REFRIGERATION

FLOATING HEAD PRESSURE CONTROLS, MULTIPLEX

SWCR007-01

CONTENTS

MEASURE NAME

Floating Head Pressure Controls, Multiplex

STATEWIDE MEASURE ID

SWCR007-01

TECHNOLOGY SUMMARY

This measure focuses on floating head pressure control retrofits on existing commercial multiplex refrigeration systems with fixed head pressure controls. The 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. The 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 heat from the refrigerant at a high temperature to the ambient at lower temperature.
3. The 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 utilizes condenser fan control. The amount of air (moist air) passing through the air cooled (evaporator-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

An alternate method for head pressure control is condenser back-flood. 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 dry-bulb, T_{db}, (wet-bulb, T_{wb}) temperatures are lower than what the air-cooled (evaporative-cooled) refrigeration system was designed for. The refrigeration system is set to have a minimum saturated condensing temperature (SCT) 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.

MEASURE CASE DESCRIPTION

This measure includes the following measure offerings:

Floating head pressure control for commercial air-cooled multiplex refrigeration systems:

- SWCR007 A - Control SCT to ambient +12 °F TD, 70 °F min, backflood setpoint of 68 °F
- SWCR007 B - Control SCT to ambient +12 °F TD, 70 °F min, backflood setpoint of 68 °F with variable-speed fan control

Floating head pressure control for commercial evaporative-cooled multiplex refrigeration systems:

- SWCR007 C - Control SCT to wetbulb +17 °F TD, 70 °F min, backflood setpoint of 68 °F
- SWCR007 D - Control SCT to wetbulb +17 °F TD, 70 °F min, backflood setpoint of 68 °F with variable-speed fan control

The application type for this measure is: Add-on equipment (AOE).

BASE CASE DESCRIPTION

The base case is defined by two technologies, one each for air-cooled multiplex refrigeration systems and evaporative-cooled multiplex refrigeration systems:

- Commercial air-cooled multiplex refrigeration systems, vintage dependent, and having a fixed condensing setpoint per vintage.
- Commercial evaporative-cooled multiplex refrigeration systems, vintage dependent and having a fixed condensing setpoint per vintage.

CODE REQUIREMENTS

The 2019 California Building Energy Efficiency Standards (Title 24) [1], effective January 1, 2020, Section 120.6(b)-Mandatory Requirements for Commercial Refrigeration, requires the following that are related to the measures in the workpaper.

[1] California Energy Commission (CEC). 2018. *2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24).* CEC-400-2018-020-CMF-Standards

- Air-cooled condensers shall use variable setpoint control logic to reset the condensing temperature setpoint in response to ambient dry bulb temperature
- Evaporative-cooled condensers shall use variable-setpoint control logic to reset the condensing temperature setpoint in response to ambient wet bulb temperature.
- The minimum condensing temperature setpoint shall be less than or equal to 70°F.
- Compressors and multiple-compressor suction groups shall include control systems that use floating suction pressure logic to reset the target saturated suction temperature based on the temperature requirements of the attached refrigeration display cases or walk-ins.

Title 24 started including commercial refrigeration and refrigerated warehouses from 2013 standards (Effective July 1, 2014). The code requirements remained the same until the latest version, Title-24 2019. Hence, this measure is only eligible for vintage 2013 and before.

This measure pertains to Add-on Equipment (AOE) type measures for which savings are not determined relative to code standards. Thus, state and federal standards are not applicable (Table 1).

Table 1. 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	Section 120.6(b)-Mandatory Requirements for Commercial Refrigeration	1/1/2014
Federal Standards	None.	n/a

NORMALIZING UNIT

Cap-ton (ton of refrigeration capacity)

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.

Implementation Eligibility

Measure Application Type	Delivery Type	Sector
Add-on Equipment	DnDeemDI	Com
Add-on Equipment	DnDeemed	Com

Eligible Products

The eligible measure offerings defined for the refrigeration case saturated condensing temperature (SCT) control measure are:

Floating head pressure control for commercial air-cooled multiplex refrigeration systems:

- Control SCT to ambient +12 °F TD, 70 °F min, backflood setpoint of 68 °F
- Control SCT to ambient +12 °F TD, 70 °F min, backflood setpoint of 68 °F with variable-speed fan control

Floating head pressure control for commercial evaporative-cooled multiplex refrigeration systems:

- Control SCT to wetbulb +17 °F TD, 70 °F min, backflood setpoint of 68 °F
- Control SCT to wetbulb +17 °F TD, 70 °F min, backflood setpoint of 68 °F with variable-speed fan control

For reducing or floating head pressure to lower SCTs, the equipment must meet the following requirements:

- Add controls to float head pressure down to a lower pressure when conditions permit (i.e., changes control from fixed set point to floating set point).
- Apply only to refrigeration systems having multiplex compressor systems with existing control of SCT at a fixed setpoint.
- The new SCT setpoint must be ambient following by controlling condenser fans with variable-speed drives or by staging condenser fans.

