility*

All measure application type, delivery type, and sector combinations 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.

### Implementation Eligibility

Measure Application Type	Delivery Type	Sector
BRO-RCx	Direct Install	Res
BRO-RCx	Down-Stream Incentive	Res
BRO-RCx	Up-Stream Incentive	Res

Note: Up-Stream Incentive is being left as an approved Delivery Type to enable Midstream offerings.

### *Eligible Products*

The following prerequisites must be met before the Quality Maintenance (QM) treatments, such as refrigerant charge adjustments, can be implemented:

- The unit and system must be capable of delivering a supply air flow rate of at least 350 cfm/ton after treatments related to air flow are completed and before refrigerant charge is tested and/or adjusted.
- The unit must be drawing power.
- The unit must have a condenser over ambient temperature (COAT) of at least 3 degrees.
- An assessment and report are required in accordance with ACCA Standard 4<sup>4</sup> prior to any treatments being applied to determine the baseline conditions and to develop QM treatment recommendations.
- The customer must agree to a QM Service Agreement.

The 350 cfm/ton air flow 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 air flow. 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 air flow treatments have been performed, refrigerant

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<sup>4</sup> Air Conditioning Contractors of America (ACCA). 2019. *Maintenance of Residential HVAC Systems*. ANSI/ACCA Standard 4 QM – 2019.

charge cannot be properly diagnosed, rendering the QM process incomplete and the savings in this work paper invalid.

#### *Eligible Building Types and Vintages*

This measure is applicable for residential single family, multifamily, and double-wide mobile homes that use central air-cooled direct expansion (DX) cooling and gas heating.

#### *Eligible Climate Zones*

This measure is applicable in all California climate zones.

### PROGRAM EXCLUSIONS

None.

### DATA COLLECTION REQUIREMENTS

Contractor must provide the amount and percent refrigerant charge added to or removed from the system to verify the applicable measure.

Further data requirements are to be determined.

### USE CATEGORY

HVAC

### ELECTRIC SAVINGS (kWh)

The electric unit energy savings (UES) of refrigerant charge adjustments of residential air conditioning (AC) units were derived from impacts in the Database of Energy Efficient Resources (DEER). All measures were updated in DEER2020. The results were reported in the Remote Ex-Ante Database Interface (READI) tool v2.5.1.

The refrigerant charge adjustment (RCA) measure in DEER uses the following Measure IDs:

- RE-HV-RefChrg-Dec-NTXV-typ
- RE-HV-RefChrg-Dec-TXV-typ
- RE-HV-RefChrg-Inc-NTXV-typ
- RE-HV-RefChrg-Inc-TXV-typ
- RE-HV-RefChrg-Inc-NTXV-typ -16pct
- RE-HV-RefChrg-Inc-TXV-typ-16pct
- RE-HV-RefChrg-Inc-NTXV-typ-4pct
- RE-HV-RefChrg-Inc-TXV-typ-4pct

## PEAK ELECTRIC DEMAND REDUCTION (kW)

The peak demand reduction of refrigerant charge adjustments of residential air conditioning (AC) units were derived from impacts in the Database of Energy Efficient Resources (DEER). All measures were updated in DEER2020 and reflect the change in the DEER peak demand period for 2020. The results were reported in the Remote Ex-Ante Database Interface (READI) tool v2.5.1.

The refrigerant charge adjustment (RCA) measure in DEER uses the following Measure IDs:

- RE-HV-RefChrg-Dec-NTXV-typ
- RE-HV-RefChrg-Dec-TXV-typ
- RE-HV-RefChrg-Inc-NTXV-typ
- RE-HV-RefChrg-Inc-TXV-typ
- RE-HV-RefChrg-Inc-NTXV-typ -16pct
- RE-HV-RefChrg-Inc-TXV-typ-16pct
- RE-HV-RefChrg-Inc-NTXV-typ-4pct
- RE-HV-RefChrg-Inc-TXV-typ-4pct

## GAS SAVINGS (THERMS)

The gas unit energy savings (UES) of refrigerant charge adjustments of residential air conditioning (AC) units were derived from impacts in the Database of Energy Efficient Resources (DEER). All measures were updated in DEER2020. The results were reported in the Remote Ex-Ante Database Interface (READI) tool v2.5.1.

The refrigerant charge adjustment (RCA) measure in DEER uses the following Measure IDs:

- RE-HV-RefChrg-Dec-NTXV-typ
- RE-HV-RefChrg-Dec-TXV-typ
- RE-HV-RefChrg-Inc-NTXV-typ
- RE-HV-RefChrg-Inc-TXV-typ
- RE-HV-RefChrg-Inc-NTXV-typ -16pct
- RE-HV-RefChrg-Inc-TXV-typ-16pct
- RE-HV-RefChrg-Inc-NTXV-typ-4pct
- RE-HV-RefChrg-Inc-TXV-typ-4pct

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

As per Resolution-4952<sup>5</sup> and Resolution-5009<sup>6</sup>, the California Public Utilities Commission (CPUC) created the Behavioral Operational Retrocommissioning (BRO-RCx) measure classification which provides corrected EUL and RUL values shown below.

#### Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs) (HV-RefChrg)	3	California Public Utilities Commission (CPUC), Energy Division. 2018. <i>DEER resolution E-4952</i> . 11 October 2018
RUL (yrs)	0	California Public Utilities Commission (CPUC), Energy Division. 2019. <i>Draft DEER resolution E-5009</i> . 15 August 2019

#### BASE CASE MATERIAL COST (\$/UNIT)

The base case is defined as the existing equipment; thus, the base case material cost is \$0.00.

