**Work Paper SCE13RN023**

**Revision 2**

**Southern California Edison Company**

**Refrigeration Floating Suction and Head Pressure Controls**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable Measure Codes:**** | RF-31355  RF-41488  RF-40395  RF-51222  RF-20965 |
| **Measure Description:** | Floating head and suction pressure controls for commercial multiplex and industrial (process) refrigeration systems |
| **Base Case Description:** | Commercial multiplex and process refrigeration systems with fixed head and suction pressure setpoints |
| **Energy Impact Common Units:** | Energy impacts are shown per ton cooling |
| **Energy Savings :** | Refer to Excel Calculation Attachment |
| **Gross Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Measure Incremental Cost ($/unit):** | Refer to Excel Calculation Attachment.  The incremental measure cost is equal to the gross measure cost. |
| **Effective Useful Life (years):** | Source: DEER2014-EUL-table-update\_2014-02-05.xls  15 years |
| **Measure Application Type:** | Retrofit Add-on (REA) |
| **Net-to-Gross Ratios:** | Source: DEER2011\_NTGR\_2012-05-16.xls  0.6 or 0.85 |
| **Important Comments:** | This work paper document does not contain a data set in conformance with the 4/1/14 CPUC Ex Ante Database Specification; SCE will provide that data set separately.  Major changes for Revision 2 include updated results based on the DEER14 database using the READi V.2.0.1 interface. The updated DEER14 consolidates savings from multiple vintages into a single “Existing” vintage. Results from all 16 California climate zones have been included. |

# Document Revision History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Workpaper and Revision # | Tech. Revision | MM/DD/YY | Author/Affiliation | Summary of Changes |
| SCE13RN023.0 | No | 5/29/2012 | Cristalle Howe/ Lincus, Inc. | Original work paper for the 2013 program cycle |
| SCE13RN023.1 | Yes | 12/20/2012 | Yun Han/SCE | * Added new measure – Floating Suction Pressure Control * Used new calculation template v1.1 |
| SCE13RN023.2 | Yes | 6/20/2014 | Yin Yin Wu, P.E./ BASE Energy  Steven Wiryadinata/BASE Energy | * Updated savings results based on the DEER14 per READi V.2.0.1 * Updated calculation methodology based on the new data structure of DEER14 * Included savings for 16 climate zones * Work paper updated for reporting period, effective 07/01/14-12/31/14 |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

The objective of this work paper is to evaluate the energy savings for commercial multiplex and industrial (process) refrigeration systems retrofitted with floating head and suction pressure controls.

The base and measure cases are summarized as follows (Section 1.2 describes these cases in greater technical detail):

Base Case: Fixed head pressure (or saturated condensing temperature, SCT) and fixed suction pressure (or saturated suction temperature, SST) setpoint controls for commercial multiplex and process refrigeration systems.

Measure Case: Floating head and suction pressure controls for commercial multiplex and process refrigeration systems. Floating head pressure is controlled based on ambient drybulb (Tdb) temperature for air-cooled systems, and on the ambient wetbulb (Twb) for evaporative-cooled systems. Floating suction pressure is controlled based on the worst-case zone demand. Table 1 describes the 5 core measures evaluated in this workpaper based on the condenser type (air-cooled or evap-cooled) and application (commercial or process).

Table 1 Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| RF-31355 | Floating Head Pressure Controls on Commercial Air-Cooled Multiplex Refrigeration System |
| RF-41488 | Floating Head Pressure Controls on Commercial Evap-Cooled Multiplex Refrigeration System |
| RF-40395 | Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System |
| RF-51222 | Floating Suction Pressure Controls on Commercial Multiplex Refrigeration System |
| RF-20965 | Floating Suction Pressure Controls on Process Evap-cooled Refrigeration System |

**Eligibility, Implementation and Documentation Requirements**

The above-described measures are eligible for installations on existing commercial multiplex and process refrigeration systems which have fixed head and suction pressure controls according to the descriptions shown in **Base Cases** in Section 1.2.

