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**COMMERCIAL REFRIGERATION**  
**COMPRESSOR RETROFIT, MULTIPLEX**  
SWCR012-01

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**MEASURE NAME**

Compressor Retrofit, Multiplex

**STATEWIDE MEASURE ID**

SWCR012-01

**TECHNOLOGY SUMMARY**

This measure pertains to the replacement of an air-cooled existing single-compressor refrigeration system with a multiplex system. The measure includes the specification of floating head pressure and condenser control methods.

**MEASURE CASE DESCRIPTION**

The measure case is defined as the installation of a code-compliant, multiplex compressor refrigeration system with an air-cooled condenser.

**Measure Case Specification**

Statewide Measure Offering ID	Measure Offering Description
SWCR012A	Multiplex Compressor, Air-cooled

A multiplex-compressor refrigeration system consists of multiple compressors drawing from a common suction header (suction group) and serving any number of display fixtures. The suction group is controlled to satisfy the lowest temperature required by any of the attached display fixtures. For this reason, the display fixtures served by a given suction group usually have similar temperature requirements; separate suction groups are typically used for low-temperature and for medium-temperature demands.

This measure is considered a code baseline measure because there is no code that requires compressors to be configured in a multiplex arrangement. Even upon burnout, the store can choose to keep the compressors arranged as singles. The installation of a multiplex system that meets the minimum California Building Energy Efficiency Standards (Title 24) is a significant improvement of energy efficiency compared to retaining a single-compressor system design with new compressors. (See Code Requirements.)

**BASE CASE DESCRIPTION**

The base case is defined as an air-cooled single-compressor refrigeration system. In a single-compressor system, each display fixture or other refrigeration load has a dedicated compressor. The compressor will cycle ON/OFF according to the fixture temperature controller.

## CODE REQUIREMENTS

This measure is not governed by either state or federal codes and standards. The code/industry standard practice baseline complies with the California Building Energy Efficiency Standards (Title 24) for a new multiplex compressor system.

### Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	None.	n/a
CA Building Energy Efficiency Standards – Title 24 (2016)	Section 120.6(b)2	January 1, 2017
Federal Standards	None.	n/a

The minimum requirements for the multiplex configuration of this measure adhere to Title 24 guidelines. According to Section 120.6(b)2 of Title 24,<sup>1</sup> a new multiplex compressor system is required to use floating suction control logic and low-temperature systems must have liquid subcooling to 50 °F or below. Both the measure case and base case (code) baseline used to estimate savings comply with these code requirements.

The California Appliance Efficiency Regulations (Title 20), Section 1601 covers new appliances sold or offered for sale in California but does not apply to compressor configurations.

## NORMALIZING UNIT

Tons of cooling capacity (Cap-tons)

## 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.*

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<sup>1</sup> California Energy Commission. 2015. *2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*. CEC-400-2015-037-CMF.Section 120.6(b)2.

**Implementation Eligibility**

Measure Application Type	Delivery Type	Sector
Normal replacement	DnDeemed	Com

*Eligible Products*

The measure offerings defined for this measure include:

- The replacement of an existing air-cooled single-compressor system with an air-cooled multiplex system of “Title 24” or to-code efficiency; including both low- and medium-temperature sub-cooling.

The eligibility requirements include the following:

- Must replace stand-alone single-compressor system with a high-efficiency multiplex compressor system.
- Must include floating head pressure control to a minimum 70 °F setpoint.
- Air-cooled condensers must use fan cycling or variable speed fans.
- Only the suction groups that are mechanically subcooled to 50 °F are eligible for rebate.

*Eligible Building Types*

This measure is applicable to any existing commercial building type, and the following vintage categories:

- Prior to 1978 (“1975”)
- 1978 - 1992 (“1985”)
- 1993 - 2001 (“1996”)
- 2002 - 2005 (“2003”)
- 2006 - 2009 (“2007”)
- 2010 - 2013 (“2011”)
- 2014 – 2016 (“2015”)
- 2017 – 2019 (“2017”)
- After 2019 (“2020”)

*Eligible Climate Zones*

This measure is applicable in all California climate zones.

**PROGRAM EXCLUSIONS**

Floating head pressure control is excluded from this measure.

**DATA COLLECTION REQUIREMENTS**

Data collection requirements are to be determined.