Eligible Building Types and Vintages

This measure is applicable to any existing Non-Residential building type in commercial sector, and the vintage categories listed below:

- Prior to 1978 (represented by typical year “1975”)
- 1978 through 1992 (“1985”)
- 1993 through 2001 (“1996”)
- 2002 through 2005 (“2003”)
- 2006 through 2009 (“2007”)
- 2010 through 2013 (“2011”)

Eligible Climate Zones

This measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

Ineligible Products

Products cannot be used in conjunction with measures that already incorporate floating head pressure controls.

In addition, the following are ineligible:

- Projects that only reprogram a controller; new hardware must be installed.
- New construction installations
- Any improvements which results in increased system energy use.

Additionally, the 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. Sub-cooler loads and air conditioning loads are ineligible for consideration.

Building vintage and refrigeration multiplex system vintage after 2013.

DATA COLLECTION REQUIREMENTS

The program should collect and verify the vintage of the building and the refrigeration multiplex system. The offerings are ineligible for multiplex systems majorly upgraded or installed after July 1, 2014 since the Title-24 code mandates the floating controls since July 1, 2014.

USE CATEGORY

ComRefrig

ELECTRIC SAVINGS (KWH)

The measure offerings existed in previous version of Database for Energy Efficient Resources (DEER) as measures D03-223, D03-224, D03-225, and D03-226.[2] The original measures and energy prototypes were created with DEER 2005, and measure information was updated in DEER 2008. These measures are not updated with DEER2020 release, and the refrigeration end use in corresponding DEER prototypes (grocery building prototypes) has not been updated since DEER2005.

SCE undertook the task of updating the refrigeration end use in DEER prototypes and released the report[3]. SCE identified no updates needed for vintages 2011 and prior because the code and industry standard practice did not impact the DEER porotypes developed in 2005 and updated in 2008 . Since the

[2] Itron, Inc. 2005. 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study - Final Report. Prepared for Southern California Edison.

See Section 6 for details of DEER Building Prototypes generated by DOE-2.2R. See Section 7.3 for general description for grocery refrigeration measures.

[3] 2020 Commercial Refrigeration Prototypes Updates

measure offerings are only eligible for vintage 2011 and after, the grocery prototypes from DEER2020 can be used without any revisions.

MASControl3, an updated version of the measure analysis software for DEER2020 is used to generate energy usage and savings for grocery building prototypes. MASControl3, released on 30 Sept 2018, uses the DOE-2.2-R52o simulation engine with eQuest Refrigeration interface and provides processing scripts for computing DEER peak demand and applying DEER2020 vintage weights. Attributes of the modeled measures are noted below:

- Since nonresidential technology codes for these measures were not distributed with MASControl3, the following technology codes were created. These have the same effect as similar technology codes from DEER 2008.
  - GrocRefg-AirCool
  - GrocRefg-AirCool-FltHdPres-VarSCT
  - GrocRefg-AirCool-FltHdPres-VarSCT-VSDFan
  - GrocRefg-EvapCool
  - GrocRefg-EvapCool-FltHdPres-VarSCT
  - GrocRefg-EvapCool-FltHdPres-VarSCT-VSDFan
- The Grocery building type was selected for all climate zones (1 – 16) and for vintage codes 1975, 1985, 1996, 2003, 2007, and 2011.
- The base case is defined as a standard air-cooled or evaporative cooled multiplex refrigeration system with fixed SCT control.
  - SCT CONTROL: FIXED
- The measure case is as defined in DEER 2008
  - SCT CONTROL: DRYBULB-RESET or WETBULB-RESET
  - REFG-SYSTEM:SCT-SETPT = 70
    REFG-SYSTEM:BACKFLOOD-SETPT = 68
- DEER2020 commercial vintage weights are applied to roll up the savings into “Ex” vintage
- The value of normalizing unit “cap-tons” used in the MASControl3 processing is the cooling capacities of refrigeration units (freezers and coolers) determined to be 17.55 tons. However, the cap-tons should be the rated capacity of compressors serving the multiplex system. This information is not directly available from DEER prototypes where the compressor capacity is in lbs/hr. The closest information to determine the compressor capacity from DEER prototypes is the peak load from .SIM files. The total peak capacity of all the compressors is compared with previous DEER measures normalizing units. While they are not same, they are of the similar magnitude. Since the previous DEER measures are peer reviewed, the capacity-tons from DEER measures which vary by climate zone are used to calculate the normalized savings.

Please refer to the folder[4] for the workbooks and back-up folders required to enable the measures in MASControl3 and the eQuest .inp files generated by running the measures in MASControl3. Please refer to the calculation file[5] for post processing analysis.

[4] SWCR007-01 eQuest Files.zip

[5] SWCR007-01 Energy impact and cost calcs.xlsx

PEAK ELECTRIC DEMAND REDUCTION (KW)

As stated before MASControl3 provides processing scripts for computing DEER peak demand. The scripts for 4PM-9PM peak period is used to generate the peak kW savings meeting the DEER2020 peak period definition.