Proposed head pressure controls must operate the refrigeration systems according to:

* 12°F temperature difference (TD) between Tdb and SCT for air-cooled commercial systems on all building types except refrigerated warehouse
* 17°F TD between Twb and SCT for evap-cooled commercial systems on all building types except refrigerated warehouse
* 9°F TD between Twb and SCT for evap-cooled process systems on refrigerated warehouses
* Minimum SCT of 70oF

The proposed suction pressure controls must operate the refrigeration systems according to:

* Worst zone demand. The maximum suction setpoint is 5oF above the design temperature. The minimum is the same as the base case.

The following are ineligible:

* New construction installations.
* Floating head pressure controls on air-cooled process refrigeration systems.
* Floating suction pressure controls on refrigeration systems with variable speed evaporator fans.
* Any improvements which results in increased system energy use

Additionally, calculation of the design cooling load (tons) is to be based on connected display cases, walk-in coolers and freezers, cooled storage and prep areas only. Subcooler loads and air conditioning loads are ineligible for consideration.

## 1.2 Technical Description

This work paper focuses on floating head and suction pressure controls retrofits on existing commercial multiplex and process refrigeration systems with fixed head and suction pressure controls. The two largest energy consuming components of a refrigeration system are the compressor(s) and the heat rejection fan(s). Critical processes in a refrigeration cycle are described as follows:

1. Refrigerant close to its saturated vapor state is compressed to a super-heated vapor state at a higher pressure and temperature.
2. The superheated vapor is fed to the fan-powered condenser where heat is rejected to the ambient via air for air-cooled condenser or the combination of air and evaporating water for evaporative condenser. The condenser is designed to cool the refrigerant to the saturated-liquid state by rejecting the refrigerant heat to the ambient at lower temperature.
3. Refrigerant at the exit of the condenser is then flashed to a lower pressure and temperature via an expansion valve which enables it to absorb heat from the refrigerated zones which are maintained at a higher temperature relative to the refrigerant. This heat absorption brings it back to the saturated vapor state at the start of the compression process.

The common method for head pressure control is through condenser fan control. The amount of air (moist air) passing through the air cooled (evap-cooled) condenser is regulated to control condenser capacity and head pressure. Air flow control is achieved through the following schemes:

* Fan cycling
* Fan staging
* Fan speed modulation

Alternate method mentioned in DEER for head pressure control is condenser backflood. Liquid refrigerant is back-flooded to (or retained in) the condenser to reduce the effective condensing surface and condenser capacity. As liquid refrigerant accumulates in the condenser, the condenser pressure increases which directly affect the compressor discharge pressure. The back flood control setpoint (BSC) controls the temperature at or above which liquid refrigerant is retained in condenser.

The installation of floating head pressure controls reduces the compressor power draw by reducing the compressor discharge pressure when the ambient Tdb (Twb) temperatures are lower than what the air-cooled (evap-cooled) refrigeration system was designed for. The refrigeration system is set to have a minimum SCT in order to maintain refrigerant pressure at the inlet of the expansion valve.

Under a constant head pressure operation in cooler ambient conditions, the condenser heat rejection can be accomplished by taking advantage of larger temperature difference (TD) between SCT and ambient temperatures and the condenser fan can be cycled off (or throttled down) more frequently. However, under floating head pressure controls, SCT follows the ambient temperature to maintain a specified TD and the condenser fan will consume more energy as it will operate more often to accomplish heat rejection. However, this increase in fan energy usage is offset by the decrease in compressor energy usage.

The installation of floating suction pressure control similarly reduces the compressor power draw by increasing the compressor suction pressure based on the worst-case zone demand.