## USE CATEGORY

Commercial refrigeration (ComRefrig)

## ELECTRIC SAVINGS (kWh)

The unit energy savings (UES) for this measure are based upon values retrieved from the 2008 version of the Database for Energy Efficient Resources (DEER). The savings for this measure were computed from energy use modeled in the DEER 2020 Grocery Prototype eQUEST models.<sup>2</sup> The models were generated from MAS Control V3.00.19. That information can be identified in the database as measures D03-214 and D03-215.

### Baseline Energy Use Consumption Models:

Different methodologies were employed to model the baseline single compressor system energy use for both code baseline and early retirement baselines for vintage 2011 and earlier, and vintages 2015 and newer. Because there were no updates to the prototype store for vintage 2011 and earlier, the (original) MAS Control V3.00.19 models were used for the early retirement baseline energy use. However, the code baseline version of the models needed to be updated since the original MAS Control baselines were several years old. For the code baseline, single compressor systems with efficient compressors and condensers were used to represent an updated code baseline.

For vintages 2015 and newer, the updated DEER prototype models were used. These prototypes were originally modeled with multiplex systems and not designed with single compressor systems so single systems were added to the existing multiplex system. The addition of the single systems came from the original MAS Control V3.00.19 baseline models and updated for the code baseline as mentioned above.

The single-compressor base case models are summarized as follows:

- Throttling range of 6 °F
- Pumping efficiency comparable to partial reed-style compressors
- The customer base case condenser was modeled as an air-cooled unit with eight fans that are staged to turn on in pairs.
- The control of the fan pairs is based directly upon ambient temperature setpoints, while the condenser size and efficiency are dependent upon vintage.
- Backflood control was set to 93 °F.

### Measure Case Energy Use Consumption Models

The simulation models of efficient multiplex systems for the air-cooled measure offering used the new DEER 2020 prototype store multiplex design. The original multiplex system in these prototypes were updated where necessary to match the terms and conditions of this measure: floating head pressure

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<sup>2</sup> Pacific Gas and Electric Company (PG&E). 2019. "SWCR012-01 Modeling Results.zip."

control to a minimum 70 °F set point; air-cooled condensers with variable speed fans, and suction groups subcooled to 50° F.

The multiplex compressor measure case models are summarized as follows:

- The modelled air-cooled condensers have four fans each and a rated efficiency of 85 Btu/W-hr at a 10 °F temperature differential (TD).
- The modelled compressors operate to a floating head pressure setpoint based on an ambient TD strategy and a throttling range of 2 °F.
- The backflood setpoint was modelled to be 68 °F.
- Mechanical subcooling is provided for both the low-temperature and medium-temperature liquid circuits.
- Subcooling is controlled to 50 °F.<sup>3</sup>
- This measure is set as a Title 24 baseline because there is no code that requires compressors to be configured in a multiplex arrangement.

### Unit Energy Savings Calculation

Model permutations were generated to derive savings for each of the 16 California climate zones and for the new consolidated building vintages: 2003, 2007, 2011, and 2015; which are part of the vintage “Ex” in the Database for Energy Efficient Resources (DEER). Energy savings were determined for this vintage only.

### PEAK ELECTRIC DEMAND REDUCTION (kW)

Peak demand reduction was derived using the methodology presented in the Electric Savings section.

### GAS SAVINGS (Therms)

Gas savings were derived using the methodology presented in the Electric Savings section. Note that the gas savings generated in MASControl V3.00.19 represent interactive effects only. Intuitively, gas savings do not seem applicable to this measure. However, the Database for Energy Efficient Resources (DEER) models report a small impact on gas use. Such negligible impacts are determined as “noise” and do not represent significant changes in facility gas energy use.

### 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

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<sup>3</sup> Itron, Inc. 2005. *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study - Final Report*. Prepared for Southern California Edison. December 2005.

alteration. The RUL is only applicable to the first baseline period for a retrofit measure with an applicable code baseline.

The methodology to calculate the RUL conforms with Version 5 of the Energy Efficiency Policy Manual, which recommends “one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values.”<sup>4</sup> This approach provides a reasonable RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.<sup>5</sup> Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised add-on equipment measures so that the EUL of the measure is equal to the lower of the RUL of the modified system or equipment or the EUL of the add-on component.<sup>6</sup>

The EUL and RUL specified for the retrofit of a single compressor refrigeration system to a multiplex system are specified below. The EUL value represents the estimated lifetime established for a refrigeration condenser upgrade.

#### Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs)	15.0	California Public Utilities Commission (CPUC), Energy Division. 2014. “DEER2014-EUL-table-update_2014-02-05.xlsx”
RUL (yrs)	5.0	California Public Utilities Commission (CPUC), Energy Division. 2013. <i>Energy Efficiency Policy Manual Version 5</i> . Page 32.

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

The estimated base case costs were not provided in the Database of Energy Efficient Resources (DEER) and therefore obtained from a refrigeration equipment supplier, ILLCO Copeland Products Distributor and Wholesale Supplier.<sup>7</sup> A weighting of 25% low-temperature compressors and 75% medium-temperature compressors was used to calculate a single average cost per ton.<sup>8</sup> Costs were converted to 2019 values using the RSMMeans Historical Cost Index.<sup>9 10</sup>

<sup>4</sup> California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

<sup>5</sup> KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

<sup>6</sup> California Public Utilities Commission (CPUC). 2016. *Resolution E-4807*. December 16. Page 13.

<sup>7</sup> The cost data was obtained from Copeland Products Distributor and Wholesale Supplier in 2012. The source file, however, has not been uploaded and/or is not publicly available.

<sup>8</sup> PECL. 2011. *Assessment of DEER Grocery Model*. Table 4.

<sup>9</sup> Gordian. (n.d.) “RSMMeans Cost Index 2019.pdf.”

<sup>10</sup> Pacific Gas and Electric Company (PG&E). 2019. “SWCR012\_Cost Updates.xlsx”

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

The measure case equipment costs were retrieved directly from the 2008 Database of Energy Efficient Resources (DEER) and converted to 2019 values using the RSMMeans Historical Cost Index<sup>11</sup>; they match the measure offerings for climate zones, building types, and vintages.<sup>12</sup>

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

The base case labor costs were retrieved from the 2008 Database of Energy Efficient Resources (DEER) and converted to 2019 values using the RSMMeans Historical Cost Index.<sup>13 14</sup>

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

The labor installation costs were retrieved directly from the Database of Energy Efficient Resources (DEER); they match the measure offerings for climate zones, building types, and vintages. Costs were converted to 2019 values using the RSMMeans Historical Cost Index.<sup>15 16</sup>

### 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 values are 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. These sector average NTGs (“default NTGs”) are applicable to all energy efficiency measures that have been offered through commercial, industrial, and agriculture 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. <i>DEER Database 2011 Update Documentation</i> . 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

<sup>11</sup> Gordian. (n.d.) “RSMMeans Cost Index 2019.pdf.”

<sup>12</sup> Pacific Gas and Electric Company (PG&E). 2019. “SWCR012\_Cost Updates.xlsx”

<sup>13</sup> Gordian. (n.d.) “RSMMeans Cost Index 2019.pdf.”

<sup>14</sup> Pacific Gas and Electric Company (PG&E). 2019. “SWCR012\_Cost Updates.xlsx”

<sup>15</sup> Gordian. (n.d.) “RSMMeans Cost Index 2019.pdf.”

<sup>16</sup> Pacific Gas and Electric Company (PG&E). 2019. “SWCR012\_Cost Updates.xlsx”

varies by end use, sector, technology, application, and delivery method. This GSIA rate 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. <i>Energy Efficiency Policy Manual Version 5</i> . Page 31.

**NON-ENERGY IMPACTS**

Non-energy impacts 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.

**DEER Difference Summary**

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	Yes
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER eQUEST Prototypes	No
DEER Version	DEER 2008 MASControl V3.00.19 (no longer used)
Reason for Deviation from DEER	DEER prototypes not updated.
DEER Measure IDs Used	D03-214 and D03-215 (no longer used with new prototypes)
NTG	Source: DEER The value of 0.60 is associated with NTG ID: <i>Com-Default&gt;2yrs</i>
GSIA	Source: DEER. The value of 1.0 is associated with GSIA ID: <i>Def-GSIA</i>
EUL/RUL	Source: DEER 2016. The value of 15 years is associated with EUL ID: <i>GrocSys-Cndsr</i> . RUL=1/3 EUL

## REVISION HISTORY

### Measure Characterization Revision History

Revision Number	Revision Completion Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision
01	03/31/2018	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: PGE3PREF117 Revision 3 (January 1, 2016) Consensus reached among Cal TF members.
	06/07/2019	Adan Rosillo, PG&E  Jennifer Holmes Cal TF Staff	Revisions for submittal of version 01.