GAS SAVINGS (THERMS)

The therms savings are also generated from MASControl3.

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. 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."[6] This approach provides a reasonable RUL estimate without the requiring any a prior knowledge about the age of the equipment being replaced.[7] Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised Add-on Equipment (AOE) 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." [8]

The EUL and RUL established for refrigeration case SCT control is specified in Table 2.

Table 2. Effective Useful Life

Parameter	Refrigeration Case SCT Controls	Source
EUL (Years) – SCT controls	6.67	California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. RUL = 1/3 EUL HOST capped at EUL of control based on 2015 SCE Ex Ante Adjustments[9]

BASE CASE MATERIAL COST ($/UNIT)

Insofar as these measures are retrofit/add-on measures, the base case costs are equal to $0.00.

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[6] California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

[7] KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

[8] California Public Utilities Commission (CPUC). 2016. Resolution E-4807. December 16. Page 13.

[9] 2015 SCE Ex Ante Adjustments-with Solution codes and WP number.xlsx

MEASURE CASE MATERIAL COST ($/UNIT)

The measure case costs were drawn from the 2010-2012 WO017 Ex Ante Measure Cost Study, May 27, 2014, conducted by Itron, Inc[10] and applying an escalation factor determined by comparing the rates from RSMeans 2013 and RSMeans 2019.

The 2010-2012 Ex Ante Measure Cost Study provides the cost of controller per discharge group (whereas the normalizing unit for savings is per-ton of cooling capacity). Thus, it was necessary to develop cost per ton of cooling capacity.

To estimate the cost per ton, it is assumed that the design capacity of a discharge group is 34 tons. This assumption was derived as the weighted average of tons per discharge group, which accounts for the proportion of supermarket and grocery stores in the market, as well as the average number of discharge groups for each store type.[11] The cost per ton is calculated as cost per discharge group reported in the 2010-2012 Ex Ante Measure Cost Study divided by 34 tons.[12]

LABOR COST ($/UNIT)

Labor costs were derived using the same methodology as measure case costs. See Measure Case Material Cost section.

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 relevant NTG value for the refrigeration case SCT Control measures is specified in Table 3. These 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. This sector average NTG ("default NTG") are applicable to all energy efficiency measures that have been offered through commercial sector programs for more than two years and for which impact evaluation results are not available.

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[10] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission.

[11] This weighting methodology was vetted during the California Technical Forum, Commercial Refrigeration Subcommittee Meeting #5 in September 2017. CalTF. 2017. *Commercial Refrigeration Measure Consolidation*. "CalTF_Commercial_Refrigeration-9-28-17.pdf"

[12] Southern California Edison (SCE). 2017. "SCE17RN023.1 Cost Calculation 2017.xlsx."

Table 3. Net-to-Gross Ratios

Parameter	Refrigeration Case SCT Controls	Source
NTG - Commercial	0.60	Itron, Inc. 2011. *DEER Database 2011 Update Documentation.* 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 varies by end use, sector, technology, application, and delivery method. The GSIA rate specific for refrigeration case SCT control is shown in Table 4. This GSIA rate is the current "default" rate specified for measures for which an alternative GSIA has not been estimated and approved.

Table 4. Gross Savings Installation Adjustment Rate

Parameter	Refrigeration Case SCT Controls	Source
GSIA	1.0	California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 31.

NON-ENERGY IMPACTS

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

DEER DIFFERENCES ANALYSIS

This section provides a summary of inputs and methods based upon the Database for Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

Table 5. DEER Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	Yes
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER eQUEST Prototypes	No
DEER Version	DEER2020
Reason for Deviation from DEER	DEER2020 does not have these measures. The offerings are added in MASControl3 and ran for grocery prototype
DEER Measure IDs Used	NA
NTG	Source DEER. NTG=0.60 is associated with NTG ID: *Com-Default>2yrs*
GSIA	Source DEER. GSIA=1.0 is associated with GSIA ID: *Def-GSIA*
EUL/RUL	2015 SCE Ex Ante Adjustments: EUL ID: *GrocSys-FltHdPres*. EUL = 6.67

REVISION HISTORY

Revision Number	Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	3/31/2018	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: SCE17RN023 Revision 1 (December 4, 2017) SCE17RN923 Revision 0 (December 9, 2016) PGE3PREF121 Revision 3 (January 1, 2016) Consensus reached among Cal TF members.
	4/25/2019	Akhilesh Endurthy Solaris-Technical	DEER2020 updates Updated impacts using DEER2020 Grocery Prototypes Updated costs Updated EUL to 6.67 years based on 2015 SCE Ex Ante Adjustments
	5/1/2020	Jesse Manao SCE	• Split "Any" BT in the Energy Impact tab. • Savings in Energy Impact tab updated to correctly reflect values in Measure Spec Data. • Fixed Delivery Type misspelling in Implementation tab. • Removed "SWCR007-01-Calc Template_Final.xlsm" (SCE Internal File)