The following list describes the base and measure cases of the five measures evaluated in this work paper, based on information provided in DEER 2014:

* **Base Cases:**

1. RF-31355: Multiplex system, air-cooled condenser, fixed SCT = 80oF
2. RF-41488: Multiplex system, evap-cooled condenser, fixed SCT = 80oF
3. RF-40395: Evap-cooled condenser, fixed SCT = 85oF
4. RF-51222: Multiplex system, air-cooled condenser, fixed SST
5. RF-20965: Fixed SST

* **Measure Cases:**
  1. RF-31355: Floating head pressure control for commercial air-cooled multiplex refrigeration systems. This measure comprises of three DEER measures, described as follows:
     1. DEER ID: D03-221: Multiplex system, air-cooled condenser, fixed SCT = 70oF
     2. DEER ID: D03-223: Multiplex system, air-cooled condenser, control SCT to ambient + 12oF TD, 70oF min, backflood setpoint of 68oF
     3. DEER ID: D03-225: Multiplex system, air-cooled condenser, control SCT to ambient + 12oF TD, 70oF min, backflood setpoint of 68oF, variable-speed fan control
  2. RF-41488: Floating head pressure control for commercial evap-cooled multiplex refrigeration systems. This measure comprises of three DEER measures, described as follows:
     1. DEER ID: D03-222: Multiplex system, evap-cooled condenser, fixed SCT = 70oF
     2. DEER ID: D03-224: Multiplex system, evap-cooled condenser, control SCT to wetbulb + 17oF TD, 70oF min, backflood setpoint of 68oF
     3. DEER ID: D03-226: Multiplex system, evap-cooled condenser, control SCT to wetbulb + 17oF TD, 70oF min, backflood setpoint of 68oF, variable-speed fan control
  3. RF-40395: Floating head pressure control for process evap-cooled refrigeration systems. This measure comprises of three DEER measures, described as follows:
     1. DEER ID: D03-307: Evap-cooled condenser, fixed SCT = 70oF, backflood setpoint of 68oF
     2. DEER ID: D03-308: Evap-cooled condenser, control SCT to wetbulb + 9oF TD, 70oF min, backflood setpoint of 68oF
     3. DEER ID: D03-309: Evap-cooled condenser, control SCT to wetbulb + 9oF TD, 70oF min, backflood setpoint of 68oF, var-speed fan control
  4. RF-51222: DEER ID: D03-220: Multiplex system, air-cooled condenser, reset SST based on worst-case demand
  5. RF-20965: DEER ID: D03-306: Reset SST based on worst-case zone demand

## 1.3 Measure Application Type

The delivery mechanisms for this measure are Financial Support Direct Install and Financial Support Down-Stream Deemed. The install type for both of these delivery mechanisms is Retrofit Add-on (REA).

Note: See Appendix A for a comparison of the application types used by and incorporated into SCE systems versus the application types available in the newest revision of DEER 2014. Appendix A will serve as a translation between the outputs of this workpaper and application types used by READi.

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

The savings presented in this workpaper were based on the DEER 2014 database (DEER14) [386] and extracted from READi V.2.0.1, an interface for DEER14. DEER14 was a major update to the DEER 2011 version and incorporates changes based on the new 2013 Title 24. The database lists energy savings for 11 floating head and suction pressure measures listed in Section 2 and described in Section 1.2 under Measure Cases. Results were available for two building types in the 16 California climate zones: Grocery, employing commercial multiplex refrigeration systems, and Refrigerated Warehouse, employing process refrigeration systems.

DEER14 contains savings results for the three measure variations in each of the solution codes RF-31355, RF-41488, RF-40395 presented in Section 1.2. Since the three measure variations address the same baseline condition (Base Case #3: Fixed SCT control for process evap-cooled refrigeration systems, for example), their savings results were averaged to obtain a single savings value for the measure. Table 2 shows the Run ID for one DEER14 measure. Refer to Section 2 for a detailed methodology description.