#### MEASURE CASE MATERIAL COST (\$/UNIT)

The measure case material and labor cost for refrigerant charge adjustments were drawn from 2010-2012 WO017 Ex-Ante Measure Cost Study conducted by Itron, Inc.<sup>7</sup> This study reports costs for a “typical” refrigerant charge measure and does not distinguish between “decrease” and “increase”, inclusion of thermal expansion valve (TXV), or amount of refrigerant charge included. Therefore, the material cost for all measure offerings are assumed to be the same.

The cost data were scaled to 2018 cost values using an average of all 12 California cities in the 2018 RS Means Historical Cost Indexes table<sup>8</sup>. 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. A comparison of the cost indexes for 2012 and 2018 for the average of 12 California cities in the 2018 (209.3 and 239.9, respectively) reveals a cost increase of 14.6%. This percentage increase value was applied to the WO017 data to reflect 2018 costs.

Inputs to develop the measure case material costs are specified below.

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<sup>5</sup> California Public Utilities Commission (CPUC), Energy Division. 2018. *DEER resolution E-4952*. 11 October 2018

<sup>6</sup> California Public Utilities Commission (CPUC), Energy Division. 2019. *Draft DEER resolution E-5009*. 15 August 2019

<sup>7</sup> Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. Prepared for the California Public Utilities Commission.

<sup>8</sup> RSMeans Historical Cost Index <https://www.rsmeansonline.com/References/CCI/3-Historical%20Cost%20Indexes/3-Historical%20Cost%20Indexes.PDF>

**Measure Caset Material and Labor Cost Inputs**

Input	Value	Source
Refrigerant Charge Adjustment Material (\$/ton)	\$9.92	Itron, Inc. 2014. <i>2010-2012 WO017 Ex Ante Measure Cost Study Final Report</i> . Prepared for the California Public Utilities Commission.
Refrigerant Charge Adjustment Labor (\$/ton)	\$26.78	
Price index adjustment (%)	14.6%	RSMeans Historical Cost Index <a href="https://www.rsmeansonline.com/references/unit/refpdf/hci.pdf">https://www.rsmeansonline.com/references/unit/refpdf/hci.pdf</a> "RSMeans Cost Index.pdf"

**BASE CASE LABOR COST (\$/UNIT)**

The base case is defined as the existing equipment; thus, the base case labor cost is \$0.00.

**MEASURE CASE LABOR COST (\$/UNIT)**

See Measure Case Material 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. This sector average NTG ("default NTG") is applicable to all energy efficiency measures that have been offered through residential sector programs for more than two years and for which impact evaluation results are not available. Resolution E-4952 provides the DEER2020 updated NTG values for airflow adjustment under the "All Other Residential HVAC Maintenance" measure column of Table 7.

**Net-to-Gross Ratios**

Parameter	Value	Source
NTG - Res-Default>2	0.55	California Public Utilities Commission (CPUC), Energy Division. 2018. <i>DEER resolution E-4952</i> . 11 October 2018. Table 7

**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 specified GSIA is in conformance to the installation rate specified by the California Public Utilities Commission (CPUC) Energy Division in the "Workpaper Disposition for Residential HVAC Quality Maintenance" issued in May 2013.

**Gross Savings Installation Adjustment Rates**

Parameter	Value	Source
GSIA – Residential Refrigerant Charge & Air Flow Adjustment	0.568	GSIA ID: "Res-RAC-All: California Public Utilities Commission (CPUC), Energy Division, Ex Ante Review Team. 2013. "Workpaper Disposition for Residential HVAC Quality Maintenance." May 2. Page 7.



## NON-ENERGY IMPACTS

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

## 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.

DEER2020 contains quality maintenance (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 condenser and evaporator coil cleaning. All measure impacts are adopted directly from referenced DEER version.

### DEER Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	Yes
DEER Measure Case	Yes
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER eQUEST Prototypes	No
DEER Version	DEER2020 per READI v2.5.1
Reason for Deviation from DEER	N/A
DEER Measure IDs Used	RE-HV-RefChrg-Dec-NoTXV-typ, RE-HV-RefChrg-Dec-TXV-typ, RE-HV-RefChrg-Inc-NoTXV-typ, RE-HV-RefChrg-Inc-TXV-typ RE-HV-RefChrg-Inc-NTXV-typ -16pct RE-HV-RefChrg-Inc-TXV-typ-16pct RE-HV-RefChrg-Inc-NTXV-typ-4pct RE-HV-RefChrg-Inc-TXV-typ-4pct
NTG	Source: DEER. The NTG of 0.55 is associated with NTG ID: <i>Res-Default&gt;2</i>
GSIA	Source: DEER. The GSIA of 0.568 is associated with GSIA ID: <i>Res-RCA-All</i>
EUL/RUL	Source: 2018 Resolution E-4952. EUL values of one to three years with retrocommissioning assigned a three-year EUL. 2019 Resolution E-5009. RUL value for BRO measures corrected to 0 years.

## REVISION HISTORY

## Measure Characterization Revision History

Revision Number	Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	09/30/2018	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: SCE17HC029, Revision 1 (May 22, 2018) WPSDGERERN001, Revision 3 (December 15, 2017) – short form WPSDGERERN001, Revision 0.1 (July 27, 2014) Consensus reached among Cal TF members.
	04/23/2019	Richard Williams TRC Companies	Updated Implementation Eligibility Table Updated DEER2020 for one measure Updated price index adjustment to include averages for state of CA Updated NTG values based on E-4952 Updated RUL value based on E-5009
	8/26/2019	Richard Williams TRC Companies	Updated measures to include TXV and NTXV Refrigerant undercharge states of 4% and 16% from DEER2020
	08/13/2021	Soe K Hla PG&E	Adopted all measures for PG&E