Table 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | See Above Paragraph |
| DEER Version | DEER14 |
| DEER Run ID and Measure Name (Sample) | D03-226 Floating Head Pressure, Variable Setpoint & Speed (Evaporative-cooled) |

**Net to Gross**

The net-to-gross ratio (NTGR) describes the free-ridership in energy efficiency programs and quantifies a particular program’s net impact based on its gross savings. The NTG ratios were obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 5 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [351]. The relevant NTGRs for this measure are shown in Table 3.

Table 3 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 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 | Com | Any | All | 0.6 |
| Ind-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Ind | Any | All | 0.6 |
| Com-Default-HTG-di | All other EEM with no evaluated NTGR; direct install to hard-to-reach only. | Com | Any | DirInstall | 0.85 |
| Ind-Default-HTG-di | All other EEM with no evaluated NTGR; direct install to hard-to-reach only. | Ind | Any | DirInstall | 0.85 |

\*Denotes that the column is taken from the DEER NTG Table.

Note that for the direct install delivery mechanism, a distinction between hard to reach and non-hard to reach markets will be made on a project by project basis. This work paper shows the NTG associated with a hard to reach direct install delivery mechanism and the Non-residential defaulted NTG value, where in fact, a measure offered through direct install and is not “hard to reach” will receive a default NTG value.

**Installation Rate**

The installation rate (IR) represent the ratio of the number of verified installations of the measure to the number of claimed installations rebated by the utility. IR is identified in the calculation attachment. This value is obtained from the support table available in READi. Currently there is no versioning on the installation rate table. To address appropriate selection of the installation rate the date of the workpaper will serve as the last date checked for updated IR values. The installation rate varies by end use, sector, technology, application, and delivery method. There are currently no IR specific for this measure and the default value of 1 has been presented in Table 4.

Table 4 Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID | Description | Sector | BldgType | ProgDelivID | GSIAValue |
| Def-GSI | Default GSIA values | Any | Any | Any | 1 |

**Spillage Rate**

Spillage represents additional energy efficiency actions that participants take outside the program. Spillage rate (SR) will also be applied to measures however the values will not be tracked in the workpapers. SR will be tracked in an external table to be supplied to the Energy Division.

**READi Technology Fields**

To support the development of the ED ex ante database, selected fields from the DEER14 database as extracted from READI V.2.0.1 has been identified in the workpaper and shown in Table 5. For a full set of values associated with the measures in the workpaper refer to the Excel calculation template.

Table 5 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | READi ID |
| Measure Case UseCategory | Commercial Refrigeration  Process Refrigeration |
| Measure Case UseSubCats | Refrigeration Equipment |
| Measure Case TechGroups | Grocery Refrigeration System  Refrigerated Storage |
| Measure Case TechTypes | Refrigerator/Freezer  Refrigerated Warehouse Cooling |
| Base Case TechGroups | Grocery Refrigeration System  Refrigerated Storage |
| Base Case TechTypes | Refrigerator/Freezer  Refrigerated Warehouse Cooling |

### 1.4.2 Codes and Standards Analysis

This work paper deals with REA-type measures whose savings are not impacted by code standards. Discussion on the standards as they relate to the measures is summarized in Table 6 and presented here for information purposes only.

Chapter 10.5 of the California’s Title 24 2013 Non-Residential Compliance Manual [359] addresses commercial refrigeration systems in retail food stores. Chapter 10.5.2, Section A requires that all new commercial air-cooled and evaporative condenser fans be continuously variable speed. Additionally, head pressure must float in response to Tdb or Twb, and the minimum SCT must be 70oF or less. Table 10-2 in Title 24 specifies the minimum specific efficiency requirements (Btu-h/Watt) for new fan-powered condensers. Chapter 10.5.3, Section A requires floating suction pressure controls based on worst-case demand for all new remote refrigeration systems.

Chapter 10.6.3 addresses the mechanical systems serving refrigerated warehouses. Section C requires that all new commercial air-cooled and evaporative condenser fans be continuously variable speed. Additionally, head pressure must float in response to Tdb or Twb, and the minimum SCT must be 70oF or less. Table 10-6 in Title 24 specifies the minimum specific efficiency requirements (Btu-h/Watt) for new fan-powered condensers. Floating suction pressure controls are not mandatory. Additionally, areas within refrigerated warehouses designed for quick chilling or freezing of products are exempt.

Table 6 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | 2013 Non-Residential Compliance Manual, Section 120.6(b)1; 120.6(B)2 | July 1, 2014 |
| Title 24 (2013) | 2013 Non-Residential Compliance Manual, Section 120.6(a)4; 120.6(a)5 | July 1, 2014 |

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### 1.4.3 Non-DEER Study Review

All data was taken from either DEER14 or Title 24 code standards.

### 1.4.4 Measure and Base Case Effective Useful Life

Effective Useful Life (EUL) represent an estimate of the median number of years that measures installed under the program are still in place and operable. To obtain the EUL value the DEER14 update documentation, EUL\_Summary\_10-1-08.xls [213], was consulted.

Remaining Useful Life (RUL) represent an estimate of the median number of years a technology or piece of equipment being replaced or altered by an energy efficiency program would remain in service and operational had the program intervention not cause the replacement or alteration. The DEER documentation “Summary of EUL-RUL Analysis for the April 2008 Update to DEER” provides the RUL value as a flat 1/3 of the EUL value. The RUL value will only be applied to the first baseline period for retrofit measures that have applicable code that will affect the energy savings. In all other installation types and retrofit with no applicable code that affects the energy savings, the RUL is not applicable to either the first or second baseline period.

Table 7 identifies the value used for the measures in this work paper.

Table 7 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID(s) | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| Grocsys-FltHdPres  Grocsys-FltSucPres | Commercial | Commercial Refrigeration | Refrigeration Upgrades – Grocery (Head Pressure, Suction Pressure) | 15 | 5 |
| RefgWrhs-FltHdPres  RefgWrhs-FltSucPres | Commercial | Process Refrigeration | Refrigeration Upgrades – Refrigerated Warehouse (Head Pressure, Suction Pressure) | 15 | 5 |

# Section 2. Energy Savings & Demand Reduction Calculations

As described in technical detail in Section 1.2, floating head and suction controls ultimately reduce the required lift (pressure increase) at the compressor and improve the overall refrigeration system efficiency.

Electrical energy and demand as well as natural gas savings for the 5 core measures (summarized in Table 8) were based on the following eleven DEER14 measures for the 16 California climate zones (CZs):

1. D03-220: Commercial Refrigeration Floating Suction Pressure
2. D03-221: Commercial Refrigeration Floating Head Pressure, Fixed Setpoint (air-cooled)
3. D03-222: Commercial Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled)
4. D03-223: Commercial Refrigeration Floating Head Pressure, Variable Setpoint (air-cooled)
5. D03-224: Commercial Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled)
6. D03-225: Commercial Refrigeration Floating Head Pressure, Variable Setpt & Speed (air-cooled)
7. D03-226: Commercial Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled)
8. D03-306: Process Refrigeration Floating Suction Pressure
9. D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled)
10. D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled)
11. D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled)

Table 8 contains the data files for measures that are taken directly from the DEER 2014 READi Tool or were created using the READi Tool. These results have not been modified and are only being included in the workpaper for reference.

Table 8 Summary of DEER Measures and READi Tool Outputs

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Name | DEER Measure ID and READi Results |
| RF-31355 | Floating Head Pressure Controls on Commercial Air-Cooled Multiplex Refrigeration System |  |
| RF-41488 | Floating Head Pressure Controls on Commercial Evap-Cooled Multiplex Refrigeration System |  |
| RF-40395 | Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System |  |
| RF-51222 | Floating Suction Pressure Controls on Commercial Multiplex Refrigeration System |  |
| RF-20965 | Floating Suction Pressure Controls on Process Refrigeration System |  |

The savings for each of the floating head pressure measures were direct averages of three DEER14 measures which address the same baseline. The remaining floating suction pressure measures were based on one DEER14 measure each. Table 8 shows the assignment of DEER14 measures to each of the core measure. Please refer to Measure Case in Section 1.2 for technical descriptions of each DEER14 measure.

Within the same core measure group, the refrigeration system capacity (tons) was the same. Therefore the savings values from the three DEER14 measures were averaged to obtain the core measure savings. The following equation was used to calculate the kWh, kW, and Therm savings values for the floating head pressure measures in each CZ:

Where:

AMSavCLZ = Average measure savings for the core measure

IMSavCLZFS,FS = Individual measure savings for a fixed SCT set point, fixed fan speed system

IMSavCLZVS,FS = Individual measure savings for a variable SCT set point, fixed fan speed system

IMSavCLZVS,VS = Individual measure savings for a variable SCT set point, variable fan speed system

Table 9 gives a sample summary of READi outputs for the three DEER14 measures comprising RF-40395 (Floating Head Pressure on Process Evap-cooled Refrigeration System) in 16 CZs. These results have not been modified and are only being included in the workpaper for reference. The sample result for RF-40395 is presented in Table 10.

Table 9 Sample READi Summary of DEER14 Savings Outputs Used for RF-40395

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| DEER14 Measure | CZ | kWh/ton Savings | kW/ton  Savings | Therm/ton Savings | |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ01 | 1460 | 0.201 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ02 | 1490 | 0.0926 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ03 | 1520 | 0.0981 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ04 | 1360 | 0.031 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ05 | 1520 | 0.184 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ06 | 1420 | 0.136 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ07 | 1350 | 0.105 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ08 | 1370 | 0.148 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ09 | 1360 | 0.0606 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ10 | 1400 | 0.0776 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ11 | 1450 | 0.104 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ12 | 1360 | 0.0771 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ13 | 1310 | 0.0728 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ14 | 1580 | 0.136 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ15 | 1350 | 0.0894 | 0 |
| D03-307: Process Refrigeration Floating Head Pressure, Fixed Setpoint (evap-cooled) | CZ16 | 1520 | 0.173 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ01 | 1460 | 0.201 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ02 | 1490 | 0.0926 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ03 | 1520 | 0.0981 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ04 | 1360 | 0.031 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ05 | 1520 | 0.184 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ06 | 1430 | 0.136 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ07 | 1360 | 0.105 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ08 | 1380 | 0.148 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ09 | 1370 | 0.0606 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ10 | 1410 | 0.0776 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ11 | 1450 | 0.103 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ12 | 1360 | 0.0769 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ13 | 1310 | 0.0726 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ14 | 1580 | 0.136 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ15 | 1350 | 0.0894 | 0 |
| D03-308: Process Refrigeration Floating Head Pressure, Variable Setpoint (evap-cooled) | CZ16 | 1520 | 0.173 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ01 | 1910 | 0.218 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ02 | 1900 | 0.0931 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ03 | 1940 | 0.0981 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ04 | 1720 | 0.031 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ05 | 1920 | 0.194 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ06 | 1860 | 0.147 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ07 | 1790 | 0.11 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ08 | 1720 | 0.153 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ09 | 1730 | 0.0608 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ10 | 1840 | 0.0781 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ11 | 1850 | 0.105 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ12 | 1770 | 0.0805 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ13 | 1700 | 0.075 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ14 | 1980 | 0.139 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ15 | 1750 | 0.0927 | 0 |
| D03-309: Process Refrigeration Floating Head Pressure, Variable Setpt & Speed (evap-cooled) | CZ16 | 1880 | 0.173 | 0 |

Table 10 Summary of Savings for RF-40395

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Core Measure | CZ | kWh/ton Savings | kW/ton  Savings | Therm/ton Savings | |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ01 | 1610 | 0.20667 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ02 | 1626.67 | 0.09277 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ03 | 1660 | 0.0981 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ04 | 1480 | 0.031 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ05 | 1653.33 | 0.18733 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ06 | 1570 | 0.13967 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ07 | 1500 | 0.10667 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ08 | 1490 | 0.14967 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ09 | 1486.67 | 0.06067 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ10 | 1550 | 0.07777 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ11 | 1583.33 | 0.104 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ12 | 1496.67 | 0.07817 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ13 | 1440 | 0.07347 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ14 | 1713.33 | 0.137 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ15 | 1483.33 | 0.0905 | 0 |
| Floating Head Pressure Controls on Process Evap-Cooled Refrigeration System | CZ16 | 1640 | 0.173 | 0 |

Below is an example of electrical energy, electrical demand and natural gas savings calculations for RF-40395 in CZ6:

kWh Savings Calculations:

AMSavCLZ6 = (1420+1430+1860)/3 = 1570 kWh

kW Savings Calculations:

AMSavCLZ6 = (0.136+0.136+0.147)/3 = 0.13967 kW

Therm Savings Calculations:

AMSavCLZ6 = 0 Therms

Refer to Attachment [B] for the detailed calculations and savings values for all measures in 16 CZs.

# 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 Refrigeration load shape. See Table 11 for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

Table 11 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Education - Community College | College\_University | Refrigeration |
| Education - University | College\_University | Refrigeration |
| Grocery | Grocery\_Store | Refrigeration |
| Food Store | Food\_Store | Refrigeration |
| Health/Medical - Hospital | Hospital | Refrigeration |
| Health/Medical - Nursing Home | Medical\_Clinic | Refrigeration |
| Health/Medical - Clinic | Medical\_Clinic | Refrigeration |
| Lodging - Hotel | Hotel\_Motel | Refrigeration |
| Manufacturing - Bio/Tech | Industrial | Refrigeration |
| Manufacturing - Light Industrial | Industrial | Refrigeration |
| Industrial | Industrial | Refrigeration |
| Misc - Commercial | Misc.\_Commercial | Refrigeration |
| Restaurant - Fast-Food | Fast\_Food\_Restaurant | Refrigeration |
| Restaurant - Sit-Down | Sit\_Down\_Restaurant | Refrigeration |
| Retail - Multistory Large | Large\_Retail\_Store | Refrigeration |
| Retail - Single-Story Large | Large\_Retail\_Store | Refrigeration |
| Retail - Small | Small\_Retail\_Store | Refrigeration |
| Storage - Conditioned | Storage\_Building | Refrigeration |
| Warehouse - Refrigerated | Refrigerated\_Warehouse | Refrigeration |

# Section 4. Base Case & Measure Costs

## 4.1 Base Case Cost

The base case cost is $0 since the existing refrigeration system can continue to operate without floating head and suction pressure controls.

## 4.2 Measure Case Cost

The measure case costs were based on the “Revised DEER Measure Cost Summary (05\_30\_2008) Revised (06\_02\_2008). xls” [218]. Table 12 summarized the measure cost. The cost for the air-cooled floating head pressure controls measure is the average of two values from the DEER cost data. The cost for the two evaporative-cooled floating heat pressure controls measures is the average of four values from the DEER cost data. Cost calculation methodologies are discussed in detail in Section 4.3.

Table 12 Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| Measure | Measure Equipment Cost ($/ton) | Measure Labor Cost ($/ton) | Gross Measure Cost ($/ton) |
| Floating Head Pressure Controls on Commercial Air-Cooled Multiplex Refrigeration System | $169.68 | $66.28 | $235.96 |
| Floating Head Pressure Controls on Commercial Evap-Cooled Multiplex Refrigeration System | $82.60 | $42.35 | $124.95 |
| Floating Head Pressure Controls Process Evap-Cooled Refrigeration System | $82.60 | $42.35 | $124.95 |
| Floating Suction Pressure Controls on Commercial Multiplex Refrigeration System | $14.69 | $29.46 | $44.15 |
| Floating Suction Pressure Controls on Process Refrigeration System | $14.69 | $29.46 | $44.15 |

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost

Per the E3, the gross measure cost (GMC) represents the cost to purchase and install an energy efficiency measure. In the case of REA, the cost invoked is the full cost of the equipment and installation of the energy efficient equipment. GMC is represented by the equation:

GMC = Measure Equipment Cost + Measure Labor Cost

2008 DEER cost data lists equipment and labor costs for air-cooled and evap-cooled systems, each under two SCT control schemes: floating head pressure with fixed speed fan, and floating head pressure with variable speed fan. These values were averaged to obtain a single value representing floating head pressure controls for air-cooled and for evap-cooled systems. Table 13 shows the equipment and labor costs for floating head controls on air-cooled system. Table 14 shows the equipment and labor costs for floating head pressure controls on evap-cooled system. Table 15 shows the equipment and labor costs for floating suction pressure controls.

Table 13 Air-Cooled System Head Pressure Control Costs from DEER

|  |  |  |  |
| --- | --- | --- | --- |
| Cost Case Description | Measure Equipment Cost ($/ton) | Measure Labor Cost ($/ton) | Gross Cost ($/ton) |
| Ambient following saturated condensing temperature (SCT) setpoint, 70°F minimum | $11.19 | $40.51 | $51.70 |
| Ambient following saturated condensing temperature (SCT) setpoint, 70°F minimum, variable-spd condenser fan | $328.18 | $92.06 | $420.23 |
| Average | $169.68 | $66.28 | $235.96 |

Table 14 Evap-Cooled System Floating Head Pressure Control Costs from DEER

|  |  |  |  |
| --- | --- | --- | --- |
| Cost Case Description | Measure Equipment Cost ($/ton) | Measure Labor Cost ($/ton) | Gross Cost ($/ton) |
| Wetbulb following saturated condensing temperature (SCT) setpoint, 70°F minimum | $9.96 | $40.51 | $50.46 |
| Wetbulb following saturated condensing temperature (SCT) setpoint, 70°F minimum, variable-spd condenser fan | $169.45 | $69.96 | $239.41 |
| Wetbulb following saturated condensing temperature (SCT) setpoint, 70°F minimum | $6.86 | $22.09 | $28.96 |
| Wetbulb following saturated condensing temperature (SCT) setpoint, 70°F min, variable-spd condenser fan | $144.13 | $36.82 | $180.95 |
| Average | $82.60 | $42.35 | $124.95 |

Table 15 Floating Suction Pressure Control Costs from DEER

|  |  |  |  |
| --- | --- | --- | --- |
| Cost Case Description | Measure Equipment Cost ($/ton) | Measure Labor Cost ($/ton) | Gross Cost ($/ton) |
| Floating saturated suction temperature (SST) control on LowTemp and MedTemp suction groups | $14.69 | $29.46 | $44.15 |

Table 12 in the preceding section summarizes the equipment and labor costs for each of the 5 core measures. Measures 2 and 3 both deal with evap-cooled condensers and have the same costs. Measures 4 and 5 deal with suction pressure controls and have the same costs.

### 4.3.2 Incremental Measure Cost

Incremental Measure Cost (IMC) is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. For REA there exists no base case to compare the measure to, and thus, IMC is equal to the GMC.

# Attachments

1. 

1. 

# References



[31][42][213][218][351][359][386]

# Appendix A – SCE/ED Application Types

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SCE Program Type | ED Application Type | 1st Baseline Savings | 2nd Baseline Savings | 1st Baseline Cost | 2nd Baseline Cost | 1st Baseline Life | 2nd Baseline Life |
| New | New Construction (Nc) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Replace on Burnout (ROB) | Replace on Burnout (Rob)/Normal Replacement (NR) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Retrofit (RET) | Early Replacement (ER) | Above Cust. Existing | Above Code/Standard | Full Cost | Incremental Cost | RUL | EUL-RUL |
| Retrofit – First Baseline Only (REF) | Early Replacement RUL (ErRul) | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |
| Retrofit Add-on (REA) | N/A | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |