HVAC Impact Evaluation FINAL Report

WO32 HVAC - Volume 2: Appendices

California Public Utilities Commission, Energy Division

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APPENDICES

A. Additional Monitoring and Analysis Detailed Description (QM)

Table A1 below summarizes the suite of monitoring equipment installed for each QM unit. Note that the monitoring equipment was modified occasionally due to unit configuration. For instance, small packaged units (5 tons or less) typically did not have economizers. Therefore, the economizer hood sensor and mixed air sensors were removed from the metering suites. In two other instances, units did not have any mixed air plenum space; instead the return air was blown directly over the bottom portion of the coil and outside air was blown directly over the top section of the coil. In these two cases, no mixed air sensors were installed.

Table A1: QM Monitoring Equipment

Measured Parameter	Typical Parameter Range	M&V Equipment Brand and Model	Sensor Count	Rated Full Scale Accuracy	Accuracy of Expected Measure-ment	Metering Interval
Supply Air – Temp/RH	45-65 °F	Onset Smart sensor S-THB-M002	2	± 0.36 °F ± 3.5% RH	± 0.36 °F ± 3.5% RH	1 minute
Return Air – Temp/RH	50-80 °F	Onset Smart sensor S-THB-M002	2	± 0.36 °F ± 3.5% RH	± 0.36 °F ± 3.5% RH	1 minute
Mixed Air – Temp/RH	50-90 °F	Onset Smart sensor S-THB-M002	4	± 0.36 °F ± 3.5% RH	± 0.36 °F ± 3.5% RH	1 minute
Economizer Hood Air – Temp/RH	40-110 °F	Onset Smart sensor S-THB-M002	1	± 0.36 °F ± 3.5% RH	± 0.36 °F ± 3.5% RH	1 minute
Ambient Air – Temp/RH	40-110 °F	Onset Smart sensor S-THB-M002	1	± 0.36 °F ± 3.5% RH	± 0.36 °F ± 3.5% RH	1 minute
Economizer Dsipalcement	8 – 50 in.	Celesco SP2-50	1	±1% of FS	±1% of FS	1 minute
True Power Pulse Transducer	0 to 30 kW	CCS Wattnode (WNB-3D-240/480-P)	1	± 0.5% of logged value	± 0.5% of logged value	1 minute

Airside Testing

In addition to installing monitoring equipment, evaluation engineers also conducted airflow tests on metered systems. These airflow measurements were used in conjunction with the metering data to estimate system cooling output and efficiency on a time series basis. Tests were performed before and after service activities to quantify the impacts of QM maintenance on airflow. Airflow and related parameters were measured using one (or more) of three core tests:

TrueFlow airflow grid measurements, anemometer traverse measurements, and external and total static pressure measurements.

Whenever possible, a TrueFlow test or a traverse was performed. TrueFlow tests were preferred because their accuracy is not constrained by the need for straight ducts runs. By contrast, traverse tests require a straight duct section of at least 10.5 hydraulic diameters in length for maximum accuracy; this condition is not commonly met in the field. The evaluation team's ability to perform TrueFlow tests was commonly limited by one of two issues: a unit was too large or there was no accessible point to install the flow grid. The evaluation team always carried an expanded TrueFlow test kit with 8 flow grids, but there were still instances where 8 grids were insufficient to fill the entire filter bank. In other cases, there was simply nowhere to insert the flow grid in the unit. Traverses were used, if possible, when TrueFlow tests could not be performed. If neither test could be performed, then external static pressure readings were collected at minimum. While external static pressure (measured as the differential pressure across a unit from the return inlet to the supply outlet) does not in and of itself constitute an airflow measurement, it provides a means of estimating relative changes in airflow by comparing readings before and after service.

Figure X demonstrates the critical measurement locations for a TrueFlow test. During a typical TrueFlow test, the evaluation engineer allowed the unit to run in cooling mode for 10 to 15 minutes in order to reach wet coil conditions. Then a measurement of normal static operating pressure (NSOP) was taken. NSOP is the difference between the supply plenum pressure and building pressure (or ambient pressure if a *building is not measurably pressurized*). The unit was then turned off and the air filters were replaced with as many TrueFlow grids as necessary to fill the filter slot. The unit was then turned back on, a TrueFlow static operating pressure reading (TFSOP) was taken (identical to NSOP but with the grids in the filters' place), and airflow through each TrueFlow grid was recorded.

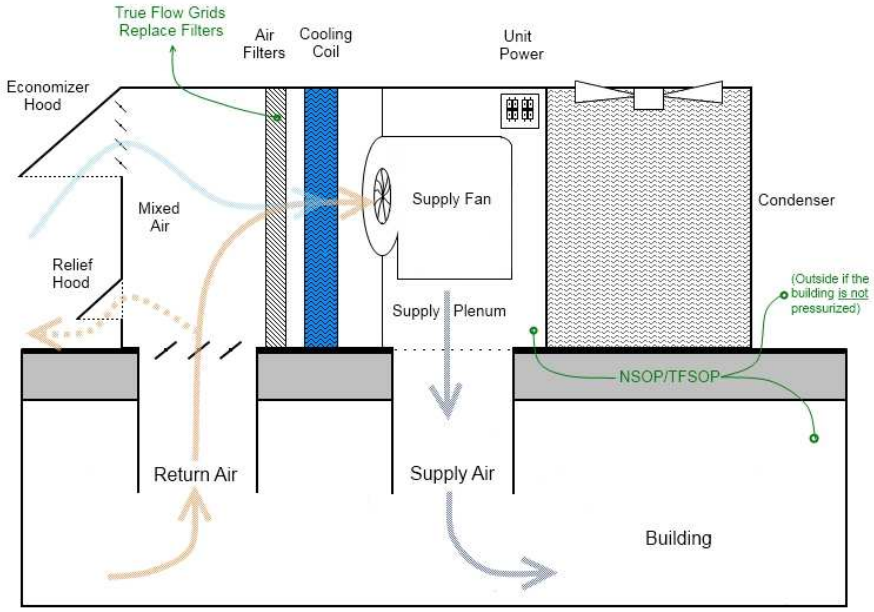

Figure 1: QM True Flow Test Schematic

A.1 Analysis Details

The first step in calculating *unit* performance was determining cooling output for each time step in the metered data set. This calculation was carried out as follows:

$$Cooling_{out-i} = \frac{CFM_{supply}}{SV_{supply-i}} \cdot \left(h_{mixed-i} - h_{supply-i}\right)\left(60\frac{min}{hour}\right)$$

Where,

- $Cooling_{out-i}$ = Cooling rate during time stamp i [Btu/h]
- CFM_{supply} = Supply air flow rate
- $SV_{supply-i}$ = Specific volume of the supply air [CF/lb-dry air]
- $h_{mixed-i}$ = Mixed air enthalpy [btu/lb]
- $h_{supply-i}$ = Supply air enthalpy [btu/lb]

The team performed a similar calculation to estimate sensible cooling output based on the dry air enthalpy values. For each timestamp, the team divided cooling rate by the unit output (in kW) to estimate efficiency.

Using the calculated cooling output and efficiency data, the evaluation team next developed empirical performance curves based on field data to characterize unit performance. The team formulated these curves to fit the following DOE2.2 packaged HVAC model:

$$kW_i = \frac{Cap_{rated} \cdot Capf(ECWB_i, OAT_i) \cdot EIR_{rated} \cdot EIRf(ECWB_i, OAT_i) \cdot EIRf(PLR_i)}{3412 \frac{Btu}{kWh}}$$

Where,

- kW_i = Power draw for time step i (less supply fan power)
- Cap_{rated} = Unit capacity (btu/h) at rated operating conditions (95 F outdoor temperature (OAT), 67 F entering coil wet bulb temperature (ECWB)).
- $Capf(ECWB_i, OAT_i)$ = A biquadratic curve characterizing the impact of ECWB and OAT on *full load* capacity. The output is normalized to a value of 1 at rated conditions.
- EIR_{rated} = EIR is the dimensionless ratio of the unit's power draw (without the supply fan) to load; it is effectively the inverse of COP. This parameter is the EIR at rated conditions (95 F OAT, 67 F ECWB).
- $EIRf(ECWB_i, OAT_i)$ = A biquadratic curve that adjusts a unit's *full load* EIR (efficiency) as a function of ECWB and OAT. The output is normalized to a value of 1 at rated conditions.
- $EIRf(PLR_i)$ = A curve characterizing how the unit's power draw changes as a function of part load ratio (PLR).

Notice that this unit model required the development of three underlying performance curves: $Capf(ECWB, OAT)$, $EIRf(ECWB, OAT)$ and $EIRf(PLR)$. The goal of the unit performance analysis was therefore to develop these three curves for each unit during each service interval.

The team created the capacity scaling function, $Capf(ECWB_i, OAT_i)$, first. They parsed a given unit's data set to identify the maximum amount of cooling provided for each unique combination of ECWB and OAT. In this way, the team identified full load points. After removing outliers, the evaluation team determined the regression coefficients for the following equation from the resulting data set:

$$Capacity = a + b \cdot ECWB + c \cdot ECWB^2 + d \cdot OAT + e \cdot OAT^2 + f \cdot ECWB \cdot OAT$$

The team then calculated output from the above curve at rating conditions (95 F OAT, 67 F ECWB). The team divided each coefficient in the above equation by this output to normalize the curve to a value of 1 at the rating conditions, yielding the desired curve: $Capf(ECWB, OAT)$. The evaluation team conducted an identical procedure to develop the full load efficiency scaling function, $EIRf(ECWB, OAT)$.

The team utilized the two full load scaling functions, $Capf(ECWB, OAT)$ and $EIRf(ECWB, OAT)$, with all points in the metered data set—including both full load and part load operating points—to determine coefficients for the part load performance scaling function $EIRf(PLR_i)$. This function is defined as:

$$EIR_{PLR} = a + b \cdot PLR + c \cdot PLR^2 + d \cdot PLR^3$$

The evaluation team calculated EIR_{PLR} for each time step in the metered data set by rearranging the fundamental DOE2.2 performance equation and plugging in values for the $Capf(ECWB, OAT)$ and $EIRf(ECWB, OAT)$ equations:

$$EIRf(PLR_i) = \frac{kW_i \cdot 3412 \frac{Btu}{kWh}}{Cap_{rated} \cdot Capf(ECWB, OAT) \cdot EIR_{rated} \cdot EIRf(ECWB, OAT)}$$

The team then calculated the dependent PLR variable in the cubic regression equation above for each time step as,

$$PLR_i = \frac{Cooling_{out-i}}{Cap_{rated} \cdot Capf(ECWB_i, OAT_i)}$$

The team calculated regression coefficients for the EIR_{PLR} equation using the $EIRf(PLR_i)$ and PLR_i values for each time stamp.

With the three regression equations composing the DOE2.2 model defined, the *unit* performance characterization was complete. To then estimate *system* performance, the evaluation team also needed to model economizer operations. For each time step in the data set with AHU fan operation, the team plotted outdoor air fraction against ambient temperature and ambient enthalpy[1]. If the outdoor air fraction was not observed to change with respect to temperature or enthalpy, then the team assumed the economizer was non-operable and fixed in a static position. If outdoor air fraction modulation was observed, then the team used metered data to define the economizer's operating strategy.

Using the *unit* performance model and the economizer control data, it was possible to model system performance for any combination of space cooling load and ambient conditions.

B. Detailed Findings from CQM Sites

Table 1: Notes from Selected Sites

Site Code	IOU	Unit	Notes
CC	SCE	AC 01	● The unit control seems improved as the unit cycling frequency seems decreased. ● The unit operating schedule changes as the unit ran continuously during the base period and it scheduled off from 10:00pm to 4:00am during weekdays and 12:00am to 11:59pm during weekends. ● At the same ambient dry bulb, the post return temperature is around 1F higher than the base return temperature. ● The base and post space cooling loads are close to each other at the same outdoor dry bulb temperature. ● The base system kw/ton based on space cooling load is very close to the post kw/ton. The system kw/ton values seem to be in the reasonable range of 1 kW/ton to 2 kW/ton. ● The unit performance did not change significantly after the service. ● The OA damper position was changed from 5% to 20% after the service. ● The post unit kW is close to the base unit kW at the same outdoor DB ● Power savings due to reduced running hours, more free cooling, and improved unit control.
CC	SCE	AC 04	● The unit control did not change during the base and post periods ● The unit operating schedule changes as the unit ran continuously during the base period and it scheduled off from 10:00pm to 4:00am during weekdays and 12:00am to 11:59pm during weekends. ● At the same ambient dry bulb, the post return temperature is around 0.5F higher than the base return temperature. At high DB end, **the space temperature seems out of control.** ● The post space cooling load is close to the base space load at the same outdoor dry bulb temperature ● **The system kw/ton values seem way higher than the normal range probably due to incorrect airflow rate.** ● The base unit kW/ton is obviously lower than the post kw/ton at the same cooling coil load due to unknown reason. ● There appears to be a small absolute change in OA ratio after the service ● Power savings due to reduced running hours, more free cooling
BP	SCE	AC 06	**No MA OA data**. Post power and post airflow are suspicious.
BP	SCE	AC 07	**Compressor 1 disconnected and compressor 2 did not run during the base**
BP	SCE	AC 08	● **No MA data**. ● There is no change on operation schedule, space return temperature, and system control after the service. ● The post return temperature is close to the base return temperature at the same ambient DB. The space temperature is out of control at high DB. ● Base and post system performance is in reasonable range and is close to each other. ● Post power is higher due to higher post space cooling load. ● Negative power savings due to increased post space cooling load
BP	SCE	AC 10	**Compressor did not run** during the base or post periods

Site Code	IOU	Unit	Notes
BP	SCE	AC 13	● Unit was shut down from 12am to 6am during the base and post periods and no change to space temperature setpoint or operating schedules. ● The post space load is slightly higher than the base space load. ● The post unit performance is slightly better than the base unit performance probably due to higher coil entering web-bulb temperature. ● OA ratio decreased from 60% to 0% after the service. ● The post power is slightly lower than the base power at the same ambient DB because of higher post unit performance.
HB	SCE	AC 01	● There is no change on operation schedule, space return temperature, and system control after the service. ● The post space cooling load is slightly higher than the base load at the same ambient DB. ● The base system kW/ton based is slightly lower than the post kw/ton at the same space load. ● The post unit performance is better than the base unit performance because the post coil load is higher than the base coil load. ● The OA ratio is fixed at 60% during the whole period. ● The post power is slightly higher than the base power at the same ambient DB because of higher unit load.
HB	SCE	AC 04	● There is no obvious change on operation schedule, and system control after the service. ● The post return temperature is around 1F lower than the base return temperature. ● The space is well maintained between 72F and 75F. From 2am to 6am, the unit was fixed at ventilation mode. ● The post space load is obviously higher than the base space load probably due to a combination of lower return temperature, higher total airflow and outside air ratio during the post period. ● The base system performance is very close to the post system performance at the same stage and the same space load. ● The unit performance did not change after the service. ● Negative power savings due to higher post space load.
HB	SCE	AC 10	● The unit appeared to be in good control, but there are **no sufficient AC running data** for baseline and post analysis as the unit was in ventilation mode. ● There is no change on operation schedule and system control. ● The post space temperature was maintained between 74F and 76F. ● The post return temperature is about 1F lower than the base period return temperature. ● Negative power savings as the compressor did not kick on during the base, while it ran for some time during the post.

Site Code	IOU	Unit	Notes
HB	SCE	AC 11	● The **mixed air sensors are missing** for the whole base and post periods ● No change on control and operating schedule. The unit was shut down from 2am to 6am. ● The post space temperature is around 1F lower than the base space return temperature. ● The unit was in cycling and the space temperature was well maintained between 73F and 75F. ● The post space load is higher than the base space load at the same DB temperature, probably due to lower space temperature. ● The system kw/ton values seem to be within the reasonable range of 1 kW/ton to 2 kW/ton. ● The post system performance is worse than the base system performance at the same space cooling load for unknown reason. ● Negative power savings due to higher post load and worse post system performance.
OH	SCE	AC 05	• The collected data was deemed insufficient to conduct Analysis
CM	SCE	AC 4F	• The baseline and post space cooling loads are different. The baseline load seems higher than the post cooling loads. • There is a slight change in the unit performance in terms of kW per ton. • The unit appeared to be cycling frequently during the base period. During the post, the unit control seemed improved with less cycling and better control. • The kW/ton value gets better in higher loads in the base-period, but over-all kW/ton values for post period is better. • The OA fraction is varying significantly, and the inspection notes mention that they were not able to fix the Economizer. They were able to clean the coils, and tune up the compressors.
EC	SDGE	AC 01	● Unit control seems improved after the service as unit cycling frequency is reduced. ● Economizer DB/RH, RA DB2/RH2 sensors are problematic and replaced ● There is no obvious return temperature change and both are in the range of 72F and 74F. ● The unit kW/ton values seem to be within the reasonable range of 1 kW/ton to 2 kW/ton. ● The baseline and post system performance is close to each other at the same space load. ● OA ratio is fixed at 10% during the whole trending period. ● Power savings is minimal
EC	SDGE	AC 03	● **No SA temperature during the post period**

Site Code	IOU	Unit	Notes
EC	SDGE	AC 06	● Unit operating schedule changed as the unit was in ventilation during the base and was shut down from 1am to 4am during the post ● There is no obvious change on system control and space return temperature after the service. ● The unit was cycling to maintain the space temperature between 70F and 73F. ● The post space load is close to the baseline space load at the same DB and both seem independent of the ambient DB. The unit ran more hours during the post than it did during the base period. ● The system kW/ton values seem to be within the reasonable range of 1 kW/ton to 2 kW/ton. ● The post unit performance is close to the base unit performance at the same coil load and same stage. ● The OA ratio is fixed at 10% during the base period and it is reduced to 6% during the post. ● Negative power savings probably due to more running hours during the post period.
EC	SDGE	AC 13	● MA temperature is missing after 12/17/2012 ● There is no obvious change on system control and operating schedules ● During the base and post periods, the unit was in ventilation mode for most of time and **there are only a few compressor running data** ● The return temperature during the post is about 2F higher than that during the base period ● Because of high OA airflow, the unit cannot maintain space temperature when it is very hot outside ● The post space load is higher than the baseline space load at the same DB due to unknown reason ● The system kW/ton values seem to be within the reasonable range of 1 kW/ton to 2 kW/ton ● The post unit performance is slightly better than the base unit performance at the same coil load ● The OA ratio is fixed at around 65% during the base and post periods ● There is little if any power savings
SD	SDGE	AC 01	● **The supply air temperature during the base period is missing** ● There is no obvious change on system control and operating schedules. The unit was scheduled off from 1am to 5am during the baseline and post periods. ● The post space temperature is around 2F higher than the base space return temperature. ● **The post system kW/ton values seem to be lower than the normal range** probably due to incorrect airflow value. ● The OA damper is fixed at 40% open. ● There is little power savings as the base and post power values are close to each other at the same DB

Site Code	IOU	Unit	Notes
SD	SDGE	AC 02	● There is no obvious change on system control and operating schedules. The unit was scheduled off from 1am to 5am during the baseline and post periods. ● The base and post return temperatures are close to each other. The space return temperature is in the range of 66F to 73F. ● The post space cooling load is slightly higher than the base space load at the same outdoor dry bulb temperature and the same stage ● The post unit performance seems slightly worse than the base performance at the same cooling coil load and the same stage. ● **The unit kw/ton values seem higher than the normal range probably due to incorrect airflow rates.** ● The OA damper is fixed at 60% open. ● There is little power savings as the base and post power values are close to each other at the same DB
SD	SDGE	AC 03	● The post return temperature is 2F higher than the base return temperature at the same ambient DB. ● **The space temperature is out of control during the base and post periods.** ● The post space load seems higher than the base space load at the same DB temperature. ● The system kW/ton values seem within the normal range. ● At the same stage, the post unit performance seems close to the base unit performance ● The OA ratio is fixed at 80% during the base and post periods. ● There is slight negative power savings as the unit ran more frequently during the post.
SD	SDGE	AC 08	**Compressor did not run** during the base periods
TE	SDGE	AC 12	• The unit was cycling most of the time, and is not stable enough to get enough analysis in the base-case. • During the post period, the unit control seemed improved with less cycling and better control. Due to excessive cycle, we do not have enough stable data to calculate the base system kW/ton values. • The OA fraction is varying significantly, and the inspection notes mention that they were not able to fix the Economizer. They were able to clean the coils, and tune up the compressors. • In base-case the fan used to run 24/7; this has been fixed; and has resulted in savings. • The space cooling tonnage has not changed with respect to base-case.
TE	SDGE	AC 08	• The unit was cycling most of the time, and is not stable enough to get enough analysis in the base-case. • During the post period, the unit control seemed improved with less cycling and better control. Due to excessive cycle, we do not have enough stable data to calculate the base system kW/ton values. • In base-case the fan used to run 24/7; this has been fixed; and has resulted in savings. • The space cooling tonnage has not changed with respect to base-case. • There is lot of missing temperature points. MA, RA, etc.

Table 2: Data from CQM Sites

Site Code	IOU	Unit	Ton Rated	Base CFM	Base fan kW	Post CFM	Post fan kW	Annual	Average	Peak	Annual per Ton	Peak Per Ton	Annual per Ton	Peak Per Ton
CC	SCE	AC 01	20	7,000	4.4	7,000	4.3	-33,142	-3.78	-7.98	-1,657	-0.40	-1,657	-0.40
CC	SCE	AC 04	10	3,500	1.6	3,600	1.7	-12,138	-1.39	0.76	-1,214	0.08	-1,214	0.08
BP	SCE	AC 06	10	4,500	2.4	2,250	1.6	11,456	1.31	2.73	1,146	0.27	1,146	0.27
BP	SCE	AC 07	10	4,644	3.3	4,644	3.5	-379	-0.04	0.19	-38	0.02	Insufficient Pre Usage	Insufficient Pre Usage
BP	SCE	AC 08	12	4,447	2.2	4,500	2.3	12,035	1.37	6.01	1,003	0.50	1,003	0.50
BP	SCE	AC 10	7.5					-997	-0.11	-0.13	-133	-0.02	Insufficient Pre Usage	Insufficient Pre Usage
BP	SCE	AC 13	10	3,076	2.2	3,076	2.2	39,261	4.48	3.04	3,926	0.30	3,926	0.30
HB	SCE	AC 01	6	1,200	1.6	1,220	1.7	-4,381	-0.50	0.11	-730	0.02	-730	0.02
HB	SCE	AC 04	20	3,148	1.5	3,300	1.7	-22,191	-2.53	-11.63	-1,110	-0.58	Insufficient Pre Usage	Insufficient Pre Usage
HB	SCE	AC 10	15	5,236	2.8	5,393	3.1	-15,255	-1.74	-6.63	-1,017	-0.44	-1,017	-0.44
HB	SCE	AC 11	5	900	0.7	1,360	1.0	7,942	0.91	2.71	1,588	0.54	1,588	0.54
OH	SCE	AC 05	5	1,750	N/A	1,798	N/A	10,902	1.24	-1.50	2,180	-0.30	2,180	-0.30
CM	SCE	AC 4F	7	4,301	2.7	3,229	2.6	38,613	4.41	4.83	5,516	0.69	5,516	0.69
OH	SCE	AC 1	2					-697	-0.08	0.81	-349	0.40	-349	0.40
OH	SCE	AC 2	4					-1,073	-0.12	1.56	-268	0.39	-268	0.39
OH	SCE	AC 3	3.5					5,299	0.60	-2.86	1,514	-0.82	1,514	-0.82
OH	SCE	AC 4	3.5					16,250	1.86	1.64	4,643	0.47	4,643	0.47
BH	SCE	AC 1	3					3,542	0.40	3.87	1,181	1.29	1,181	1.29
CM	SCE	4C	7.5					-33,719	-3.85	-7.50	-4,496	-1.00	-4,496	-1.00

Site Code	IOU	Unit	Ton Rated	Base CFM	Base fan kW	Post CFM	Post fan kW	Annual	Average	Peak	Annual per Ton	Peak Per Ton	Annual per Ton	Peak Per Ton
CM	SCE	5 B	10					-9,875	-1.13	-9.51	-988	-0.95	-988	-0.95
CC	SCE	AC 02						No Post	No Post	No Post			Insufficient Pre Usage	Insufficient Pre Usage
CC	SCE	AC 03						No Pre	No Pre	No Pre			Insufficient Pre Usage	Insufficient Pre Usage
EC	SDGE	AC 01	15	5,655	3.1	5,393	3.2	6,357	0.73	1.66	424	0.11	424	0.11
EC	SDGE	AC 03	10	2,194	2.0	3,340	2.0	-26,589	-3.04	-3.40	-2,659	-0.34	-2,659	-0.34
EC	SDGE	AC 06	15	4,000	2.1	4,094	2.3	-25,985	-2.97	-10.94	-1,732	-0.73	-1,732	-0.73
EC	SDGE	AC 13	5	1,531	1.0	1,531	1.0	-12,892	-1.47	-5.60	-2,578	-1.12	Insufficient Pre Usage	Insufficient Pre Usage
SD	SDGE	AC 01	10	3,050	1.4	3,050	1.4	-44,478	-5.08	-7.49	-4,448	-0.75	-4,448	-0.75
SD	SDGE	AC 02	10	3,172	1.6	3,172	1.6	12,376	1.41	-2.65	1,238	-0.26	1,238	-0.26
SD	SDGE	AC 03	10	3,071	1.5	3,071	1.5	-9,544	-1.09	-1.67	-954	-0.17	-954	-0.17
SD	SDGE	AC 08	7.5	1,870	0.9	2,390	1.3	-9,901	-1.13	2.04	-1,320	0.27	Insufficient Pre Usage	Insufficient Pre Usage
TE	SDGE	AC 12	12.5	4,706	1.5	4,706	1.5	-67,724	-7.73	-15.73	-5,418	-1.26	-5,418	-1.26
TE	SDGE	AC 08	7	3,117	1.8	3,117	1.8	-38	0.00	0.05	-5	0.01	-5	0.01
TE	SDGE	AC 2	10					-9,902	-1.13	-3.71	-990	-0.37	-990	-0.37
TE	SDGE	AC 13	12.5					-15,991	-1.83	-14.36	-1,279	-1.15	-1,279	-1.15
SP	SDGE	AC 1	5					No Post	No Post	No Post			Insufficient Pre Usage	Insufficient Pre Usage
SP	SDGE	AC 2	3					No Post	No Post	No Post			Insufficient Pre Usage	Insufficient Pre Usage

Site Code	IOU	Unit	Ton Rated	Base CFM	Base fan kW	Post CFM	Post fan kW	Annual	Average	Peak	Annual per Ton	Peak Per Ton	Annual per Ton	Peak Per Ton
SE	SDGE	AC 1	4					-5,114	-0.58	-0.51	-1,278	-0.13	-1,278	-0.13
SE	SDGE	AC 2	4					-2,939	-0.34	-0.26	-735	-0.07	-735	-0.07
SS	SDGE	AC 1	5					No Post	No Post	No Post			Insufficient Pre Usage	Insufficient Pre Usage
SN	SDGE	1	4					No Post	No Post	No Post			Insufficient Pre Usage	Insufficient Pre Usage
SN	SDGE	2	2.5					No Post	No Post	No Post			Insufficient Pre Usage	Insufficient Pre Usage
SD	SDGE	4						No Post	No Post	No Post			Insufficient Pre Usage	Insufficient Pre Usage

B.1 SCE Statewide – Metered Sites

B.1.1 Site BP

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) This SCE statewide site has a total of twenty one (21) RTUs and five were enrolled in the program. EM&V observations were conducted of five (5) units on 10-12-12, 10-13-12, 11-09-12, and 11-20-12.
   1) Carrier 50TFQ008-601GA, S/N3901G32058, SCE Sticker 002-6421, RTU 10,
   2) Carrier 50TFQ012-601GA, S/N0701G34262, SCE Sticker 002-6406, RTU 7,
   3) Trane YSC120A4EMA2R, S/N62910664L, SCE Sticker 002-6405, RTU 6,
   4) Trane YSC120A4EMA2R, S/N629100780L, SCE Sticker 002-6407, RTU 13, and
   5) Carrier 50HJQ014-610QA, S/N4101F15719, SCE Sticker 002-6420, RTU 8.

3) The following information is provided regarding the Work Order 032 EM&V HVAC master technician observations of the Contractor who performed work at [site name]. The Contractor was recruited to participate in the WO32 observation sample for the SCE program. The participating contractor provides quarterly maintenance including changing filters and washing condensers with water every three months. During EM&V observations of each unit the technician performed the following services: changed air filters, cleaned condensers with water, and cleaned evaporator coils with brush. Technician did not check or replace contactors or capacitors. Coils did not have any visible corrosion. One technician was observed diagnosing refrigerant charge and airflow with digital pressure gauge manifolds with EPA 608 low-loss fittings on two sets of gauges, Type-K thermocouple clamps, and Type-K thermocouple bead probes with wick to measure wetbulb air temperatures. Technician hooked up refrigerant hoses and attempted to purge non-condensables with refrigerant from system.

4) WO32 EM&V pre-observation was performed on 10-13-12 of the 7.5-ton Carrier model 50TFQ008-601GA, sticker 002-6421, RTU 10. Compressors were disabled but blower fan was wired to operate continuously 24 hours per day. The unit had a refrigerant leak and loss of refrigerant in circuit 1 which was off on low pressure switch and circuit two was disconnected, and condenser fan wires were disconnected. Blower fan operated, but filters were very dirty. Micrometl economizer model 0688HJ712EC was disconnected and not functioning, outdoor air sensor was missing, and outdoor air dampers were 25% open (2 fingers). Cabinet missing approximately 20 screws and others were stripped. Standard A50 fan belt was worn, frayed, cracking, and misaligned by ¼ inch.

WO32 EM&V technician observation was performed on 11-09-13 of RTU 10. The technician tightened but did not replace or align the belt or repair economizer. Technician properly diagnosed that compressors were disabled and blower fan was wired to operate continuously 24 hours per day. Technician attempted to perform refrigerant charge and airflow tests, but was unable to complete tests due to issues noted above. Technician put new screw in filter access door. Technician indicated the contractor would provide a cost estimate for repairs.

WO32 EM&V team did not perform post-observations of RTU 10.

5) WO32 EM&V pre-observation was performed on 10-13-12 of the 10-ton Carrier model 50TFQ012-601GA, sticker 002-6406, RTU 7. Condensate pan was not draining properly and water was overflowing out the back of unit. The unit was found with compressor 1 disconnected since 2005 (writing on electrical cover "compressor 1 has bad valves"). Therefore, RCA evaluation was only performed of circuit 2. Blower wheel, shaft, and both pulleys were recently replaced but alignment was off by 1/3 inch. Standard A51 fan belt was too tight causing belt to be frayed and almost failing. Evaporator condensate pan was not draining properly and overflowing on back of unit. Condenser fan wires were loose and close to hitting blades. Condenser coil was vandalized with approximately 25% of coil pushed in. 10-15 screws missing from cabinet. Economizer was not functioning due to failed damper motor and Molex plug disconnected and located in between damper blades which are 25% open (2 fingers). Pre-observation temperature split was 6.2°F or -12 below 18.2°F CEC RCA target indicating low capacity and failed compressor. Circuit 2 superheat was 25.5°F or 8 above 17°F CEC RCA target indicating undercharge. Subcooling was 19°F and above 11 +/- 4°F program tolerance, evaporator saturation temperature (EST) was 36.7F and below 46 +/- 6°F program tolerance, and condenser over ambient (COA) was 36.2F and above 25 +/- 5°F program tolerance indicating heat transfer issues or non-condensables.

   WO32 EM&V technician observation was performed on 11-09-13 of RTU 7. The technician discovered compressor 1 not working and discovered a refrigerant leak on circuit 2 and disconnected power to compressor 2. Technician found fan belt off the pulley and reinstalled the belt, but did not check alignment or repair economizer. Technician was unable to complete RCA tests and indicated the contractor would provide a cost estimate for repairs.

   WO32 EM&V team did not perform post-observations of RTU 7.

6) WO32 EM&V pre-observation was performed on 10-12-12 of the 10-ton Trane model YSC120A4EMA2RD, sticker 002-6405, RTU 6. The condensate pipe was cut near the P-trap and connected with electrical tape. Condenser coil was vandalized with approximately 10% of coil fins pushed in. 5 screws were missing from cabinet and 5 screws were stripped. Trane economizer model BAYECON088A was not functioning due to corroded and detached

control wires and minimum damper position was 10% open (1 finger). Notched AX35 fan belt was properly tensioned but misaligned by ¼ inch. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of outdoor air temperature (OAT) and return air wetbulb (RWB) temperature (Service Facts YSC120-SF-3, YSC120ADRLA, YSC120ADRHA, Package Gas/Electric, YSC120-SF-3.pdf).[2] The CEC RCA protocol provides target temperature split as a function of RWB and return drybulb (RDB) temperature and target superheat (SH) as a function of OAT and RWB temperature.[3] Pre-observation temperature split was 19.5°F and within 0.9 of 18.6°F CEC RCA target. Circuit 1 pre-observation suction pressure was 71 psig or -2.9 below 73.9 psig manufacturer target and within tolerance. Circuit 1 discharge pressure was 214 psig or 17.5 above 195.6 psig manufacturer target indicating overcharge. Circuit 1 superheat was 30.5°F or 15.8 above 14.7°F manufacturer target indicating undercharge. Circuit 1 EST was 41.6°F and within 46 +/- 6°F program tolerance. Circuit 2 pre-observation suction pressure 71 psig or -3 below 74 psig manufacturer target and within tolerance. Circuit 2 discharge pressure was 208 psig or -21.1 below 229.1 psig manufacturer target indicating undercharge. Circuit 2 superheat was 32.3°F or 17.6 above 14.7°F manufacturer target indicating undercharge. Circuit 2 EST was 41.6°F and within 46 +/- 6°F program tolerance.

WO32 EM&V technician observations were performed on 11-09-12 of RTU 6. The technician did not check fan belt alignment or repair economizer. Technician temporarily repaired condensate drain by installing additional electrical tape. Technician did not perform initial temperature split measurement. Technician initial circuit 1 superheat was 21.7°F or 7.7 above 14°F CEC RCA target at 68°F OAT and 58.1°F RWB indicating undercharge but within 20 +/- 5°F program tolerance. Technician initial circuit 2 superheat was 32.8°F or 18.8 above 14°F CEC RCA target and above 20 +/- 5°F program tolerance indicating undercharge. Technician added 27 ounces of refrigerant to circuit 1 and 28.2 ounces to circuit 2. Technician final temperature split was 23°F or 2.7 above 20.3°F CEC RCA target. Technician final circuit 1 superheat was 8.5°F or -5.5 below 14°F CEC RCA target at 68°F OAT and 58.1°F RWB and outside 20 +/- 5°F program tolerance indicating overcharge. Circuit 1 superheat was 8.5°F or -3.9 below 12.4°F manufacturer target and within tolerance. Circuit 1 suction pressure was 68.7 psig or 1 above 67.7 psig manufacturer target and within tolerance. Circuit 1 discharge pressure was 220 or 31.2 above 188.8 psig manufacturer target indicating overcharge. Circuit 1 EST was 40°F and within 46 +/- 6°F program tolerance. Technician final circuit 2 superheat was 12.2°F or -1.8 below 14°F CEC RCA target and

[2] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

[3] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

outside 20 +/- 5°F program tolerance. Circuit 2 superheat was 12.2°F or -0.2 below 12.4°F manufacturer target and within tolerance. Circuit 2 suction pressure was 70 psig or 1.6 above 68.4 psig manufacturer target and within tolerance. Circuit 2 discharge pressure was 212.5 or 9.9 above 202.6 psig manufacturer target and within tolerance. Circuit 2 EST was 40.9°F and within 46 +/- 6°F program tolerance. Technician indicated contractor would provide customer with a cost proposal for repairs.

WO32 EM&V post-observation was performed on 11-09-12 of RTU 6. Post-observation temperature split was 21.7°F or 1.9 above 19.8°F CEC RCA target and within 20 +/- 2°F program tolerance. Circuit 1 post-observation suction pressure was 69 psig or 2.5 above 66.5 psig manufacturer target. Circuit 1 discharge pressure was 201 or 11.7 above 189.3 psig manufacturer target indicating overcharge. Circuit 1 superheat was 14.5°F or 0.7 above 13.8°F manufacturer target at 65°F OAT and 57.7°F RWB. Circuit 1 EST was 40.2°F and within 46 +/- 6°F program tolerance. Circuit 2 post-observation suction pressure was 70 psig or 2.9 above 67.1 psig manufacturer target. Circuit 2 discharge pressure was 193 psig or -1.8 below 194.8 psig manufacturer target. Circuit 2 superheat was 21.2°F or 7.9 above 13.3°F manufacturer target at 65.3°F OAT and 57.5°F RWB indicating undercharge,. Circuit 2 EST was 40.9°F and within 46 +/- 6°F program tolerance.

7) WO32 EM&V pre-observation was performed on 10-12-12 of the 10-ton Trane model YSC120A4EMA2RD, sticker 002-640, RTU 13. The condensate pipe was cut, P-trap was installed backwards and connected with electrical tape and not draining. 5 screws were missing from cabinet and 5-10 screws were stripped. Economizer was functional but damper seal was coming off blade and minimum damper position was closed. Notched AX35 fan belt was properly tensioned and aligned. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of OAT and RWB (Service Facts YSC120-SF-3, YSC120ADRLA, YSC120ADRHA, Package Gas/Electric, YSC120-SF-3.pdf). Pre-observation temperature split was 20.2°F or 2 above 18.2°F CEC RCA and within 20 +/- 2°F program tolerance. Circuit 1 pre-observation suction pressure was 73 psig or 0.3 above 72.7 psig manufacturer tolerance. Circuit 1 discharge pressure was 228 psig or 28 above 200 psig manufacturer target indicating overcharge. Circuit 1 superheat was 14.3 or -0.2 below 14.5°F manufacturer target at 74.1°F OAT and 61.8°F RWB. Circuit 1 EST was 42.9°F and within 46 +/- 6°F program tolerance. Circuit 2 pre-observation suction pressure was 71 psig or -1.9 below 72.9 psig manufacturer target. Circuit 2 discharge pressure was 214 or -9.3 below 223.3 manufacturer tolerance. Circuit 2 superheat was 20.8°F or 6.3 above 14.5°F manufacturer target at 74.1°F OAT and 61.8°F RWB indicating undercharge. Circuit 2 EST was 41.6°F and within 46 +/- 6°F program tolerance.

WO32 EM&V technician observation was performed on 11-20-12 of RTU 13. The technician checked fan-belt tension by hand but did not check alignment. Technician applied Nu-Calgon V-belt dressing to the belt to reduce friction and prolong life.[4] Technician did not repair P-trap drain, nor repair economizer. Technician did not perform initial or final temperature split measurement. Technician circuit 1 suction pressure was 71.2 psig or -0.5 below 71.7 psig manufacturer tolerance. Circuit 1 discharge pressure was 200.3 psig or 4.6 above 195.7 psig manufacturer target. Circuit 1 superheat was 24.1°F or 4 above 20.1°F manufacturer target and within 20 +/- 5°F program tolerance at 68°F OAT and 63.3°F RWB. Circuit 1 EST was 41.7°F and within 46 +/- 6°F program tolerance. Technician circuit 2 suction pressure was 70.8 psig or -1 below 71.8 psig manufacturer tolerance. Circuit 2 discharge pressure was 184.8 psig or -21.6 below 206.4 psig manufacturer target indicating undercharge. Circuit 2 superheat was 25.8°F or 5.7 above 20.1°F manufacturer target and outside 20 +/- 5°F at 68°F OAT and 63.3°F RWB. Circuit 2 EST was 41.5°F and within 46 +/- 6°F program tolerance. Technician indicated that contractor would provide customer with a cost proposal for repairs. WO32 EM&V team did not perform post-observations due to time constraints and technician not adjusting refrigerant charge.

8) WO32 EM&V pre-observations were performed on 10-12-12 of the 12-ton Carrier model 50HJQ014-610QA, sticker 002-6420, RTU 8. The condensate pipe had two P-traps and not draining properly. Condenser coil was vandalized with approximately 15% of coil fins pushed in. 5 screws were missing from cabinet and 5-10 screws were stripped. Economizer was non-functional due to wires being cut and minimum damper position was closed. Notched BX42 fan belt was improperly tensioned (too tight) and misaligned by 1/8 inch. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and OAT (50HJQ014-016 Single-Package Rooftop Heat Pump Units, Installation, Start-up, and Service Instructions, 50hjq-3si.pdf).[5] Pre-observation temperature split was 14.5°F or -3 below 17.5°F CEC RCA target and below 20 +/- 2°F program tolerance. Pre-observation suction temperature was 71.4°F or -7.9 below 79°F manufacturer target indicating overcharge. Superheat was 31.1°F or 10.3 above 20.8°F CEC RCA target at 68.3°F OAT and 63.3°F RWB indicating undercharge. Subcooling was 12.7°F and within 11 +/- 4°F program tolerance, EST was 40.2°F and within 46 +/- 6°F program tolerance, and COA was 19.2°F and below 25 +/- 5°F tolerance.

   WO32 EM&V technician observation was performed on 11-20-12 of RTU 8. The technician checked fan-belt tension by hand but did not check alignment. Technician cleaned evaporator coil and applied Nu-Calgon-Cal-spray. Condensate pan was scrubbed with brush and biological growth inhibitor pad was added. Technician did not repair economizer.

[4] V-belt dressing can cause respiratory illnesses (http://www.nucalgon.com/assets/MSDS/English/4086.pdf).

[5] Manufacturer suction temperature tolerance is +/-5°F.

Technician did not perform initial temperature split measurement. Technician initial superheat was 34.9°F or 11.9°F above 22.7°F CEC RCA target at 67°F OAT and 64.3°F RWB and outside 20 +/- 5°F program tolerance indicating undercharge. Initial suction temperature was 75.6°F or 5.6 above 70°F manufacturer target indicating undercharge. Technician added 10 ounces of R22 refrigerant. Final technician superheat was 22.8°F or 0.7 above 22.1°F CEC RCA target 68°F OAT and 64.3°F RWB and within program tolerance. Final suction temperature was 69.7°F or -0.3 below 70°F manufacturer target. Subcooling was 11.9°F and within 11 +/- 4°F program tolerance, EST was 46.9°F and within 46 +/- 6°F program tolerance, and COA was 23.1°F and within 25 +/- 5°F tolerance. Technician indicated contractor would provide customer with cost proposal for other repairs.

WO32 EM&V post observations were performed on 11-20-12 of RTU 8. Post temperature split was 19.4°F and within 1.5 of 17.9°F CEC RCA target and within 20 +/- 2°F program tolerance. Post superheat was 29.3°F or 9 above 20.3°F CEC RCA target at 71.3°F OAT and 63.8°F RWB and above 20 +/- 5°F program tolerance indicating undercharge. Post-observation suction temperature was 73.6°F or -11.5 below 85.1°F manufacturer tolerance indicating overcharge. Subcooling was 15.6°F and within 11 +/-4°F manufacturer subcooling, EST was 44.3°F and within 46 +/- 6°F program tolerance, and COA was 19.3°F and below 25 +/- 5°F tolerance.

B.1.2 Site CM

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) The SCE statewide site has a total of twenty two (22) RTUs and eight were enrolled in the program when the EM&V team conducted observations. EM&V observations were conducted of three (3) units on 10-10-12 and 11-07-12. WO32 team performed a subsequent economizer inspection on 7-22-13.
   1) Carrier 50HJQ006-511, S/N2003G20149, SCE Sticker 002-1172, RTU 4C,
   2) Carrier 50HJQ012-531, S/N1803G50531, SCE Sticker 002-1171, RTU 5B, and
   3) Carrier 48HJF008-V531, S/N0900G30226, SCE Sticker 002-1170, RTU 4F.

3) The following information is provided regarding the Work Order 032 EM&V HVAC master technician observations of the Contractor who performed work at [site name]. The Contractor was recruited to participate in the WO32 observation sample for the SCE program. The participating contractor provides quarterly maintenance including changing filters and washing condensers with water every three months. During EM&V observations of each unit the technician performed the following services: changed air filters, cleaned

condensers with water, and cleaned evaporator coils with brush. Observed units at the site had significant condenser and evaporator coil corrosion and deterioration due to coastal salty air. Technician diagnosed refrigerant charge and airflow using digital pressure gauge manifolds with EPA 608 low-loss fittings on one set of gauges and no low-loss hoses on the other, Type-K thermocouple clamps, and Type-K thermocouple bead probes with wick to measure wetbulb air temperatures. Technicians did not purge hoses from one unit to next unit.

4) WO32 EM&V pre-observation was conducted on 10-10-12 of the 5-ton model 50HJQ006-511, sticker 002-1172, RTU 4C. The condenser and evaporator coils were found to be significantly corroded and deteriorated due to coastal salt air. The fan-belt was cracked and alignment was off by ¼ inch. Micrometl economizer model 0688-0100-54920 was not functioning and Molex plug was stuck in the dampers to keep 15% open (1.5-fingers). 5-10 screws were missing from the cabinet. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and outdoor air temperature (OAT) (50HJQ004-007 Single-Package Rooftop Heat Pump Units, Installation, Start-up, and Service Instructions, 50hjq-13si.pdf).[6] The CEC RCA protocol provides target temperature split as a function of return wetbulb (RWB) and return drybulb (RDB) temperature and target superheat (SH) as a function of OAT and RWB temperature.[7] Pre-observation temperature split was 17°F and within CEC RCA tolerance. Pre-observation superheat was 39.1°F or 22.3°F above 16.8°F CEC RCA target at 67°F OAT and 60°F return wetbulb (RWB) and above 20 +/- 5°F program tolerance indicating undercharge. Pre-observation suction temperature was 72.1°F or 37.6°F above 34.5°F manufacturer target indicating undercharge. Evaporator saturation temperature (EST) was 33°F which was outside 46 +/- 6°F program tolerance.

   WO32 EM&V technician observation was conducted on 11-07-12 of RTU 4C. Technician conducted general maintenance and performed RCA services, but did not perform economizer repairs. Technician initial temperature split was 18.6°F and within CEC RCA tolerance. Technician initial superheat was 36.2°F or 17°F above 19.2°F CEC RCA target at 73°F OAT and 64.1°F RWB and above 20 +/- 5°F program tolerance indicating undercharge. Technician initial suction temperature was 68.5°F or 37.1 above 31.4°F manufacturer target indicating undercharge. Technician added 3 ounces of refrigerant. Technician final temperature split was 20°F or 3.7 above 16.3°F CEC RCA target. Technician final superheat was 21°F or 1.8°F above 19.2°F CEC RCA target at 73°F OAT and 64.1°F RWB and within 20

[6] Manufacturer suction temperature tolerance is +/-5°F.

[7] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

+/- 5°F program tolerance. Technician final suction temperature was 57°F or 17.7 above 39.3°F manufacturer target. Technician final EST was 36°F below 46 +/- 6°F program tolerance.

WO32 EM&V post-observation was conducted on 11-07-12 of RTU 4C. Post-observation temperature split was 18.9°F and within CEC RCA tolerance. Post-observation superheat was 6.2°F or –13.7°F below 19.9°F CEC RCA target at 65°F OAT and 61.3°F RWB indicating overcharge. Post-observation suction temperature was 36.9°F or 6.5°F above 30.4°F manufacturer target at 65°F OAT indicating undercharge. EST was 30.7°F and below 46 +/- 6°F program tolerance. Low EST and superheat opposite of suction temperature indicate potential heat transfer or refrigerant restriction issues.

5) WO32 EM&V pre-observation was conducted on 10-10-12 of the 10-ton Carrier model 50HJQ012-531, sticker 002-1171, RTU 5B. The condenser and evaporator coils were found to be significantly corroded and deteriorated due to coastal salt air. The fan-belt was cracked, loose, and alignment was off by 1/8 inch. Wiring in compressor compartment was not secured. Economizer was not functioning, unplugged, and one outdoor damper blade was missing causing 30% opening. Condensate pipe was discovered cut after the P-trap and connected with electrical tape which is not water-proof. 20 screws were missing from the cabinet and 10-15 stripped. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and OAT (Carrier 50HJQ014-016 Single-Package Rooftop Heat Pump Units, Installation, Start-up, and Service Instructions, 50hjq-3si.pdf).[8] Pre-observation temperature split was 16.8°F and within CEC RCA tolerance. Circuit 1 pre-observation suction temperature was 54.7°F or 14.1 above 40.6°F manufacturer target indicating undercharge. Circuit 1 superheat was 18°F or –0.5°F below 18.5°F CEC RCA target at 71.7°F OAT and 62.6°F RWB and within tolerance. Circuit 2 pre-observation suction temperature was 59.4°F or 23.4 above 36°F manufacturer target indicating undercharge. Circuit 2 superheat was 24.9°F or 6.4°F above 18.5°F CEC RCA target and within 20 +/- 5°F program tolerance.

   WO32 EM&V technician observation was conducted on 11-07-12 of RTU 5B. The technician conducted general maintenance, but did not perform economizer repairs (economizer missing outdoor damper blade and return damper was stuck partially closed). Technician indicated advanced decay of condenser and evaporator coils due to coastal salt air. Technician indicated condensate pipe was cut and connected with electrical tape. Technician initial temperature split was 17.1°F and within 1.9 of 15.2°F CEC RCA target but outside 20 +/- 2°F program tolerances. Circuit 1 initial suction temperature was 47.5°F or 7.3 above

[8] Manufacturer suction temperature tolerance is +/-5°F.

40.2°F manufacturer target indicating undercharge. Circuit 1 initial superheat was 11.5°F or -11.2 below 22.7°F CEC RCA target at 67°F OAT and 64.1°F RWB indicating overcharge. Circuit 1 initial EST was 36°F and below 46 +/- 6°F program tolerance. Circuit 2 initial suction temperature was 56°F or 11.7 above 44.3°F manufacturer target indicating undercharge. Circuit 2 initial superheat was 19.3°F or -3.4 below 22.7°F manufacturer target and within 20 +/- 5°F program tolerances. Circuit 2 EST was 36.7°F and below 46 +/- 6°F program tolerance. Technician was in process of adding refrigerant when utility program personal interfered with the EM&V observation and stopped the technician from completing maintenance services on the unit.

WO32 EM&V master technician was unable to perform post-observation.

7) WO32 EM&V pre-observation was conducted on 10-10-12 of the 7.5-ton Carrier model 48HJF008-V531, sticker 002-1170, RTU 4F. The condenser and evaporator coils were found to be significantly corroded and deteriorated due to coastal salt air. The fan-belt was cracked, loose, and alignment was off by 1/4 inch. Blower was wired to operate 24 hours per day and 7 days per week. Second compressor had a time delay added that needed to be secured in the electrical panel. Micrometl model 0699-0200-54930 economizer was not functioning, wires were cut, and dampers were 25% open (2-fingers). 10 screws were missing from the cabinet and 5-10 stripped. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and OAT (48HJD/HJE008-014, 48HJF008-012, Single-Package Rooftop Heating/Cooling Units, Installation, Start-up, and Service Instructions, 48hj-15si.pdf).[9] Pre-observation temperature split was 15.7°F and within -1.9 of 17.6°F CEC RCA target but below 20 +/- 2°F program tolerance. Circuit 1 suction temperature was 46.4°F or -13.3 below 59.7°F manufacturer target indicating overcharge. Circuit 1 superheat was 4.1°F or –11.8°F below 15.9°F CEC RCA target at 74°F OAT and 62.2°F RWB and below 20 +/- 5°F program tolerance indicating overcharge. EST was 42.3°F and within 46 +/- 6°F program tolerance. Circuit 2 suction temperature was 67.5°F and 24.2 above 43.3°F manufacturer target indicating undercharge. Circuit 2 superheat was 26.6°F or 10.7°F above 15.9°F CEC RCA target and above 20 +/- 5°F program tolerance indicating undercharge. EST was 40.9°F and within 46 +/- 6°F program tolerance.

WO32 EM&V technician observation was conducted on 11-07-12 of RTU 4F. Technician conducted general maintenance, but did not perform economizer repairs (economizer was not repairable). Technician indicated advanced decay of condenser and evaporator coils due to coastal salt air. Technician initial temperature split was 16.5°F and within 0.2 of 16.3F CEC RCA target at 72°F RDB and 64°F RWB and below 20 +/- 2°F program tolerance.

[9] Manufacturer suction temperature tolerance is +/-5°F.

Technician initiated refrigerant testing on circuit 1 with the temperature sensor clamp attached to circuit 2 and the sensor for circuit 2 attached to circuit 1. Based on incorrect measurements, the technician was planning to adjust refrigerant charge on circuit 1. Program personnel intervened and informed the technician of temperature sensors being installed incorrectly. Technician corrected the temperature sensor installation issues and determined that circuit 1 initial superheat was 19.8°F and within -2.9 of 22.7°F CEC RCA target and within 20 +/- 5°F program tolerance at 67°F OAT and 64°F RWB. Circuit 2 initial superheat was 34°F or 11.3 above 22.7°F CEC RCA target and above 20 +/- 5°F program tolerance indicating undercharge. The technician determined that circuit 2 was outside program specifications and added 26.5 ounces. Technician final temperature split was 17°F and within 0.7 of 16.3°F CEC RCA target but below 20 +/- 2°F program tolerance. Circuit 1 final superheat was 22.5°F and within -0.2 of 22.7°F CEC RCA target at 67°F OAT and 64°F RWB and within 20 +/- 5°F program tolerance. Circuit 1 suction temperature was 62°F and within 2.1 of 59.9°F manufacturer target. Circuit 1 EST was 39.5°F and below 46 +/- 6°F program tolerance. Circuit 2 final superheat was 23.4°F and within 0.7 of 22.7°F CEC RCA target and within 20 +/- 5°F program tolerance. Circuit 2 suction temperature was 63.6°F or 14.5 above 49.1°F manufacturer target indicating undercharge. Circuit 2 EST was 40.2°F and within 46 +/- 6°F program tolerance.

WO32 EM&V master technician was unable to perform post-observation.

B.1.3 Site HB

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) This SCE statewide site has a total of eleven (11) RTUs and all were enrolled in the program when the EM&V team conducted observations. WO32 EM&V pre-observation, technician ride-along, and post-observations were performed of four (4) units on 10-11-12, 11-08-12, and 11-19-12. WO32 team performed a subsequent economizer inspection on 7-24-13
   1) Carrier 48HGD024J-E511AE, S/N3206G10072, SCE Sticker 002-6402 (RTU 4),
   2) Carrier 48HGD016JBE511AE, S/N2406G50076, SCE Sticker 002-6403 (RTU 10),
   3) Carrier 48HJL006-B57133, S/N2806G40596, SCE Sticker 002-6401 (RTU 11), and
   4) Carrier 48HJD007-MB57133, S/N3806G50413, SCE Sticker 002-6404 (RTU 1).

3) The following information is provided regarding the EM&V HVAC master technician observations performed at [site name]. The Contractor was recruited to participate in the WO32 observation sample for the SCE program. The participating contractor provides quarterly maintenance including changing filters and washing condensers with water every

three months. During EM&V observations of each unit the technician performed the following services: changed air filters, cleaned condensers with water, and cleaned evaporator coils with brush. Technician did not check or replace contactors or capacitors. Observed units at the site had copper coils and fins which were coated to prevent corrosion. One technician was observed diagnosing refrigerant charge and airflow with digital pressure gauge manifolds with EPA 608 low-loss fittings on two sets of gauges, Type-K thermocouple clamps, and Type-K thermocouple bead probes with wick to measure wetbulb air temperatures. Technician hooked up refrigerant hoses and attempted to purge non-condensables with refrigerant from system.

4) WO32 EM&V pre-observation was performed on 10-11-12 for the 20-ton Carrier model 48HGD024J-E511AE, sticker 002-6402 (RTU 4). Error codes indicated temperature thermistor failure on circuit C for condenser fan motors 9-12-12 (i.e., failure causes condenser fan for circuit C to not operate when compressor C is operating). The notched fan-belt was in fair condition and properly aligned. There are three circuits with TXVs on each circuit. The economizer was not functioning due to missing outdoor air sensor (OAS) and dampers were closed. No cabinet screws were missing. Condensate pipe was cut after the P-trap and connected with electrical tape which was leaking. Manufacturer provides unit-specific liquid temperature (LT) charts as a function of liquid pressure (LP) (48HG014-028 Single Package Rooftop Units Electric Cooling/Gas Heating, Installation, Start-up, and Service Instructions, 48hg-2si.pdf).[10] The CEC RCA protocol provides target temperature split as a function of return wetbulb (RWB) and return drybulb (RDB) temperature and target superheat (SH) as a function of outdoor air temperature (OAT) and RWB temperature.[11] Temperature split was 26.8°F or 10.5°F above 16.3°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. Circuit 1 LT was 70.7°F or -2.5 below 73.2°F manufacturer target and within tolerance. Circuit 1 superheat was 20.9°F and within 20 +/- 5°F program tolerance, subcooling was 12°F and within 11 +/- 4F program tolerance, evaporator saturation temperature (EST) was 33.8°F and below 46 +/- 6°F program tolerance, and condenser saturation over ambient (COA) was 16°F and below 25 +/- 5°F program tolerance. Circuit 2 LT was 78.4°F or -1.6 below 80°F manufacturer target and within tolerance. Circuit 2 superheat was 17.3°F and within program tolerance, subcooling was 11.1°F and within program tolerance, EST was 37.4°F and below program tolerance, and COA was 22.8°F and within program tolerance. Circuit 3 LT was 67.2°F or -4.8°F below 72°F manufacturer target indicating overcharge. Circuit 3 superheat was 21.3°F

[10] Manufacturer does not provide liquid temperature (LT) tolerance. WO32 EM&V assumes +/-3°F tolerance.

[11] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

and within program tolerance, subcooling was 14.2°F and below program tolerance, EST was 33°F and below program tolerance, and COA was 14.7°F and below program tolerance.

WO32 EM&V technician observations were performed on 11-08-12 of RTU 4. Technician conducted general maintenance and performed RCA services, but did not perform economizer repairs. Technician did not measure supply air temperatures (or temperature split), and assumed target subcooling of 12°F. Technician did not adjust refrigerant charge even though circuits 1 and 3 were outside program specifications (-6.1 and -5.9°F below 12°F target). This is because the technician measured discharge pressure instead of liquid pressure which provided higher condenser saturation and subcooling temperatures (unit has liquid pressure Schrader valves but discharge valves were easier to access). Circuit 1 LT was 79.6°F or 9.7 above 69.9°F manufacturer target indicating undercharge. Circuit 1 superheat was 18.2°F and within tolerance, subcooling was -0.3°F and below 11 +/- 4F program tolerance, EST was 38.8°F which was below 46 +/- 6°F program tolerance, and COA was 9.3°F which was below 25 +/- 5°F program tolerance. Circuit 2 LT was 81.5°F or 2.3 above 79.2°F manufacturer target indicating undercharge. Circuit 2 superheat was 19.3°F and within tolerance, subcooling was 7.2°F and below tolerance, EST was 39.5°F and below tolerance, and COA was 18.7°F and below program tolerance. Circuit 3 LT was 78.2°F or 9.5°F above 68.7°F manufacturer target indicating undercharge. Circuit 3 superheat was 22.6°F and within tolerance, subcooling was -0.2°F and below tolerance, EST was 36°F and below tolerance, and COA was 8°F and below tolerance. Technician did not adjust refrigerant charge on any of the circuits. Technician indicated the contractor would provide a bid for repairs.

WO32 EM&V post-observations were performed on 11-08-12 with 64°F OAT of RTU 4. Temperature split was 26°F or 8.4 above 17.6°F CEC RCA target indicating low airflow and outside 20 +/- 2°F program tolerance. Circuit 1 post-observation LT was 67.3°F or -1.8 below 69.1°F manufacturer target. Circuit 2 LT was 76.8°F or -4°F below 80.8°F manufacturer target indicating overcharge. Circuit 3 LT was 70.7°F or -3.3°F below 74°F manufacturer target for circuit 3 indicating overcharge. Circuit 1 superheat was 16.8°F and within tolerance, subcooling was 11.1°F and within tolerance, EST was 38.1°F and below tolerance, and COA was 14°F and below tolerance. Circuit 2 superheat was 17.5°F and within tolerance, subcooling was 13.4°F and within tolerance, EST was 38.8°F and below tolerance, and COA was 25.8F and within tolerance. Circuit 3 superheat was 18.9°F and within tolerance, subcooling was 12.8°F and within tolerance, EST was 36°F and below tolerance, and COA was 19.1F and below tolerance.

5) WO32 EM&V pre-observation was performed on 10-11-12 for the 15-ton Carrier model 48HGD016JBE511AE, sticker 002-6403 (RTU 10). Notched fan-belt was in fair condition,

properly aligned, but tension was too tight. Unit has three circuits with TXVs on each circuit. Economizer was not functioning due to missing outdoor air sensor (OAS) and dampers were 15% open (1.5 fingers). No cabinet screws were missing. Blower wheel was dirty and in need of cleaning. Unit return insulation was starting to come off and needed to be secured again. Manufacturer provides unit-specific liquid temperature charts as a function of liquid pressure (48HG014-028 Single Package Rooftop Units Electric Cooling/Gas Heating, Installation, Start-up, and Service Instructions, 48hg-2si.pdf). Temperature split was 19°F or 1.8 above 17.2°F CEC RCA target and within 20 +/- 2F program tolerance. Circuit 1 liquid temperature was 83.1°F or -2.4 below 85.5°F manufacturer target and within tolerance. Circuit 2 LT was 78.6°F or -12.4°F below 91°F manufacturer target indicating overcharge, and circuit 3 LT was 68.2°F or -14.2°F below 82.4°F manufacturer target indicating overcharge. Circuit 1 superheat was 16.6°F and within 20 +/- 5°F program tolerance, subcooling was 14.5°F and within 11 +/- 4F program tolerance, EST was 38.8°F and below 46 +/- 6°F program tolerance, and COA was 29.5°F and within 25 +/- 5°F program tolerance. Circuit 2 superheat was 13.6°F and below tolerance, subcooling was 24.2°F and above tolerance, EST was 40.9°F and within tolerance, and COA was 34.7°F and above tolerance. Circuit 3 superheat was 15.3°F and within tolerance, subcooling was 26.5°F and above tolerance, EST was 37.4°F and below tolerance, and COA was 26.6°F and within tolerance.

WO32 EM&V technician observations were performed on 11-08-12 and 11-19-12 of RTU 10. On -11-08-12 the technician conducted general maintenance, but did not perform economizer repairs. Technician checked fan-belt tension by hand, but did not check alignment. On 11-19-12 the technician performed RCA services. Technician initial temperature split was 19.5°F and within the CEC RCA tolerance. Technician assumed target subcooling of 12°F and used discharge pressure instead of liquid pressure to measure condenser saturation temperature for calculating subcooling. The resulting subcooling for all three circuits was within 1°F of the assumed 12°F target subcooling, so the technician did not adjust refrigerant charge. If the technician had measured LP correctly, then the technician would have known that the condenser saturation and subcooling temperatures were lower. Based on the manufacturer protocol circuit 1 liquid temperature (LT) was 75.8°F or 5.6 above 70.2°F target indicating overcharge. Circuit 2 LT was 80.6°F or 7.2 above 73.4°F target indicating overcharge. Circuit 3 LT was 77.6°F or 7.2°F above 70.4F target indicating overcharge. Circuit 1 superheat was 25.9°F and above 20 +/- 5°F program tolerance, subcooling was -0.9°F and below 11 +/- 4F program tolerance, EST was 31.5°F and below 46 +/- 6°F program tolerance, and COA was 7.9°F and below 25 +/- 5°F program tolerance.[12]

[12] Technician measurements indicate negative subcooling due to instrument error.

Circuit 2 superheat was 25.8°F and above tolerance, subcooling was -2.6°F and below tolerance, EST was 31.5°F and below tolerance, and COA was 11°F and below tolerance. Circuit 3 superheat was 17.3°F and within tolerance, subcooling was -2.7°F and below tolerance, EST was 40.9°F and within tolerance, and COA was 7.9°F and below tolerance. Technician indicated the contractor would provide a bid for repairs.

WO32 EM&V post-observations were performed on 11-19-12 of RTU 10. Post-observation temperature split was 14.9°F or 6.2 above 8.7°F CEC target indicating low airflow. Refrigerant charge was within manufacturer LT specifications for all three circuits. Circuit 1 LT was 70°F or 2.3 above 67.7°F manufacturer target, circuit 2 LT was 71.2°F or 0.2 above 71°F manufacturer target, and circuit 3 LT was 70°F or 2.3°F above 67.7F target. Circuit 1 superheat was 16.8°F and within above 20 +/- 5°F program tolerance, subcooling was 10.2°F and within 11 +/- 4F program tolerance, EST was 39.5°F and below 46 +/- 6°F program tolerance, and COA was 16.2°F and below 25 +/- 5°F program tolerance. Circuit 2 superheat was 14.9°F and below tolerance, subcooling was 12.3°F and within tolerance, EST was 41.6°F and within tolerance, and COA was 19.5°F and below tolerance. Circuit 3 superheat was 17.5°F and within tolerance, subcooling was 10.2°F and within tolerance, EST was 39.5°F and below tolerance, and COA was 16.2°F and below tolerance. Even though the technician used the subcooling method and incorrectly measured discharge instead of liquid pressure, no refrigerant charge adjustment was necessary based on manufacturer protocols.

6) WO32 EM&V pre-observation was performed on 10-11-12 for the 5-ton Carrier model 48HJL006-B57133, sticker 002-6401 (RTU 11). The standard fan-belt was in good condition, but misaligned by 1/3 inch. Micrometl economizer model 0640-0102-BH971 was not functioning due to faulty outdoor temperature “snap disk” sensor and dampers being stuck 15% open (1.5 fingers). 10 cabinet screws were missing and a third of remaining screws stripped. Condenser coil had corrosion on 10% of coil. Condensate pipe was cut before the P-trap and connected with electrical tape which was leaking. Pre-observation temperature split was 25.4°F or 6.6°F above 18.8°F CEC RCA target indicating low airflow. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and outdoor air temperature (OAT) (48HG004-007 Single Package Rooftop Heating/Cooling Units, Installation, Start-up, and Service Instructions, 48hj-22si.pdf).[13] Pre-observation suction temperature was 63.3°F or 27.3°F above 36°F manufacturer target indicating undercharge. Pre-observation superheat was 25.9°F or 11.4°F above 14.5°F CEC RCA target indicating undercharge at 73.7°F OAT and 60.6°F return wetbulb (RWB). EST was 37.4°F and below 46 +/- 6°F program tolerance.

[13] Manufacturer suction temperature tolerance is +/-5°F.

WO32 EM&V technician observations were performed on 11-08-12 of RTU 11. Technician conducted general maintenance and performed RCA services, but did not perform economizer repairs. Technician added 5 screws to panels. Technician installed a new notched fan belt (AX40), checked belt tension by hand, but did not check alignment. Technician measured refrigerant temperature and pressures within 7 minutes of turning on unit. Technician initial temperature split was 25.6°F or 8.2 above 17.4°F CEC RCA target indicating low airflow. Technician initial superheat was 24.5°F or 3.6 above 20.9°F CEC RCA target at 70°F OAT and 64°F RWB and within program tolerance but technician made charge addition. Technician added 7 ounces of refrigerant over a 5-minute period. Technician final temperature split was 25°F or 7.6 above 17.4°F CEC RCA target indicating low airflow. Technician final superheat was 20°F or -0.9 below 20.9°F CEC RCA target at 70°F OAT and 64°F RWB. Technician final suction temperature was 56°F or 23.5 above 30.5°F manufacturer tolerance. EST was 36°F and below 46 +/- 6°F program tolerance. Technician indicated the contractor would provide a bid for repairs.

WO32 EM&V post observation was performed on 11-08-12 of RTU 11. Post temperature split was 22.5°F or 5.4 above 17.1°F CEC RCA target indicating low airflow. Post suction temperature was 59.9°F or 18.6°F above 41.3°F manufacturer target indicating undercharge. Post superheat was 21.8°F or 3.4 above 18.4°F CEC RCA target at 70°F OAT and 62°F RWB. Post EST was 38.1°F and below tolerance.

7) WO32 EM&V pre-observation was performed on 10-11-12 of the 6-ton Carrier model 48HJD007-MB57133, sticker 002-6404 (RTU 1). The blower fan motor was hard-wired to operate 24 hours per day. The fan-belt was worn and misaligned by ¼ inch. Micrometl economizer model 0640-0102-BH971 was not functioning and closed. 10 cabinet screws were missing and a quarter of remaining screws stripped. Condensate pipe was cut before the P-trap and connected with electrical tape which was leaking. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and OAT (48HJ004-007 Single Package Rooftop Heating/Cooling Units, Installation, Start-up, and Service Instructions, 48hj-22si.pdf).[14] Pre-observation temperature split was 18.8°F or 1.2 above 17.6°F CEC RCA target. Pre-observation suction temperature was 66.9°F or 16.3 above 50.6°F above manufacturer target indicating undercharge. Pre-observation superheat was 26.7°F or 12 above 14.7°F CEC RCA target indicating undercharge. EST was 40.2°F and within 46 +/- 6°F program tolerance.

[14] Manufacturer suction temperature tolerance is +/-5°F.

WO32 EM&V technician observation was performed on 11-19-13 of RTU 1. Technician conducted general maintenance and performed RCA services, but did not perform economizer repairs. Technician installed a Molex plug between dampers opening them to 24%. Technician installed a new standard fan belt (A40), checked belt tension by hand, but did not check alignment. Technician checked RCA immediately after turning on unit. Technician initial temperature split was 21.2°F or 3.8 above 17.4°F CEC RCA target. Technician initial suction temperature was 70°F or 21.3 above 48.7°F above manufacturer target indicating undercharge. Technician initial superheat was 31.2°F or 12.6 above 18.6°F CEC RCA target at 74°F OAT and 64.3°F RWB and outside program tolerance of 20 +/- 5°F indicating undercharge. EST was 38.8°F and below 46 +/- 6°F program tolerance. Technician added 64.4 ounces (33% of factory charge) of refrigerant over a 32-minute period. Technician final temperature split was 24.9°F or 7.5 above 17.4°F CEC RCA target. Technician final suction temperature was 61.3°F or 5.8 above 55.5°F above manufacturer target indicating undercharge. Technician final superheat was 19°F or 0.4 above 18.6°F CEC RCA target at 74°F OAT and 64.3°F RWB and within CEC RCA tolerance and program tolerance of 20 +/- 5°F. EST was 42.3°F and within 46 +/- 6°F program tolerance. Technician indicated the contractor would provide a bid for repairs.

WO32 EM&V post observation was performed on 11-19-12 of RTU 1. Post temperature split was 20.5°F or 3 above 17.5°F CEC RCA target. Post refrigerant suction temperature was 63.5°F or 9.1°F above 54.4°F manufacturer target indicating undercharge. Post superheat was 21.9°F or 3.4 above 18.5°F CEC RCA target and within tolerances at 72°F OAT and 63.4°F RWB. Post EST was 41.6°F and within tolerance.

B.1.4 Site CC

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) The observed site has 4 RTUs participating in the program. EM&V observations were conducted of four units on 10-04-12, 02-15-13, and 08-19-13.
1) Carrier 48HJD012-551 S/N 1599G30780, sticker 001-1354, RTU 4,
2) Carrier 48DP016, S/N 2793F57699, sticker 001-1352, RTU 2,
3) Carrier 48DP020, S/N 2793F57731sticker 001-1353, RTU 3, and
4) Carrier 48TJD024, S/N 2993F58428, sticker 001-1355 RTU 1.

3) The following information is provided regarding the Work Order 032 EM&V HVAC master technician observations of the Contractor who performed work at [site name]. The Contractor was recruited to participate in the WO32 data logger observation sample for the

SCE program. Pre-observations were performed on 10-4-12 and 10-5-12 when KEMA installed data loggers on all four units. Technician observations were performed on 2-15-13. Ex post observations were performed on 8-19-13 and 9-3-13. The technicians performed CSA tasks including cleaning condenser coil with water only, replacing fan belts, tightening wire connections, and changing air filters on 2-15-13. WO32 team was not present when Contractor's technicians performed other CSA tasks. All units are controlled by energy management system (EMS). Units shared communal condensate line which was cut probably due to a plugged drain so all condensate water pooled up on surface of concrete pad.

4) WO32 EM&V pre-observation was performed on 10-04-12 of the 10-ton Carrier 48HJD012-551, sticker 001-1354, RTU 4. The condenser fan blade was cracked, fan contactor was failing, and 3 wires were burned creating a fire hazard. The contractor was notified to make repairs the following day. Economizer was not functioning and was in the closed position. Economizer outdoor air temperature changeover setting was D (63°F). Fan belt was worn, cracked, and loose with alignment off by ¼ inch. 5-10 screws were missing from the cabinet. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and outdoor air temperature (OAT) (48HJD/HJE008-014, 48HJF008-012 Single-Package Rooftop Heating/Cooling Units, 48hj-15si.pdf).[15] The CEC RCA protocol provides target temperature split as a function of return wetbulb (RWB) and return drybulb (RDB) temperature and target superheat (SH) as a function of OAT and RWB temperature.[16] Pre-observation temperature split was 17.7°F and -2.2 below 19.9°F CEC RCA target and outside 20 +/- 2°F program tolerance. Circuit 1 suction temperature was 79.2°F or 31.5°F above 47.7°F manufacturer target indicating undercharge. Superheat was 38.2F or 33.5 above 4.7°F CEC RCA target at 85.7°F OAT and 60.4°F RWB indicating undercharge. Circuit 1 evaporator saturation temperature (EST) was 40.9°F and within 46 +/- 6°F program tolerance, and condenser over ambient (COA) was 37.1°F and outside 25 +/- 5°F program tolerance. High COA, suction temperature, and superheat indicate undercharge or heat transfer issues. Circuit 2 suction temperature was 57°F or -12.6°F below 69.6°F manufacturer target indicating overcharge. Superheat was 8.2°F or 3.5 above 4.7°F CEC RCA target. Circuit 2 EST was 48.7°F and COA was 27.9°F and both were within program tolerances. Low suction temperature indicates undercharge or heat transfer issues.

   WO32 EM&V technician observation was conducted on 02-15-13 of RTU 4. Technicians performed general maintenance but did not perform RCA or economizer repair services.

[15] Manufacturer suction temperature tolerance is +/-5°F.

[16] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

Start of first maintenance, cleaned coils, changed belt, replaced filters, blew out control panel, tighten wire connection. Standard fan belt was cracked and worn and replaced with standard belt with tension adjusted by hand. Wiring of fan contactor bad, 3 wires burnt, fire hazard, site and technician notified, and replaced following day. First condenser fan cracked.

WO32 EM&V post observation was performed on 08-19-13 of RTU 4. New economizer outdoor air sensor was installed. The economizer was tested with cold spray but dampers were not opening or functioning properly. Economizer outdoor air temperature changeover setting was A (73°F). New capacitor was installed on the condenser fan motor. A burned wire was found on the 1st stage compressor contactor due to a loose connection. Post temperature split was 17.5°F or -1.5 below 19°F CEC RCA target and outside 20 +/- 2°F program tolerance. Circuit 1 suction temperature was 48.3°F or -19 below 67.3°F manufacturer target indicating overcharge. Circuit 1 superheat was 1.4F or -8.2F below 9.6F CEC target indicating overcharge. Subcooling was 23.1°F and above 11 +/- 4°F program tolerance, EST was 46.9°F and within 46 +/- 6°F program tolerance, and COA was 28.2°F and within 25 +/- 5°F program tolerance. Circuit 2 suction temperature was 75°F or 20.4 above 54.6°F manufacturer target indicating undercharge. Circuit 2 superheat was 32.1°F or 22.5 above 9.6°F CEC target indicating undercharge. Subcooling was 17.7°F and within 11 +/- 4°F program tolerance, EST was 42.9°F and within 46 +/- 6°F program tolerance, and COA was 37.1°F and outside 25 +/- 5°F program tolerance.

5) WO32 EM&V pre-observation was performed on 10-04-12 of the 15-ton Carrier 48DP016, sticker 001-1352, RTU 2. The economizer was not functioning and opening or closing incorrectly. Economizer outdoor air temperature changeover setting was C (67°F). Fan belt was worn and loose and alignment was off by 3/16 inch. Fan blade on 1 of 2 blower wheels is loose and squeaks. One of the two blower wheels has damaged blades and needs inspection. Standing water in pan indicates drainage issue. 5-10 screws were missing from the cabinet. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and OAT (48DP, DR, 48DPE, DRE Single-Package Rooftop Units Electric/Gas Heating, 48dpr-4si.pdf).[17] Pre-observation temperature split was 31.2°F or 9.8 above 21.4°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. Pre suction temperature was 43.9°F or 14.5°F above 29.4°F manufacturer target indicating undercharge. Superheat was 16.2°F or 4.8 above 11.4°F CEC RCA target at 72°F OAT and 57.6°F RWB and within 20 +/- 5°F program tolerance. Subcooling was 27.7°F and above 11 +/- 4°F program tolerance, EST was 27.6°F and below 46 +/- 6°F program tolerance, and COA was 29.1°F and within 25 +/- 5°F program tolerance.

[17] Manufacturer suction temperature tolerance is +/-5°F.

WO32 EM&V technician observation was performed on 02-15-13 of RTU 2. Technicians conducted general maintenance but did not perform RCA or economizer repair services. Technician did not change cracked and worn fan belt due to failed bearings on pulley and damaged blower wheel. Cleaned coils, replaced filters, blew out control panel, tightened wire connections.

WO32 EM&V post observation was performed on 8-19-13. RTU 2 was replaced with a new Carrier Model 48HCDD17A6A5A0F0A0, S/N 2513P16592, and sticker 001-1406 with R410A refrigerant. Economizer outdoor air temperature changeover setting was B (70°F). The circuit 2 compressor was short cycling and the WO32 EM&V master technicians called the Contractor to revisit the site to correct the problem. Contractor visited the site later that day and was observed attaching pressure gauges on the refrigerant system. The high- and low-side pressure went down indicating a refrigerant leak on circuit 2 (and possible filter-drier restriction). Technician informed the WO32 EM&V team that the circuit had low pressure when installed and they added refrigerant. The liquid line drier replacement, evacuation, and recharge were not observed.

After repairs another WO32 EM&V post observation was performed on 09-03-13. A new filter drier was installed on circuit 2. The manufacturer provides charts of outdoor coil leaving (liquid) temperature as a function of measured liquid pressure (48HC*04---09 Nominal 3 to 8.5 Tons With Puron (R-410A) Refrigerant Service and Maintenance Instructions, 48hc-01sm.pdf).[18] Post observation temperature split was 23.7°F or 4.9 above 18.8°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. Circuit 1 post observation liquid temperature was 101.9°F or -8.8 below 110.7°F manufacturer target indicating undercharge. Circuit 1 superheat was 18.4°F or 13.4 above , 5°F CEC RCA target at 101.5°F OAT and 65.1°F RWB. Subcooling was 18°F and above 11 +/- 4°F program tolerance, EST was 44.7°F, and COA was 18.4°F. Circuit 2 post observation liquid temperature was 103.9°F or -5.1 below 109°F manufacturer target indicating undercharge. Superheat was 20.8°F or 15.8 above 5°F CEC RCA target and within 20 +/- 5F program tolerance. Subcooling was 13.8°F and within 11 +/- 4°F program tolerance, EST was 47°F and within 46 +/- 6°F program tolerance, and COA was 16.2°F and below 25 +/- 5°F program tolerance. Airflow should be checked and refrigerant charge should be recovered (evacuated) and recharged to evaluate the unit.

[18] Manufacturer does not provide tolerances. WO32 EM&V assumes +/-3°F liquid temperature tolerance. "Take the outdoor ambient temperature and read the liquid pressure gauge. Refer to chart to determine what liquid temperature should be. If liquid temperature is low, add refrigerant. If liquid temperature is high, carefully recover some of the charge. Recheck the liquid pressure as charge is adjusted."

6) WO32 EM&V pre-observation was performed on 10-04-12 of the 18-ton Carrier 48DP020, sticker 001-1353, RTU 3. The economizer was not functioning and one finger open. Economizer outdoor air temperature changeover setting was D (63°F). Damper linkage was disengaged from motor and broken (snap disk OA sensor). Fresh air intake was locked in closed position. Fan belt was cracked and worn. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and OAT (48DP, DR, 48DPE, DRE Single-Package Rooftop Units Electric/Gas Heating, 48dpr-4si.pdf).[19] Pre-observation temperature split was 22.3°F or 4 above 18.3°F CEC RCA target indicating low airflow. Circuit 1 pre-observation suction temperature was 51.6°F or -13.4 below 65°F manufacturer target indicating overcharge. Circuit 1 superheat was 8.6°F or -4.5 below 13.1°F CEC RCA at 73.6°F OAT and 59.8°F RWB. Subcooling was 0.3°F and below 11 +/- 4°F program tolerance, EST was 42.9°F and within 46 +/- 6°F program tolerance, and COA was 20.4°F and within 25 +/- 5°F program tolerance. Circuit 2 pre-observation suction temperature was 65.8°F or 32.7 above 33.1°F manufacturer target indicating undercharge. Circuit 2 superheat was 34.2°F or 21.1 above 13.1°F CEC RCA target indicating undercharge. Subcooling was 21.4°F and above 11 +/- 4°F program tolerance, EST was 31.5°F and below 46 +/- 6°F program tolerance, and COA was 33.8°F and outside 25 +/- 5°F program tolerance.

   WO32 EM&V performed technician observations on 02-15-13 of RTU3. Technicians conducted general maintenance but did not perform RCA or economizer repair services. Standard fan belt was cracked and worn and replaced with standard belt with tension adjusted by hand.

   WO32 EM&V post-observation was performed on 08-19-13 of RTU 3. New economizer actuator and linkage was installed on 08-05-13. The economizer was tested with cold spray and dampers were functioning properly. Economizer outdoor air temperature changeover setting was A (73°F). New blower motor sheave was also installed. Post temperature split was 19.6°F or 1.3 above 18.3°F CEC target and within 20 +/- 2°F program tolerance. Circuit 1 post-observation suction temperature was 64.6°F or 18.4 above 46.2°F manufacturer target indicating undercharge. Circuit 1 post-observation superheat was 24.3°F or 10.6 above 13.7°F CEC target but within 20 +/- 5F program tolerance at 84.6°F OAT and 65.1°F RWB. Circuit 1 subcooling was 19.5°F and above 11 +/- 4°F program tolerance, EST was 40.2°F and within 46 +/- 6°F program tolerance, and COA was 37.1°F and above 25 +/- 5°F program tolerance. High COA, high suction temperature, and high subcooling indicate heat transfer issues or non-condensables for circuit 1. Circuit 2 post-observation suction temperature was 49°F or -23.6 below 72.6°F manufacturer target indicating overcharge. Circuit 2 superheat

[19] Manufacturer suction temperature tolerance is +/-5°F.

was -0.4°F or -14.1 below 13.7°F CEC RCA target and below 20 +/- 5°F program tolerance. Circuit 2 subcooling was 2.1°F and below 11 +/- 4°F program tolerance, EST was 49.4°F and within 46 +/- 6°F program tolerance, and COA was 18.8°F and below 25 +/- 5°F program tolerance. Low suction and low superheat indicate overcharge and low subcooling indicates undercharge which together indicate heat transfer issues for circuit 2. Airflow should be checked and refrigerant charge should be recovered (evacuated) and recharged to evaluate the unit.

7) WO32 EM&V pre-observation was performed on 10-5-12 of the 20-ton Carrier 4TJD024, sticker 001-1355, RTU 1. Economizer outdoor air temperature changeover setting was D (63°F). The economizer was not functioning and one finger open. Damper linkage was disengaged from motor and broken (snap disk OA sensor). Fresh air intake was locked in closed position. Drain pan was not draining properly. Fan belt was cracked and worn (notched belt was replaced by technician with standard belt). The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat which are functions of OAT and RWB (48DP, DR, 48DPE, DRE Single-Package Rooftop Units Electric/Gas Heating, 48dpr-4si.pdf). Pre-observation temperature split was 12.9°F or -4.8 below 17.7°F CEC RCA target indicating low capacity and outside 20 +/- 2°F program tolerance. Circuit 1 pre-observation suction temperature was 71.2F or 22.4 above 48.8F manufacturer target indicating undercharge. Circuit 2 was flat and could not be checked.

   WO32 EM&V technician observation was performed on 02-15-13 of RTU1. Technicians conducted general maintenance but did not perform RCA or economizer repair services. Technician cleaned coils, replaced filters, blew out control panel, tightened wire connections, checked economizer by adjusting minimum position screw from open to closed. Technician did not perform cold spray test of sensor. Fan belt was cracked and worn and notched belt was replaced with standard belt. Technician adjusted new standard belt tension by hand.

   WO32 EM&V post-observation was performed on 08-19-13 of RTU1. New economizer actuator and controller (Honeywell W7459A1001) installed on 08-05-13. The economizer was tested with cold spray and dampers were functioning properly. Economizer outdoor air temperature changeover setting was B (70°F). Circuit 2 was repaired with new liquid line drier. New contactors were installed for both condenser fan motors. Economizer was found operating properly, new damper motor was installed, condensate pan was not draining due to dirt and rust in drain line. Post temperature split was 18.9°F or 0.3 above 18.6°F CEC target and within 20 +/- 2°F program tolerance. Circuit 1 post-observation suction temperature was 57°F or -3.3 below 60.3°F manufacturer target and within tolerance. Circuit 1 post-observation superheat was 13.3°F or 1.8 above 11.5°F CEC target at 88.7°F OAT and 65.4°F RWB. Subcooling was 16.7°F and within 11 +/- 4°F program tolerance, EST was 43.6°F and with 46 +/- 6°F program tolerance, and COA was 34.1°F and outside 25 +/-

5°F program tolerance. Circuit 2 post-observation suction temperature was 53.1°F or -24.9 below 78°F manufacturer target indicating overcharge. Circuit 2 superheat was 3.1°F or -8.4 below 11.5°F CEC RCA target and below 20 +/- 5°F program tolerance indication overcharge. Circuit 2 subcooling was 24°F and above 11 +/- 4°F program tolerance, EST was 50°F and within 46 +/- 6°F program tolerance, and COA was 41.8°F and above 25 +/- 5°F program tolerance. High COA and low suction temperature indicate heat transfer issues or non-condensables for circuit 2. Airflow should be checked and refrigerant charge should be recovered (evacuated) and recharged to evaluate the unit.

B.1.5 Site BH

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) EM&V pre-observations were performed on 09-14-12 and ex post EM&V observations were performed on 11-14-12. The observed site has one 3-ton and one 2-ton RTUs.
1) Carrier 50ZH-36-501, S/N 3898G42202, SCE Sticker 002-3251, RTU 1, and
2) Arcoaire PHD324000K000C, S/NC101974815, SCE Sticker 002-3253, RTU 3.

3) The following information is provided regarding the Work Order 032 EM&V HVAC master technician observations of the Contractor who performed work at [site name]. The Contractor was recruited to participate in the WO32 data logger observation sample for the SCE program. Technician(s) performed tasks without informing the WO32 team so technician(s) were not directly observed.

4) WO32 EM&V pre-observation was performed on 9-14-12 of the 3-ton Carrier 50ZH-36-501, S/N 3898G42202, SCE Sticker 002-3251, RTU 1. Top of blower area was missing insulation, cabinet panel screws were missing or stripped, condenser coil was dirty on inside and evaporator coil was dirty, condensate line needs to be re-piped not draining, electrical contactor needs replacement, and wires need to be secured in blower and control area. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and outdoor air temperature (OAT) (Carrier Installation Instructions, 50ZH 10 SEER Single Packaged Heat Pump 2-5 Nominal Tons Sizes 024-060, 50zh-07si.pdf).[20] The CEC RCA protocol provides target temperature split as a function of return wetbulb (RWB) and return drybulb (RDB) temperature and target superheat (SH) as a function of OAT and

[20] Manufacturer suction temperature tolerance is +/-5°F.

RWB temperature.[21] Pre-observation temperature split was 10.8°F or -6.7°F below 17.5°F CEC RCA target and below 20 +/- 2°F program tolerance indicating low capacity, plugged air filter, iced coil, low airflow, or low charge. Pre-observation superheat was 6.3°F or -7.1°F below 13.4F CEC RCA target at 100°F OAT and 68.8°F RWB and below 20 +/- 5°F program tolerance indicating overcharge. Pre-observation suction temperature was 55°F or -11.5°F below 66.5°F manufacturer target at 100°F OAT and 82 psig suction pressure. Pre-observation evaporator saturation temperature (EST) was 48.7°F and within 46 +/- 6°F program tolerance.

WO32 EM&V pre-observation was performed again on 10-03-12 of RTU 1 after technician repaired a Schrader valve refrigerant leak. Pre-observation temperature split was 14.5°F or -3 below 17.5°F CEC RCA target and outside program specifications of 20 +/- 2F. Superheat was 30.1°F or 6.8°F above 23.3°F CEC RCA target at 71°F OAT and 66.4°F RWB and above 20 +/- 5F program tolerance indicating undercharge. Suction temperature was 71°F or 0.2 above 70.8°F manufacturer target at 71°F OAT and 70 psig suction pressure. EST was 40.9°F and within 46 +/- 6°F program tolerance.

Technician(s) performed maintenance tasks on RTU 1 without informing the WO32 team so technician(s) were not directly observed. In the CSA form obtained from program implementers, the technician indicated target superheat (TSH) of 20°F at 91°F OAT and 63°F RWB which is consistent with 20 +/- 5°F program target. Technician measured superheat was 2°F or -4.1 below 6°F CEC RCA target at 91°F OAT and 63°F RWB and below 20 +/- 5°F program tolerance. Technician measured suction temperature was 42°F or 1 above 43°F manufacturer target at 91°F OAT and 69 psig suction pressure. Technician indicated unit is "At or near nominal charge, functioning properly."

WO32 EM&V post-observation was performed on 11-14-12 of RTU 1. Condenser coil appeared to be cleaned. Otherwise most of the issues discovered during the pre-observation were not repaired. Post-observation temperature split was 26°F or 6.1°F above 19.9°F CEC RCA target, also above program specifications of 20 +/- 2F. Post-observation suction temperature was 56.8°F or 19.3°F above manufacturer target of 37.5°F at 66.7°F OAT and 55 psig suction pressure indicating undercharge. Post observation superheat was 26.8°F or 16.6 above 10.2°F CEC RCA target and above 20 +/- 5°F program tolerance indicating undercharge. EST was 30°F and outside 46 +/- 6°F program tolerance. Low EST and high suction temperature and superheat indicate possible heat transfer issues or restriction.

[21] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

WO32 EM&V master technician visited the site again on 01-30-14 to observe RTU 1. The 3-ton Carrier 50ZH-36-501 unit had writing on the top cover "3/15/2013 48 R/R compressor contactor, 4/19/13 48 R/R (remove replace compressor and drier." This note appears to indicate compressor contactor replacement on 03-15-13 and compressor and liquid line drier replacement on 04-19-13. Unresolved maintenance issues include: top of blower area was missing insulation, cabinet panel screws were missing or stripped, condenser coil was dirty on inside and evaporator coil was dirty, condensate line needs to be re-piped, and wires need to be secured in blower and control area.

5) WO32 EM&V pre-observation was performed on 9-14-12 of the 2-ton Arcoaire PHD324000K000C, sticker 002-3253, RTU 3. The manufacturer provides unit-specific charts of liquid temperature as a function of liquid pressure and outdoor air temperature (OAT) (see page 28, Figure 22, Arcoaire Cooling Charging Table - Subcooling, Installation Instructions R-410A Single Packaged Heat Pumps PHD324-60, 51601220302.pdf).[22] The unit-specific manufacturer refrigerant chart was mounted on the inside of cabinet door covering the compressor. Pre-observation temperature split was 21.6°F or 2.3 above 19.3°F CEC RCA target and within 20 +/- 2°F program tolerance. Pre-observation liquid temperature was 101°F or 6.5°F above 94.5°F manufacturer target at 358 psig liquid pressure indicating undercharge. Pre-observation superheat was 0.6°F or -8.2 below 8.8°F CEC RCA target at 101°F OAT and 67.2°F RWB and below 20 +/- 5°F program tolerance indicating overcharge. EST was 47.4°F and within 46 +/- 6°F program tolerance.

   WO32 EM&V master technicians were unable to directly observe technicians performing work on RTU 3. In the CSA form obtained from program implementers, the Contractor provided the following information regarding the 2-ton Arcoaire unit 3. "Other fault condition (non-condensables in system, liquid-line restriction, TXV malfunction, refrigerant flooding, etc.), flooding TXV, indoor TXV replacement." the Contractor measured the actual subcooling as 5°F and assumed 10°F target subcooling (program target is 14°F). The CSA form indicates the technician added 16 ounces of refrigerant. Initial measurement indicated subcooling within program tolerance of +/-10°F. Adding 16 ounces yielded 5°F actual subcooling (same as initial measurement) which is within +/-10°F of target subcooling (assumed by technician based on CSA form).

   WO32 EM&V master technicians performed post-observations on 11-14-12. The TXV was not replaced. Post RCA measurements were not performed. WO32 master technicians are unaware of any other site visits conducted by the Contractor to correct non condensables or

[22] Manufacturer subcooling and liquid temperature tolerance is +/-2°F.

liquid-line restrictions noted in the CSA form. WO32 EM&V master technician visited the site again on 01-30-14 to check if the TXV was replaced. The TXV was replaced, but the sensing bulb was mounted upside down and the liquid line drier was not replaced. Manufacturer recommends installing a "bi-flow filter drier whenever the system has been opened for repair." New bi-flow filter drier must be installed on R410A systems to remove moisture from polyolester (POE) oils. R410A POE oil is very hygroscopic and quickly absorbs moisture from air which will cause acid formation. Moisture cannot be removed by 500 micron vacuums developed by evacuation pumps.

B.1.6 Site OH

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) This SCE statewide site has a total of five (5) RTUs and 5 were enrolled in the program. The EM&V team conducted observations of five units 9-12-12, 10-2-12 and 2-25-13.
1) 2-ton Carrier 50HS024-311AB, S/N2299G43312, SCE Sticker N/A, unit 1,
2) 4-ton Carrier 50HS048-621AB, S/N2299G42932, SCE Sticker N/A, unit 2,
3) 3.5-ton Carrier 50HS042-611AB, S/N2599G43067, SCE Sticker 001-0359, unit 3,
4) 3.5-ton Carrier 50HS042-611AB, S/N1499G42792, SCE Sticker 001-0357, unit 4,
5) 5-ton Bryant 601APX060000AAAG, S/N4006G20949, SCE Sticker N/A, unit 5.

3) The following information is provided regarding the Work Order 032 EM&V HVAC master technician observations of the Contractor who performed work at [site name]. The Contractor was recruited to participate in the WO32 data logger observation sample for the SCE program. During EM&V observations of each unit the technician performed the following services: replaced air filters, pressure washed condenser and evaporator coils with rinse water, chemicals, and final water rinse, and measured blower motor amps. Technician diagnosed refrigerant charge and airflow using analog pressure gauge manifold without EPA 608 low-loss fittings, Type-K thermocouple with black electrical tape to measure suction and liquid line temperature, Type-K thermocouple bead probes with wick to measure wetbulb air temperatures, and digital wetbulb sensor. Technician hooked up refrigerant hoses without purging non-condensables.

4) WO32 EM&V pre-observation was performed on 9-12-12 of the 2-ton Carrier model 50HS024-311AB, Sticker N/A, non-TXV unit 1. Cabinet insulation was missing or falling off and wires were loose. The fresh return-air vent was 100% open. Airflow was measured with a clean filter. Measured airflow was 356 cfm or 178 cfm/ton or 55% lower than manufacturer recommendation. The manufacturer provides unit-specific charts of superheat versus

outdoor air temperature (OAT) and return wetbulb (RWB) (Carrier 50HS018-060 Single-Package Heat Pump Units, 50hs-12si.pdf).[23] The CEC RCA protocol provides target temperature split as a function of RWB and return drybulb (RDB) temperature and target superheat (SH) as a function of outdoor air temperature (OAT) and RWB temperature.[24] Temperature split was 20.4°F which is the CEC RCA target and within 20 +/- 2°F program tolerance. Pre-observation indicated unit was undercharged and leaking refrigerant. Pre-observation superheat was 31.4°F which was 19.8°F above 11.6°F unit-specific manufacturer target at 97°F OAT and 64.8°F RWB indicating undercharge. Superheat was 24.4°F above 7°F CEC RCA target indicating undercharge Evaporator saturation temperature (EST) was 45.6°F and within 46 +/- 6°F program tolerance.

WO32 EM&V technician observation was performed on 10-2-12. The technician checked electrical control area, but contactors were not checked. Technician installed thermocouple bead probes on liquid and suction lines with electrical tape after sanding lines and inserted drybulb thermocouples in the return and supply. Technician did not measure return or supply wetbulb temperatures so target values cannot be evaluated. Technician attached analog pressure gauges to the refrigerant Schrader valves without EPA 608 low loss fittings or purging lines of non condensables. The initial test indicated the unit was undercharged but the technician did not check for leaks. Technician temperature split was 6.9°F, superheat was 20.4°F (at 110°F OAT) and below 20 +/- 5°F program tolerance, and EST was 43.6F and within 46 +/- 6°F program tolerance. Technician added 10 oz. of R22 refrigerant and waited 15 minutes. Technician final temperature split was 18°F, superheat was 15°F (at 104°F OAT) and within 20°F +/- 5°F program tolerance, and EST was 45°F and within 46 +/- 6°F program tolerance. Another WO32 EM&V technician observation was performed on 2-25-13. Technician performed quarterly maintenance, changed air filters, and measured 16°F temperature split. Technician installed refrigerant pressure gauges on suction side and measured 52 psig. Technician did not find any leaks and said leaks might be due to EM&V data logger pressure hoses. Technician did not measure wet bulb temperature to evaluate target superheat and check refrigerant charge and airflow. Technician added 11 ounces of R22, and then added another 5 ounces within 3 minutes for a total of 16 ounces. Technician did not measure return/supply wetbulb temperatures. Technician final temperature split was 18°F and within 20°F +/- 2°F program tolerance and superheat was 15°F (at 70°F OAT) and within 20°F +/- 5°F program tolerance. Technician final EST was 45°F and within 46 +/- 6°F tolerance.

[23] Manufacturer superheat temperature tolerance is +/-3°F.

[24] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

WO32 EM&V post-observation was not performed unit 1.

5) WO32 EM&V pre-observation was performed on 9-12-12 of the 4-ton Carrier model 50HS048-621AB, Sticker N/A, non-TXV unit 2. Wires were loose and compressor contactor was pitted. Airflow was measured with a clean filter. Measured airflow was 850 cfm or 213 cfm/ton or 47% lower than manufacturer recommendation. Temperature split was 16.3°F and within 0.9F of 17.2°F CEC RCA target and within 20 +/-2°F program tolerance. The manufacturer provides unit-specific charts of superheat as a function of OAT and RWB (50HS018-060 Single-Package Heat Pump Units, 50hs-12si.pdf). Pre-observation superheat was 17.9°F and within 0.9 of 17°F manufacturer target at 86°F OAT and 66.8°F RWB and within 20 +/- 5°F program tolerance. Pre-observation EST was 48.1°F and within 46 +/- 6°F program tolerance.

   WO32 EM&V technician observation was performed on 10-2-12. The technician initial temperature split was 16°F. Technician did not measure return or supply wetbulb temperatures so target values cannot be evaluated. Technician initial superheat was 13.8°F (at 102°F OAT) and below 20 +/- 5°F program tolerance. The technician believed unit was undercharged and added 32 ounces of R22 or 23% of 141 ounce factory charge. Technician final temperature split was 23°F and outside 20 +/- 2°F program tolerance. Technician final superheat was 33.4°F (at 102°F OAT) and outside 20°F +/- 5°F program tolerance. Technician EST was 46.2°F and within 46°F +/- 6°F program tolerance. Another WO32 EM&V technician observation was conducted on 2-25-13. The technician performed quarterly maintenance, secured loose wires, changed air filters, and measured return and supply temperature split.

   WO32 EM&V post-observation was not performed for unit 2.

6) WO32 EM&V pre-observation was performed on 9-12-12 of the 3.5-ton Carrier model 50HS042-611AB, Sticker 001-0359, non-TXV unit 3. Condensate pan was not draining, loose wires were not secured, and air filter was very dirty and plugged. Outdoor return-air vent was fully open. Airflow was measured with a clean filter. Measured airflow was 599 cfm or 171 cfm/ton or 67% lower than manufacturer recommendation. Pre temperature split was 7.6°F or -7.9°F below the 15.5°F CEC RCA target and well below the 20 +/- 2°F program tolerance. Dirty filter and low airflow caused ice formation on the evaporator which caused low temperature split, low capacity, low suction pressure, low evaporator saturation temperature (EST), low discharge pressure, and low condenser over ambient (COA) temperature. The manufacturer provides unit-specific charts of superheat versus OAT and RWB (50HS018-060 Single-Package Heat Pump Units, 50hs-12si.pdf). Pre-observation superheat was 18°F which is equal to the 18°F manufacturer target superheat at 89°F OAT and 70°F RWB. EST was 18°F and well below the 46 +/- 6°F program tolerance. COA was

15.4°F and below 25 +/- 5°F program tolerance. Low EST and low COA indicate heat transfer issues due to low airflow, evaporator coil icing, and possible restriction.

WO32 EM&V technician observation was performed on 10-2-12. Technician did not check contactors or capacitors. Technician secured loose wires but did not correct the plugged condensate drain. Technician did measure wetbulb after program personnel indicated this was required. Technician initial temperature split was 11°F or -11.1 below the 22.1°F CEC RCA target and program 20 +/- 2°F target indicating low capacity, plugged air filter, iced coil, low airflow, or low charge. Technician initial superheat was 37.7°F or 32.7 above 5°F CEC RCA target at 108°F OAT and 65°F RWB and outside 20 +/- 5°F program tolerance indicating undercharge. Technician believed unit was undercharged and added 20 ounces of R22, waited 3 minutes, added 4 ounces, waited 8 minutes and removed 4 ounces. Technician final temperature split was 21°F and within 2.1 of 22.1°F CEC RCA target and within program tolerance. Technician final superheat was 15.2°F or 10.2°F above 5°F CEC RCA target at 110°F OAT and 65°F RWB but within 20 +/- 2°F program tolerance.

WO32 EM&V technician observation was performed again on 2-25-13. Technician measured return/supply temperature split (17.5°F), attached pressure manifold and measured 49 psig on low side and checked for leaks. When attaching the cabinet door, technician accidentally grabbed the hose and pulled EM&V pressure sensors off the Schrader valve causing a leak. Technician installed new Schrader valve and liquid line drier, leak checked with Nitrogen, and evacuated for 30 minutes without vacuum gauge. Technician charged the system with the 8 pounds of refrigerant. Final measurements were performed without measuring return or supply wetbulb temperatures. Final temperature split was 17°F and superheat was 29.1°F which was outside 20°F +/- 5°F program tolerance. Technician did not measure liquid temperature. EST was 40.9°F which was within 46 +/- 6°F program tolerance, and COA was 34.7°F which was outside 25 +/- 5°F tolerance. High COA and superheat indicate heat transfer issues or non-condensables.

WO32 EM&V post-observation was not performed for unit 3.

7) WO32 EM&V pre-observation was performed on 9-12-12 of the 3.5-ton Carrier model 50HS042-611AB, Sticker 001-0357, non-TXV unit 4. Condensate pan was not draining, blower wheel was dirty, air filter was dirty and plugged, cabinet was missing insulation, condenser fan motor contactor was pitted and capacitor was failing (low capacitance), and loose wires were not secured. Airflow was measured with a clean filter. Measured airflow was 539 cfm or 154 cfm/ton or 62% lower than manufacturer recommendation. Dirty filter and low airflow caused ice formation on evaporator which caused low temperature split, low capacity, low suction pressure, low evaporator saturation temperature (negative), low discharge pressure, and low condenser over ambient (COA) temperature. Outdoor return-air

vent was fully open. The manufacturer provides unit-specific charts of superheat as a function of OAT and RWB (50HS018-060 Single-Package Heat Pump Units, 50hs-12si.pdf). Pre-observation temperature split was 0.8°F or -14.2 below 15°F CEC RCA target and well below 20 +/- 2°F program tolerance indicating low airflow, undercharge or possible liquid line drier restriction. Airflow should be corrected before diagnosing refrigerant charge. Pre-observation superheat was 18.2°F or -7.1°F below manufacturer target of 25.3°F at 85°F OAT and 72.2°F RWB indicating coil icing or overcharge. EST was -5.1°F and well below 46 +/- 6°F program tolerance. COA was 2.9°F and well below 25 +/- 5F program tolerance. Low airflow, low temperature split (i.e., 0.8°F), low EST, and low COA indicate refrigerant leak, dirty filter, and/or possible liquid line drier restriction. Airflow needs to be corrected before diagnosing refrigerant charge.

WO32 EM&V technician observation was performed on 10-2-12 of RTU 4. Technician did not check contactors or capacitors. Technician initial temperature split was 20°F or -1.5 below 21.5°F CEC RCA tolerance and within 20 +/- 2°F program tolerance. Technician initial superheat was 6.5°F or 1.5 above 5°F manufacturer target at 114°F OAT and 65°F RWB which is below 20 +/- 5°F program tolerance. Technician assumed unit was overcharged and removed 11 ounces of R22 refrigerant. Technician final temperature split was 17°F or -2.9 below 19.9F CEC RCA target and below 20 +/- 2°F program tolerance. Technician final superheat measurement was 12.7°F or 7.7 above 5°F CEC RCA target at 106°F OAT and 65°F RWB indicating undercharge. Subcooling was 19.2F and above 14 +/- 4F program tolerance, EST was 53.5°F and above 46 +/- 6°F program tolerance and COA was 39.2°F and above 25 +/- 5°F program tolerance. High superheat, high COA, and high subcooling indicate heat transfer issues or non condensables. Another WO32 EM&V technician observation was performed on 2-25-13. Technician performed quarterly maintenance, secured loose wires, tightened contactor wires, measured return/supply temperature split (2°F), attached pressure manifold and measured zero psig on low side (unit was flat), and checked for leaks (no EPA 608 low loss fittings or purging). Technician pressurized the system with Nitrogen to 100 psig and found a leak on the Schrader pressure relief fitting on suction line. Technician stopped work to provide the customer with a cost estimate to repair the leak.

WO32 EM&V post-observation was not performed for unit 4.

8) WO32 EM&V pre-observations were performed on 9-12-12 of the 5-ton Bryant 601APX060000AAAG, Sticker N/A, non-TXV unit 5. Airflow was measured with a clean filter. Measured airflow was 1412 cfm or 282 cfm/ton or 30% lower than manufacturer recommendation. Following problems were observed: missing screws, cover off compressor wires, condensate drain pan plugged, insulation wet on door. Outdoor return-air vent was fully open. The manufacturer provides unit-specific charts of suction temperature as a

function of suction pressure and OAT (Bryant Installation, Start-up and Operating Instructions Single-Package Heat Pump Units, 601A 602A, ii601a-18-1.pdf).[25] Pre-observation temperature split was 20.2°F or 3.4°F above 16.8°F CEC RCA target and within 20 +/- 2°F program tolerance. Pre-observation suction temperature was 42°F or -8°F below 50°F manufacturer target at 77°F OAT and 64.4°F RWB indicating overcharge. Pre-observation superheat was 3°F or -13.8 below 16.8°F CEC RCA target and below 20 +/- 5°F program tolerance indicating overcharge. EST was 38.8°F and below 46 +/- 6°F program tolerance. Low EST, low suction temperature, and low superheat indicate undercharge or heat transfer issues.

WO32 EM&V technician observation was performed on 10-2-12. Technician installed compressor wire cover and air filters but did not fix drain pan leak causing wet insulation. Technician initial temperature split was 24°F or 3.6 above 20.4°F CEC RCA target. Technician initial superheat was 7.3°F or -0.5F below 7.8°F CEC RCA target at 103°F OAT and 67°F RWB, but outside 20 +/- 5°F program target. Initial technician suction temperature was 56°F or -7.4 below 63.4°F manufacturer target indicating overcharge. Initial EST was 48.7°F and within 46 +/- 6°F program tolerance. Technician believed unit was overcharged and removed 39 ounces of R22. Final technician temperature split was 25F or 4.6 above 20.4F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. Technician final superheat was 10.8°F or -0.9 below 9.9°F CEC RCA target at 99°F OAT and 67°F RWB. Final technician suction temperature was 57°F or 0.4 above 56.6°F manufacturer target and within tolerance. Final EST was 46.2°F and within 46 +/- 6°F program tolerance. Technician changed air filters, but no additional work was performed due to daylight issues.

WO32 EM&V post-observations were not performed for unit 5.

B.2 SCE Statewide – Observations for top contractors

B.2.1 Site BB

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

[25] Manufacturer suction temperature tolerance is +/-5°F.

2) EM&V observations of technicians performing program services on five (5) 17.5-ton and one (1) 5 ton units were performed on 05-17-13. Unit information is as follows:
1) Lennox 17.5-ton LGC210H4BH2G, S/N 5607L17993, Sticker 001-2646, RTU 1,
2) Lennox 17.5-ton LGC210H4BH2G, S/N 5607L17992, Sticker 001-2645, RTU 2,
3) Lennox 17.5-ton LGC210H4BH2G, S/N 5607L17991, Sticker 001-2644, RTU 3,
4) Lennox 17.5-ton LGC210H4BH2G, S/N 5607L17990, Sticker 001-2643, RTU 4,
5) Lennox 17.5-ton LGC210H4BH2G, S/N 5607L17994, Sticker 001-2647, RTU 5, and
6) Lennox 5-ton LGA060H4BS5G, S/N 5607L18501, Sticker 001-2642, RTU 6.

3) WO32 EM&V technician observations were performed on 05-17-13. The contractor indicated they were working with FDSI in the program. The Contractor was recruited to participate in the WO32 observation sample for the SCE program. The Contractor technicians performed CSA quarterly maintenance tasks including changing air filters, checking and adjusting belts on blower motor, and checking alarm codes. The technician installed 1" thick filter media per [company protocol] which is less than the 2" thick pleated filters installed at the factory and recommended by the manufacturer (MERV 7 or MERV 11, Lennox Service Literature, Unit Information, Corp. 9913–L7, LGA/LGC, LCA/LCC, 21-30 TON, Revised 12–2005, LENNOX%20LGA,%20LGC,%20LCA,%20LCC%20PACKAGE.pdf). Condenser coils and evaporator coils were not cleaned. The technician used his hands to test belt tension by checking if the belt deflection was more than ½" when pulled together. The technician did not use tension or alignment tools to check or adjust belts.

4) For RTU 1, 2, 5, and 6, the technician did not find any error codes or belt tension issues.

5) For RTU 3 the technician had alarm code 26, which is low pressure switch open. Technician attached Fieldpiece SMAN 3 gauges with low-loss fitting hoses to the service valves of circuit 3. No pressure was found in circuit 3 due to loss of 410A refrigerant. Technician indicated they would submit a quote to repair the leaking circuit.

6) For RTU 4 the technician did not find any error codes, but determined that the belt tension was too loose. The technician tightened the belt, but did not check alignment.

B.2.2 Site DS

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) The site has 5 RTUs. EM&V observations were conducted on 04-26-13 of one (1) RTU.
1) Rheem 5-ton RJNA-A060DM000, S/N 7327F270708463, sticker 001-2837, RTU 4.

3) WO32 EM&V technician observation was performed on 4-26-12. The following information is provided regarding the Work Order 032 EM&V HVAC master technician observations of the Contractor who performed work at [site name]. The Contractor was recruited to participate in the WO32 observation sample for the SCE program. The technician recovered refrigerant, replaced heat pump reversing valve, evacuated the system, and added refrigerant to the unit. Technician diagnosed refrigerant charge and airflow using digital pressure gauge manifold with EPA 608 low-loss fittings, Type-K thermocouple clamps, and digital humidity sensor to measure wetbulb air temperatures. Technician hooked up refrigerant hoses with refrigerant in them and then hoses were put into a vacuum. When refrigerant was added to system, charging hose was purged. Technician finished job by taken off high side from service valve and purging high side into low side Technician used torch, reclaiming machine, vacuum pump, leak detector and digital scale. Insulation was hanging partially off the blower panel. Technician attached hoses for recovery with middle hose attached to vacuum pump. Technician started recovery and refrigerant went into the vacuum pump. Technician stopped and attached middle hose to recovery machine but did not attach correctly. Recovered for about 10 minutes and noticed the recovery process was not working properly. Technician stopped and reattached hoses correctly to properly recover refrigerant. Technician recovered refrigerant until the manifold gauge was reading 0 psig (not a vacuum). Technician installed the new 3-way reversing valve and liquid-line drier. Technician checked for leaks with nitrogen and an electronic leak detector. Technician attached the vacuum pump, but did not change oil in the pump. Technician operated the vacuum pump for 1.5 hours, and then added 7 pounds of used R22 refrigerant from the R22 recovery tank. The remainder of the 4.5 pounds of charge (11.5 lbs total) was added from a new R22 refrigerant tank. The manufacturer provides charts (inside cabinet panel) of discharge pressure as a function of outdoor temperature (OAT) and suction pressure (Rheem Packaged Heat Pump Units, RJNA High Efficiency Series, Form No. P11-763 Rev. 1, 92-22904-30-00.pdf).[26] The CEC RCA protocol provides target temperature split as a function of return wetbulb (RWB) and return drybulb (RDB) temperature and target superheat (SH) as a function of OAT and RWB temperature.[27] Technician initial temperature split was 25.7°F or 4.2 above 21.5°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. Technician initial discharge pressure was 191 psig is -4.4 psig below the 196 psig manufacturer target discharge pressure at 79°F OAT and 65 psig suction pressure. The manufacturer does not provide superheat or subcooling charging information. Technician initial superheat was 6.6°F or -4.5 below 11.1°F CEC RCA and outside 20°F +/- 5°F program target at 79°F OAT and 60.2°F RWB. Initial evaporator

[26] Manufacturer does not provide target discharge pressure tolerances.

[27] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

saturation temperature (EST) was 37.4°F and outside 46 +/- 6°F program tolerance. Technician added another 24 ounces of R22 refrigerant to system. Technician final temperature split was 25°F or 4 above 21°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. Technician final superheat was 5.3°F or -3.4 below the 8.7°F CEC RCA target and outside the 20°F +/- 5°F program target indicating overcharge at 80°F OAT and 60.2°F RWB. The technician final discharge pressure was 192.8 psig or -5.4 psig below 198.2 psig manufacturer target discharge pressure. Final EST was 37.2°F and outside 46 +/- 6°F program tolerance.

B.2.3 Site IC

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) EM&V observations of technicians performing program services on two (2) units were done on 05-16-13. The following units were evaluated:
1) Trane SXHFC6040M56C8AD3F01D, S/N J97E71420, SCE Sticker QM 004-125, RTU 1, and
2) Trane SXHFC6040M56C8AD3F01D, S/N J97E71421, SCE Sticker QM 005-626, RTU 2.
The manufacturer does not provide refrigerant charge specifications for these units.

3) WO32 EM&V team performed technician observations on 05-16-13 of the 60-ton Trane Model SXHFC6040M56C8AD3F01D, Sticker QM 004-125, RTU 1. Technicians performed quarterly maintenance customer service agreement (CSA) tasks including cleaning condenser and evaporator coils with water only and greasing blower motor bearings. Electrical contactors are pitted and appeared to need replacement. Filters are replaced by an outside contractor. Access holes to measure temperature split were too small and had to be drilled out and enlarged to accommodate probes. Previous technician used Type-K thermocouple bead probes with wick to measure wetbulb air temperatures. This technician used a digital humidity sensor to measure wetbulb air temperatures. Technician took temperature-split measurements in the door (partially in the insulation and barely in the airstream) due to 1.5" temperature probes (which are not long enough to properly measure temperature split). The CEC RCA protocol provides target temperature split as a function of return wetbulb (RWB) and return drybulb (RDB) temperature and target superheat (SH) as a function of outdoor air temperature (OAT) and RWB temperature.[28] Technician

[28] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

temperature split was 31.2°F or 11.7°F above 19.5°F CEC RCA target and above 20 +/-2°F program tolerance indicating low airflow. WO32 EM&V master technician temperature split was 22.2°F and within 2.8°F of 19.4°F CEC RCA target and within 20 +/-2°F program tolerance. Other CSA tasks were not observed

4) WO32 EM&V team performed technician observations on 05-16-13 of the 60-ton Trane Model SXHFC6040M56C8AD3F01D, Sticker QM 005-626, RTU 2. Technicians performed quarterly maintenance CSA tasks including cleaning condenser and evaporator coils with water only and greasing blower motor bearings. Electrical contactors are pitted and appeared to need replacement. Filters are replaced by an outside contractor. Technician measured temperature-split in the door (partially in the insulation and barely in the airstream) due to 1.5" temperature probes (which are not long enough to properly measure temperature split). Other CSA tasks were not observed. Technician temperature split was 15.4°F and within -0.6°F of 16°F CEC RCA target and below the 20 +/-2°F program tolerance. Insufficient time was available for WO32 EM&V master technician to measure temperature split on RTU 2.

B.2.4 Site IT

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) This SCE statewide site has a total of twenty two (22) RTUs and 22 were enrolled in the program when the EM&V team conducted observations. EM&V observations were conducted on 05-15-13 of the following thirteen (13) non-TXV equipped RTUs:
1) Trane WSC036A4RA1CA2, S/N433100605L, SCE Sticker 002-0708, RTU HP-8
2) Trane WSC060A4RA1BA2, S/N432101511L, SCE Sticker 002-0722, RTU HP-22
3) Trane WSC060A4RA1BA2, S/N432102433L, SCE Sticker 002-0707, RTU HP-7
4) Trane WSC090A4R0A1GD0, S/N433100823L, SCE Sticker 002-0705, RTU HP-5,
5) Trane WSC060A4RA1BA2, S/N433100537L, SCE Sticker 002-0720, RTU HP-20
6) Trane WSC060A4RA1BA2, S/N432102503L, SCE Sticker 002-0709, RTU HP-9
7) Trane WSC060A4RA1BA2, S/N432102049L, SCE Sticker 002-0721, RTU HP-21
8) Trane WSC060A4RA1BA2, S/N432101443L, SCE Sticker 002-0710, RTU HP-10
9) Trane WSC060A4RA1BA2, S/N433100136L, SCE Sticker 002-0711, RTU HP-11
10) Trane WSC072A4R0A001S, S/N433100697L, SCE Sticker 002-0719, RTU HP-19,
11) Trane WSC090A4R0A001S, S/N433100755C, SCE Sticker 002-0712, RTU HP-12,
12) Trane WSC120A4R0A1DD, S/N333100544L, SCE Sticker 002-0713, RTU HP-13, and
13) Trane WSC180B400HA, S/N433101035D, SCE Sticker 002-0703, RTU HP-03.

3) WO32 EM&V technician observation was performed on 05-15-13. The Contractor was recruited to participate in the WO32 observation sample for the SCE program. Technician observations were performed during semi-annually maintenance. The participating

contractor provides semi-annual maintenance including changing filters and washing condensers with water every six months. During EM&V observations the technician performed the following services on each unit: changed air filters, cleaned evaporator coils with brush, cleaned condensate p-trap with water, cleaned condensers with water. Electrical controls, contactors, and capacitors were not checked. No RCA services or tests were performed on any unit. Fan belt tension was checked on all units except HP-5, HP-8, and HP-19. The technician used his hands to test belt tension by checking if the belt deflection was more than ½" when pulled together. The technician did not use tension or alignment tools to check or adjust belts. Economizers were tested without cold spraying OA sensors on HP-5, HP-19, HP-12, HP-13, and HP-3. All changeovers were set to "D." HP-5 had a bad OA sensor not repaired (zero resistance). HP-12 economizer filter was damaged. Technicians did not verify proper economizer operation with cold spray. Economizer outdoor-air dampers were 10% open (1-finger) on HP-5, HP-19, HP-12, and HP-13. Economizer OA dampers were closed on HP-3.

B.2.5 Site TM

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) This SCE statewide site has many RTUs and 3 were observed by the EM&V team. EM&V observations were conducted on 04-25-13 and 4-29-13 of the following three (3) RTUs:
   1) Carrier 48HJD006-531, S/N 1401G24450, sticker 334403, RTU 1,
   2) Carrier 48HJD006-531,S/N 2001G23496, sticker 334415, RTU 5, and
   3) Carrier 48HJD006-531, S/N 1401G24457, sticker 334414, RTU 7.

3) The following information is provided regarding the Work Order 032 EM&V HVAC master technician observations of the Contractor who performed work at [site name]. The Contractor was recruited to participate in the WO32 observation sample for the SCE program. Technician observations were performed on 4-25-13. The technicians was observed completing CSA maintenance tasks which involved cleaning control panel, and checking economizers. Fan-belts were replaced with notched AX40 v-belts on RTU 1 and 5. Fan-belt tension was performed by hand without tools to check proper tension and alignment. All other CSA tasks were performed without WO32 master technicians. Condensate drain line air vents were on wrong side of drain line on all units. Filters are replaced by School maintenance personnel. RTU 1 economizer dampers were closed. RTU 5 and 7 economizer outdoor air dampers were 10% open (1-finger). The outdoor air sensors are Honeywell model 7650 and the technician will provide the customer with a quote to replace with Honeywell 7660 sensors. RTU-7 evaporator blower bearings and motor sheave were failing and needed replacement. RTU 1 and 5 need new capacitors for combustion air

motor (heating). Technician indicated they would provide the customer with a quote for all repairs. No RCA services were performed. All units are controlled by energy management system (EMS).

4) WO32 EM&V post-observation was performed on 4-25-13 and 4-29-13 of RTU 1. Economizer was not functioning with cold spray. Outdoor air sensor was not working. Technician checked but did not repair economizer. RTU 1 economizer dampers were closed initially, but minimum position was 10% open on 4-29-13. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and OAT (48HJ004-007 Single Package Rooftop Heating/Cooling Units, Installation, Start-up, and Service Instructions, 48hj-22si.pdf).[29] Suction temperature was 64°F or 28°F above the 36°F manufacturer target indicating undercharge. The CEC RCA protocol provides target temperature split as a function of return wetbulb (RWB) and return drybulb (RDB) temperature and target superheat (SH) as a function of outdoor air temperature (OAT) and RWB temperature.[30] Technician temperature split was 16.6°F and within -2.4 of 19°F CEC RCA tolerance but outside 20 +/- 2°F program tolerance. Suction temperature was 64°F or 28°F above 36°F manufacturer target indicating undercharge. Superheat was 30.4°F or 19.3°F above 11.1°F CEC RCA at 68.1°F OAT and 56.4°F RWB and above 20 +/- 5°F program tolerance indicating undercharge. Evaporator saturation temperature (EST) was 33.6°F and below 46 +/- 6°F program tolerance.

5) WO32 EM&V post-observation was performed on 4-29-13 of RTU 5. Outdoor air sensor was not working. Technician checked but did not repair economizer. RTU 5 economizer outdoor air dampers were 10% open (1-finger). Temperature split was 19.1°F or 0.8 above 18.3°F CEC RCA target and within 20 +/- 2°F program tolerances. Suction temperature was 61.5°F or 25.5°F above 36°F manufacturer target indicating undercharge. Superheat was 26.8°F or 13.7°F above 13.1°F CEC RCA target at 74°F OAT and 59.5°F RWB and above 20 +/- 5°F program tolerance indicating undercharge. EST was 34.7°F and below 46 +/- 6°F program tolerance. Blower pulley, bearings, and motor sheave are worn and need to be replaced.

6) WO32 EM&V post-observation was performed on 4-29-13 of RTU 7. Outdoor air sensor was not working. Technician checked but did not repair economizer. RTU 7 economizer outdoor air dampers were 10% open (1-finger). Temperature split was 25.6°F or 6.8 above 18.8°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. Low

[29] Manufacturer suction temperature tolerance is +/-5°F.

[30] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

airflow indicated by high temperature split was due to failing blower pulley bearings and motor sheave. Contractor provided cost estimated for new pulley bearings and sheave. Suction temperature was 64°F or 28 above the 36°F manufacturer target indicating undercharge. Superheat was 30°F or 18.3 above 11.7°F CEC RCA target and above 20 +/- 5°F program tolerance indicating undercharge. EST was 34°F and below 46 +/- 6°F program tolerance. Fan-belt was not checked on RTU 7.

B.2.6 Site IV

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) This SCE statewide site has a total of twelve (12) RTUs and 12 were enrolled in the program when the EM&V team conducted observations. EM&V observations were conducted of five units on 05-13-13 and 05-14-13.
   1) Lennox GCS11-1853-300A-1G, S/N N/A, SCE Sticker QM 001-318, RTU AC-1,
   2) Trane YCD180B4LOHA, S/N330101402D, SCE Sticker QM 001-323, AC-2
   3) Trane YSC120A4ELA1600000, S/N333102406L, SCE Sticker QM 001-324, AC-5,
   4) Trane YSC090A4ELA170000, S/N333101269L, SCE Sticker QM 001-322, AC-3, and
   5) American Standard TCC024F100BG, S/N3383PM024, SCE Sticker QM 001-321, AC-10.

3) The following information is provided regarding the Work Order 032 EM&V HVAC master technician observations of the contractor who performed work at [site name]. The Contractor was recruited to participate in the WO32 observation sample for the SCE program. Observations were performed on 5-13-13 and 5-14-13. Technicians were observed completing CSA maintenance tasks which involved changing air filters, brushing evaporator coils, washing condenser coils with water only, changing belts or adjusting, taking amp readings on blower motor, and cleaning control panels on each unit. All other CSA tasks were performed without WO32 master technicians. Technician diagnosed refrigerant charge and airflow using digital and analog pressure gauge manifold with EPA 608 low-loss fittings, Type-K thermocouple clamps, and digital humidity sensor to measure wetbulb air temperatures. Technician hooked up refrigerant hoses with refrigerant in them and purged non-condensables with di minimis refrigerant from system. Technician finished each job by taken off high side from service valve and purging high side into low side. Technician also had digital meters and belt tension tool.

4) WO32 EM&V technician observation was performed on 05-13-13 for the 15-ton TXV Lennox model GCS11-1853-300A-1G, sticker QM 001-318, AC-1. Technician removed Novent locking Schrader caps and replaced with non-locking brass caps with o-ring seals. The technician checked fan-belt tension with tension tool but did not follow manufacturer instructions. Technician did not check belt alignment. Maintenance work was not performed on the economizer which was in the closed position. The unit is old and manufacturer protocols are unavailable for this model. The CEC RCA protocol provides target temperature split as a

function of return wetbulb (RWB) and return drybulb (RDB) temperature and target superheat (SH) as a function of outdoor air temperature (OAT) and RWB temperature.[31] Technician performed RCA test-in only on both circuits. Temperature split was 14°F or -1.3°F below the 15.3°F CEC RCA target and below 20 +/- 2°F program tolerance. Circuit 1 subcooling was 23.4°F and above 11 +/- 4°F program tolerance and above 10 +/- 3°F CEC RCA tolerance indicating overcharge. Circuit 2 subcooling was 14°F and within 11°F +/- 4°F program tolerances. According to the technician, test results showed both circuits were over charged, due to subcooling being above program requirements. Circuit 1 superheat was 10.7°F and below 20 +/- 5°F program tolerance and evaporator saturation temperature (EST) was 42.3°F and within 46 +/- 6°F program tolerance. Circuit 1 condenser saturation over ambient (COA) was 22.9°F and within 25 +/- 5°F program tolerance. Circuit 2 superheat was 27.7°F and above 20 +/- 5°F program tolerance, and EST was 35.3°F and outside 46 +/- 6°F program tolerance. Circuit 2 COA was 29°F which was within 25 +/- 5°F program tolerance. Although the evaluation did not recover and weigh out charge, circuit 1 appears to be overcharged and circuit 2 appears to be correctly charged based on program tolerances. Technician indicated a bid would be provided to customer for repairs.

5) WO32 EM&V technician observation was performed on 05-13-13 for 15-ton non-TXV Trane model YCD180B4LOHA, sticker QM 001-323, AC-2. The technician checked fan-belt tension with tension tool but did not follow manufacturer instructions. Technician did not check belt alignment. Technician measured blower motor amperage. The economizer did not function properly due to failed mixed air temperature sensor. The economizer damper was left 15% open (1.5 fingers open). Technicians performed RCA test-in only on both circuits. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of OAT and RWB temperature (Trane Service Facts YCD/YCH180, etc. Packaged Cooling/Gas Heat 15 Tons – Downflow & Horizontal Micro-Electronic Controls, YCD180-SF-2B.pdf).[32] Temperature split was 31°F or 10.6°F above the 20.4°F target indicating low airflow. Circuit 1 superheat was 7.1°F or 1.3 above 5.8°F CEC RCA target and -2.5°F below 9.6°F manufacturer target at 99°F OAT and 65°F RWB. Circuit 1 suction pressure was 61 psig or -13.4 psig below the 74.4 psig manufacturer target indicating undercharge. Circuit 1 discharge pressure was 282 psig or -30.3 psig below the 312.3 psig manufacturer target indicating undercharge. Circuit 1 subcooling was 16°F, EST was 34.5°F which was below 46 +/- 6°F program tolerance. Circuit 1 COA was 23°F which was within 25 +/- 5°F program tolerance. Circuit 2 superheat was 6.2°F or 0.4 above 5.8°F CEC RCA target

[31] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

[32] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, superheat tolerance is +/-5°F.

and -3.4°F below 9.6°F manufacturer target. Circuit 2 suction pressure was 67 psig or -7.4 psig below the 74.4 psig target indicating undercharge. Circuit 2 discharge pressure was 270 psig or -42.3 psig below 313.3 psig target indicating undercharge. Circuit 2 subcooling was 15.6°F, EST was 33.8°F which was below 46 +/- 6°F program tolerance, and COA was 19.6°F which was below 25 +/- 5°F program tolerance. Although the evaluation did not recover and weigh out charge, the unit appears to be undercharged based on suction and discharge pressure, but correctly charged based on superheat. Technician indicated a bid would be provided to customer for repairs.

6) WO32 EM&V technician observation was performed on 05-14-13 for the 10-ton Trane model YSC120A4ELA1600000, sticker QM 001-324, AC-5. The technician replaced the pre-existing BX62 notched fan belt with a B62 standard v-belt. Technician did not follow manufacturer instructions to check belt tension, and did not check belt alignment Technician measured blower motor amperage. The economizer did not function properly due to failed controller and snap disk sensor. The economizer damper was left in the closed position. Technicians performed RCA tests on both circuits. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of OAT and RWB temperature (Trane Service Facts YSC120ADRLA Packaged Gas/Electric, YSC120-SF-3.pdf). Temperature split was 23.8°F or 2.9°F above the 20.9°F CEC RCA target, but outside 20 +/- 2°F program tolerance. Circuit 1 superheat was 6.3°F or 1 above 5.3°F CEC RCA target and 1.3°F above 6.3°F manufacturer target at 82°F OAT and 57.9°F RWB. Circuit 1 suction pressure was 68 psig or -3.4 psig below the 71.4 psig manufacturer target and within tolerance. Circuit 1 discharge pressure was 244 psig or 16 psig above the 228 psig target indicating undercharge. Circuit 1 EST was 39.5F and outside 46 +/- 6°F program tolerance, and COA was 28.8°F and within 25 +/- 5°F program tolerance. Circuit 2 superheat was 5.9°F or 0.6 above 5.3°F CEC RCA target and 0.9°F above 5.9°F manufacturer target at 82°F OAT and 57.9°F EWB. Circuit 2 suction pressure was 68 psig or -1.8 psig below the 69.8 psig manufacturer target and within tolerance. Circuit 2 discharge pressure was 278 psig or 46 psig above 232 psig target indicating overcharge. Circuit 2 EST was 39.5°F and outside 46 +/- 6°F program tolerance, and COA was 38.9°F and outside 25 +/- 5°F program tolerance. Suction pressure and superheat are within tolerances, but discharge pressure and EST were high indicating heat transfer issues. Technician indicated a bid would be provided to customer for repairs.

7) WO32 EM&V technician observation was performed on 05-14-13 for the 7.5-ton Trane model YSC090A4ELA170000, sticker QM 001-322, AC-3. The technician replaced pre-existing AX32 notched belt with a standard A32 fan belt, but did not follow manufacturer instructions to check belt tension. Technician did not check belt alignment. Technician measured blower motor amperage. The economizer did not function properly due to failed outdoor air temperature sensor and damper motor. The economizer damper was left in the

closed position. Technician performed RCA test on the unit. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of OAT and RWB temperature (Trane Service Facts YSC090-SF-2, YSC090A3EHA0A, etc., Packaged Gas Electric 7.5 Ton, YSC090-SF-2.pdf). Temperature split was 23°F or 2.8°F above the 20.2°F CEC RCA target. Superheat was 24.4°F or 19.4°F above the 5°F CEC RCA target and manufacturer target at 88°F OAT and 57.4°F RWB indicating undercharge. Subcooling was 6.6°F or -3.4°F below the 10°F target. Suction pressure was 62 psig or -4 psig below 66 psig manufacturer target. EST was 35.3°F which was below 46 +/- 6°F program tolerance, and COA was 14.4°F which was below 25 +/- 5°F program tolerance. Technician indicated a bid would be provided to customer for repairs.

8) WO32 EM&V technician observation was performed on 05-14-13 for the 2-ton American Standard model TCC024F100BG, sticker QM 001-321, AC-10. The technician checked belt tension but did not follow manufacturer instructions, and did not check belt alignment The technician measured blower motor amperage and evaluated temperature split and refrigerant charge (test-in only). The manufacturer provides unit-specific charts of suction pressure and discharge pressure as a function of OAT and RWB, and superheat as a function of OAT and return air drybulb (RDB) temperature (American Standard, Inc. Service Facts TCC024-SF-1, TCC024F100AA, TCC024F10PAA, Single Packaged Cooling / Electric Heat – Convertible 2 Ton, TCC024-SF-1.pdf).[33] Technician temperature split was 24.2°F or 3.8°F above the 20.4°F target indicating low airflow. Technician superheat was 5.3°F or 0.3 above 5°F CEC RCA target at 87°F OAT and 58.6°F RWB, but below 20°F +/- 5°F program tolerance. Superheat was 5.3°F or -3.5 below 8.8°F manufacturer target at 87°F OAT and 73.5°F RDB. Suction pressure was 67 psig or -7.1 below 74.1 psig manufacturer target indicating undercharge. EST was 35.3°F and below 46 +/- 6°F program tolerance. Refrigerant charge tests are inconclusive since superheat was within tolerance and suction pressure was outside tolerances indicating undercharge. WO32 EM&V team did not have time to recover and weigh out charge. Technician indicated a bid would be provided to customer for repairs.

B.3 PG&E Air Care Plus

B.3.1 Site ET

1) The ACP program provides incentives for the following services: 1) basic package (zone and RTU modules, brass Schrader caps, thermostat programmable, and economizer changeover check), 2) refrigerant pre-test, 3) refrigerant charge and airflow service, 4) functional

[33] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, superheat tolerance is +/-5°F.

economizer test and repair, 5) economizer adjustment, 6) economizer control package, 7) programmable thermostat replacement, and 8) programmable thermostat adjustment.

2) EM&V personnel observed technicians performing work on five units during 04-18-13 and 04-19-13. The following units were observed.
1) York 4-ton, B3CH048A25B, S/N HDCM030697, PG&E ACP sticker 619-727, RTU 36,
2) York 5-ton, B3CH060A25A, S/N NDCM029094, PG&E ACP sticker 619-726, RTU 35,
3) York 4-ton, B3CH048A25B, S/N NDCM030688, PG&E ACP sticker 619-725, RTU 34,
4) York 3-ton, B2CH036A25A, S/N NDWM187763, PG&E ACP sticker 647-110, RTU 32, and
5) York 5-ton, B3CH060A25A, S/N NDCM029048, PG&E ACP sticker 619-724, RTU 31.
According to program data, technicians diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings and a shut-off valve on the high-side pressure hose, but no EPA 608 low-loss fittings. WO32 EM&V master technicians were unable to directly observe thermostats in the building. As noted below, technician attempted to jumper economizer control wires to adjust set screw but no damper actuation occurred. Thermostat Y1 and Y2 had jumper wires between them causing units to operate as single-stage thermostats with no economizer function for first stage. No thermostat occupancy wires were connected to economizers. Therefore, economizers would not function.

3) WO32 EM&V technician observation was performed on 4-18-13 of the 4-ton B3CH048A25B, sticker 619-727, RTU 36. The economizer outdoor air damper was fully closed. Technician cleaned condenser and evaporator coils with water only. The filters were replaced with Flanders Pre-Pleat 40 filters. Technician placed jumper wires on economizer control and tried to adjust set screw but no damper actuation occurred. Technician stopped economizer work and did no other economizer troubleshooting. Thermostat Y1 and Y2 had a jumper wire between them causing the unit to operate as a single-stage thermostat with no economizer function for the first stage. Initial refrigerant test was performed with existing air filters and dirty coils. Technician only waited 5-10 minutes after turning on unit to obtain initial measurements. Technician initial temperature split was 21°F or 0.9 above 20.1°F CEC RCA target and within tolerance. Technician superheat was 27.6°F or 22.2 above 5.5°F CEC RCA target at 72°F OAT and 54°F RWB and above 20 +/- 5°F program tolerance indicating undercharge. Superheat was 27.6°F or 21.6°F above 6°F manufacturer target indicating undercharge (York Superheat Charging Table, Courtesy of York Corporation, Unitary Products Group, www.achrnews.com/articles/superheat-charging-curves-for-technicians). Evaporator saturation temperature (EST) was 28.4°F and below 46 +/- 6°F program tolerance. Technician added 22 ounces of refrigerant. Technician performed final measurements within 5-8 minutes of charge adjustment. Technician final temperature split was 22°F or 2.1 above 19.9°F CEC RCA target and within tolerance. Technician superheat was 9.2°F or 4.2 above 5°F CEC RCA target at 73°F OAT and 50.4°F RWB within tolerance.

Superheat was 9.2°F or 5°F above 4.2°F manufacturer target within tolerance. EST was 33.8°F and below 46 +/- 6°F program tolerance. Technician put existing machine fit caps back on unit. EM&V post-observation found dirty blower wheel in need of cleaning.

WO32 EM&V post-observation was performed on 4-18-13 of RTU 36. Post-observation temperature split was 26.5°F or 5.8 above 20.7°F above CEC RCA target indicating low airflow. Post-observation superheat was 13.1°F or 8.1 above 5°F CEC RCA target at 74°F OAT and 51.1°F RWB indicating undercharge. Superheat was 13.1°F or 9°F above 4.1°F manufacturer target indicating undercharge. EST was 31.5°F and below 46 +/- 6°F program tolerance.

4) Observation on 4-18-13 for the 5-ton B3CH060A25A, sticker 619-726, RTU 35, found economizer outdoor air damper fully closed. Dampers were jammed and would not actuate and motor actuator was disconnected from dampers. Thermostat Y1 and Y2 had jumper wire between them causing the unit to operate as a single-stage thermostat with no economizer function for first stage cooling. Technician cleaned condenser and evaporator coils with water only. The filters were replaced with Flanders Pre-Pleat 40 filters. Initial refrigerant test performed with existing air filters and dirty coils. Technician initial temperature split was 25°F or 2.6 above 22.4°F CEC RCA target and within tolerance. Technician superheat was 12.5°F or 3.3 above 9.2°F CEC RCA target at 75°F OAT and 57.7°F RWB and within tolerance. Superheat was 14.7°F or 6.1°F above 8.6°F manufacturer target and within tolerance (York Superheat Charging Table, Courtesy of York Corporation, Unitary Products Group, www.achrnews.com/articles/superheat-charging-curves-for-technicians). EST was 32.3°F and below 46 +/- 6°F program tolerance. Technician added 7 ounces of refrigerant and performed final measurement within 7 minutes of charge adjustment. Final temperature split was 24°F or 2.6 above 21.4°F CEC RCA target and within tolerance. Technician superheat was 12.5°F or 3.3 above 9.2°F CEC RCA target at 75°F OAT and 57.7°F RWB and within tolerance. Superheat was 12.5°F or 4°F above 8.6°F manufacturer target and within tolerance. EST was 34.5°F and below 46 +/- 6°F program. Technician put existing brass caps with rubber o-ring seal on unit.

   WO32 EM&V post-observation was performed on 4-18-13 of RTU 35. Blower wheel was dirty and in need of cleaning. Post-observation temperature split was 25.1°F or 3.1 above 22°F CEC RCA target. Superheat was 11°F or 3.5 above 7.5°F CEC RCA target at 77.1°F OAT and 57.5°F RWB and within tolerance. Superheat was 11°F or 4.5°F above 6.5°F manufacturer target and within tolerance. EST was 34.5°F and below 46 +/- 6°F program tolerance.

5) Observation on 4-19-13 for the 4-ton B3CH048A25B sticker 619-725, RTU 34, found economizer outdoor air damper fully closed. Technician tried to adjust economizer set screw,

but the dampers did not actuate, and the technician did no further economizer testing. Technician cleaned condenser and evaporator coils with water only. Technician did not replace filters (they were fairly clean). Pre-existing filters Flanders Pre-Pleat 40 filters. Initial refrigerant test performed with existing air filters and dirty coils. Technician initial temperature split was 20°F or 4.1 above 15.9°F CEC RCA target indicating low airflow. Technician superheat was 26°F or 4.6 above 21.4°F CEC RCA target at 69°F OAT and 63.2°F RWB. Superheat was 26°F or 7.1°F above 18.9°F manufacturer target indicating undercharge (York Superheat Charging Table, Courtesy of York Corporation, Unitary Products Group, www.achrnews.com/articles/superheat-charging-curves-for-technicians). EST was 30°F and below 46 +/- 6°F program tolerance. Technician added 6 ounces of refrigerant and performed final measurement within 5 minutes of charge adjustment. Technician final temperature split was 24°F or 4 above 20°F CEC RCA target. Technician superheat was 9.7°F or 4.6 above 5.1°F CEC RCA target at 72°F OAT and 53.3°F RWB and within tolerance. Superheat was 9.7°F or 4.6°F above 5.1°F manufacturer target and within tolerance. EST was 32.3°F and below 46 +/- 6°F program tolerance. Technician put one existing machine fit cap and one existing brass cap with rubber o-ring seal on unit.

WO32 EM&V post-observation was performed on 4-19-13 of RTU 34. Blower wheel was dirty and in need of cleaning. Post-observation temperature split was 25.6°F or 5 above 20.6°F CEC RCA target indicating low airflow. Superheat was 6.4°F or 1.4 above 5°F CEC RCA target and 2.6°F above 3.8°F manufacturer target at 76.9°F OAT and 52°F RWB and within tolerance. EST was 32.3°F and below 46 +/- 6°F program tolerance.

6) Observation on 4-19-13 for the 3-ton B2CH036A25A, sticker 647-110, RTU 32, found economizer outdoor air damper fully closed. Technician tried to adjust economizer set screw, the dampers did not actuate, and the technician did no further economizer testing. Technician cleaned condenser and evaporator coils with water only. Technician did not replace filters (they were fairly clean). Pre-existing filters Flanders Pre-Pleat 40 filters. Technician refrigerant test performed with existing air filters and dirty coils. Technician initial temperature split was 24°F or 5.3 above 18.7°F CEC RCA target indicating low airflow. Technician superheat was 11°F or -3.7 below 14.7°F CEC RCA target and within tolerance. Superheat was 11°F or -4.2°F below 15.2°F manufacturer target at 76°F OAT and 62°F RWB and within tolerance (York Superheat Charging Table, Courtesy of York Corporation, Unitary Products Group, www.achrnews.com/articles/superheat-charging-curves-for-technicians). EST was 36°F and below 46 +/- 6°F program tolerance. Program software indicated unit was within proper tolerances, so technician did not adjust refrigerant charge after coils were cleaned with water. Air filters were not replaced. Technician put existing machine fit caps back on unit.

WO32 EM&V post-observation was performed on 4-19-13 of RTU 32. Blower wheel was dirty and in need of cleaning. Post-observation temperature split was 26.5°F or 4.1 above 22.4°F CEC RCA target indicating low airflow. Superheat was 5.5°F or 0.4 above 5.1°F CEC RCA target and 0.7°F above 4.8°F manufacturer target at 80.2°F OAT and 57.4°F RWB. EST was 36°F and below 46 +/- 6°F program tolerance.

7) Observation on 4-19-13 for the 5-ton B3CH060A25A, sticker 619-724, RTU 31, found economizer outdoor air damper fully closed. Dampers were jammed and would not actuate and motor actuator disconnected from dampers. Thermostat Y1 and Y2 had jumper wire between them causing it to run as single stage thermostat with no economizer function only for first stage. Technician cleaned condenser and evaporator coils with water only. Technician did not replace filters (they were fairly clean). Pre-existing filters Flanders Pre-Pleat 40 filters. Initial refrigerant test performed with existing air filters and dirty coils. Technician initial temperature split was 22°F or 0.7 above 21.3°F CEC RCA target and within tolerance. Technician superheat was 32.2°F or 24.8 above 7.4°F CEC RCA target at 75°F OAT and 56.5°F RWB indicating undercharge. Superheat was 32.2°F or 25.5°F above 6.8°F manufacturer target indicating undercharge (York Superheat Charging Table, Courtesy of York Corporation, Unitary Products Group, www.achrnews.com/articles/superheat-charging-curves-for-technicians). EST was 33.8°F outside 46 +/- 6°F program tolerance. Technician added 32 ounces of refrigerant. Technician performed final measurement within 10 minutes of charge adjustment. Technician final temperature split was 20°F or -0.6 below 20.6°F CEC RCA target and within tolerance. Technician superheat was 14.2°F or 8.9 above 5.3°F CEC RCA target at 77°F OAT and 56.1°F RWB indicating undercharge. Superheat was 14.2°F or 8.7°F above 5.5°F manufacturer target indicating undercharge. EST was 38.8°F and below 46 +/- 6°F program tolerance. Technician put new machine fit caps on unit.

   WO32 EM&V post-observation was performed on 4-19-13 of RTU 31. Blower wheel was dirty and in need of cleaning. Post-observation temperature split was 20.6°F or -0.7 below 21.3°F CEC RCA target and within tolerance. Superheat was 7.1°F or 2 above 5.1°F CEC RCA target and within tolerance. Superheat was 7.1°F or 2.8°F above 4.3°F manufacturer target at 79.8°F OAT and 57.2°F RWB and within tolerance. EST was 36°F and below 46 +/- 6°F program tolerance.

B.3.2 Site MC

1) ACP program provides incentives to the contractor for the following services: 1) basic package (zone and RTU modules, brass Schrader caps, thermostat programmable, and economizer changeover check), 2) refrigerant pre-test, 3) refrigerant charge and airflow service, 4) functional economizer test and repair, 5) economizer adjustment, 6) economizer control package, 7) programmable thermostat replacement, and 8) programmable thermostat adjustment.

2) WO32 EM&V post inspections were conducted of work performed in the program. The PG&E ACP program reported eighty seven (87) RTUs enrolled at [site name]. EM&V observations were performed of nine units on 7-31, 8-1, and 8-2-13.
   1) Trane 4-ton, YCD049C4L0BE, S/N L05107840, PG&E ACP sticker 649-456, RTU 54,
   2) Trane 5-ton, YCH061C4L0BE, S/N L04101011D, PG&E ACP sticker 649-451, RTU 49,
   3) Trane 5-ton, YCD061C4L0BE, S/N L04101810D, PG&E ACP sticker 649-452, RTU 50,
   4) Trane 10-ton, YCD121B4H0DD, S/N L041026960, PG&E ACP sticker 649-463, RTU 61,
   5) Trane 4-ton, YCD049C4L0BE, S/N L04103792D, PG&E ACP sticker 649-465, RTU 63,
   6) Trane 5-ton, YCD061C4L0BE, S/N L04103354D, PG&E ACP sticker 649-459, RTU 57,
   7) Trane 4-ton, YCD049C4L0BE, S/N L04103791D, PG&E ACP sticker 649-466, RTU 64,
   8) Trane 7.5-ton, YCD09104L0BE, S/N L04100993D, PG&E ACP sticker 649-418, RTU 16,
   9) Trane 7.5-ton, YCD09104L0BE, S/N L0410090D, PG&E ACP sticker 649-417, RTU 15.
   According to program data, technicians diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings and a shut-off valve on the high-side pressure hose, but no EPA 608 low-loss fittings. WO32 EM&V master technicians did not directly observe technicians performing work in the program.

3) WO32 EM&V post-observation was performed on 07-31-13 of the 4-ton model YCD049C4L0BE, sticker 649-456, RTU 54. The compressor contactor connections were loose and causing electrical arcing which is a safety hazard requiring immediate attention by the technician, site contact made aware of problem. The contactor needed replacement. Filters were wrong size (two 16”x25”x1”), should be two of 20”x25”x1”. Blower motor inlet, blower wheel, and evaporator coils dirty. New outdoor air humidity sensor wires not crimped correctly with insulation cut through and outdoor air thermistor was either not working or not compatible with Honeywell Jade causing economizer to not function properly. Economizer minimum damper position was closed. WO32 EM&V observations did not include an assessment of RCA.

4) WO32 EM&V post-observation was performed on 07-31-13 of the 5-ton model YCH061C4L0BE, sticker 649-451, RTU 49. The supply side ductwork was failing and approximately 2”x16” hole in supply leaving unit causing much of the conditioned air to leave to outdoors and potential issue for water and animals to get into building. Where the supply ductwork entered building was also crushed slightly causing more conditioned air leakage and water and other materials could enter building. Evaporator coil found to be fairly dirty. Economizer outdoor air thermistor was either not working or not compatible with Honeywell Jade causing economizer to not function properly. Economizer minimum damper position was closed. WO32 EM&V observations did not include an assessment of RCA.

5) WO32 EM&V post-observation was performed on 08-01-13 of the 5-ton model YCD061C4L0BE, sticker 649-452, RTU 50. Economizer minimum damper position was closed. New outdoor air humidity sensor wires installed with incentives were not crimped correctly (insulation was cut through) and outdoor air thermistor was either not working or not compatible with Honeywell Jade causing economizer to not function properly. Air filters and evaporator coil fairly dirty. Return plenum was very dirty. Condensate drain pan could use cleaning. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of outdoor air temperature (OAT) and return air wetbulb (RWB) temperature (see Trane Service Facts YC*061-SF-2C, YCD061C4L0BE, Packaged Gas/Electric 5 Ton Rooftop Units with Micro-Electronic Controls, YC_061-SF-2C.pdf).[34] The CEC RCA protocol provides target temperature split as a function of RWB and return drybulb (RDB) temperature and target superheat (SH) as a function of OAT and RWB temperature.[35] Temperature split was 16.5°F or -1.4°F below 17.9°F CEC RCA target and within tolerances, but outside 20 +/- 2°F program tolerance. Superheat was 1.7°F or -3.3 below 5°F CEC RCA target at 80°F OAT and 51.5°F RWB and within tolerance. Superheat was 1.7°F or -1.3 below 3°F manufacturer target and within tolerance. Suction pressure was 61.8 psig or 1.7 above 60.1 psig manufacturer target and within tolerance. Discharge pressure was 201.3 psig or -7.2 below 208.5 psig manufacturer target and within tolerance. Evaporator saturation temperature (EST) was 35.1°F and below 46 +/- 6°F program tolerance. Refrigerant charge suction and discharge pressure and superheat were within manufacturer tolerances.

6) WO32 EM&V post-observation was performed on 08-01-13 of the 10-ton model YCD121B4H0DD, sticker 649-463, RTU 61. The first stage compressor had no refrigerant and did not turn on. Unit only operates second compressor with cooling call. A large piece of metal was stuck in return damper not allowing damper to move. Damper motor had failed probably due to this problem. Filters installed backwards. Economizer outdoor air thermistor was either not working or not compatible with Honeywell Jade causing economizer to not function properly. Economizer minimum damper position was closed. WO32 EM&V observations did not include an assessment of RCA.

7) WO32 EM&V post-observation was performed on 08-02-13 of the 4-ton model YCD049C4L0BE, sticker 649-465, RTU 63. The economizer outdoor air thermistor was not working or not compatible with Honeywell Jade controller causing economizer to not

[34] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

[35] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

function properly. Economizer minimum damper position was closed. WO32 EM&V observations did not include an assessment of RCA.

8) WO32 EM&V post-observation was performed on 08-02-13 of the 5-ton model YCD061C4L0BE, sticker 649-459, RTU 57. The economizer outdoor air thermistor was not working or not compatible with Honeywell Jade controller causing economizer to not function properly. Minimum outdoor air position of economizer was fully open causing maximum outdoor air intake at all times. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of outdoor air temperature (see Trane Service Facts YC*061-SF-2C, YCD061C4L0BE, Packaged Gas/Electric 5 Ton Rooftop Units with Micro-Electronic Controls, YC_061-SF-2C.pdf). Temperature split was 21.8°F or 1.9°F above 19.9°F CEC RCA target and within tolerances. Superheat was 3.2°F or -6.1 below 9.3°F CEC RCA target at 77.4°F OAT and 59.2°F RWB indicating overcharge based on CEC RCA protocol. Superheat was 3.2°F or -4.7 below 7.9°F manufacturer target and within tolerance. Suction pressure was 71.2 psig or 1.2 above 70 psig manufacturer target and within tolerance. Discharge pressure was 218.3 psig or 8.3 above 210 psig manufacturer target and within tolerance. EST was 41.7°F and within 46 +/- 6°F program tolerance. Refrigerant charge suction and discharge pressure and superheat were within manufacturer tolerances. However, low superheat indicates low airflow, but temperature split is within tolerances.

9) WO32 EM&V post-observation was performed on 08-02-13 of the 4-ton model YCD049C4L0BE, sticker 649-466, RTU 64. The economizer outdoor air thermistor was not working or not compatible with Honeywell Jade controller causing economizer to not function properly. Economizer minimum damper position was closed. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of outdoor air temperature (see Trane Service Facts YC*049-SF-3C, YCD049C4L0BE, Packaged Gas/Electric 4 Ton Rooftop Units with Micro-Electronic Controls, YC_049-SF-3C.pdf). Temperature split was 14.8°F or -4.5°F below 19.3°F CEC RCA target indicating low capacity, dirty or plugged air filter, low airflow or low charge. Superheat was 1.4°F or -3.6 below 5°F CEC RCA target 89.7°F OAT and 57.6°F RWB indicating and within tolerance. Superheat was 1.4°F or -1.6 below 3°F manufacturer target and within tolerance. Suction pressure was 67.7 psig or -1.8 below 69.5 psig manufacturer target and within tolerance. Discharge pressure was 224.5 psig or -12 below 236.5 psig manufacturer target indicating undercharge. EST was 39.3°F and below 46 +/- 6°F program tolerance. Low superheat and low temperature split indicate low airflow which can cause incorrect diagnostics.

10) WO32 EM&V post-observation was performed on 08-02-12 of the 7.5-ton model YCD09104L0BE, sticker 649-418, RTU 16. The economizer outdoor air thermistor was not

working or not compatible with Honeywell Jade controller causing economizer to not function properly. Economizer minimum damper position was closed. WO32 EM&V observations did not include an assessment of RCA.

11) WO32 EM&V post-observation was performed on 08-02-13 of the7.5-ton model YCD09104L0BE, sticker 649-417, RTU 15. The economizer outdoor air thermistor was not working or not compatible with Honeywell Jade controller causing economizer to not function properly. Economizer minimum damper position was closed. WO32 EM&V observations did not include an assessment of RCA.

B.3.3 Site UC

1) The ACP program provides incentives to contractors for the following services: 1) basic package (zone and RTU modules, machine fit Schrader caps (without o-rings), thermostat programmable, and economizer changeover check), 2) refrigerant pre-test, 3) refrigerant charge and airflow service, 4) functional economizer test and repair, 5) economizer adjustment, 6) economizer control package, 7) programmable thermostat replacement, and 8) programmable thermostat adjustment.

2) The site has approximately 99 RTUs records submitted for incentives under the program. ACP program work was performed from June through August of 2010. The units range in cooling capacity from 3 to 12.5 tons. Ex post EM&V observations were performed of seven (7) units from 04-30-13 to 05-08-13. The following units were evaluated:
1) 5-ton Carrier, 50HJQ006-621HQ, S/N 4204G20356, sticker 501-537 (RTU HP-W),
2) 4-ton Carrier 50HJQ005-631HQ, S/N 4304G10210, sticker, 501-528 (RTU HP-E),
3) 3-ton Carrier 50HJQ004-321HQ, S/N 4304G10247, sticker 501-527 (RTU HP-N),
4) 7.5-ton Carrier 50HJQ008-621HQ, S/N 4204G11292, sticker 501-530 (RTU HP-S),
5) 12.5-ton Carrier 50HJQ014-621AA, S/N 4204F63939, sticker 501-536 (RTU HP-I),
6) 7.5-ton Carrier 50HJQ008-621HQ, S/N 4204F11294, sticker 501-538 (RTU HP-L),
7) 10-ton Carrier 50HJQ012-631HQ, S/N 4204G20556, sticker 501-519 (RTU HP-I 1).
According to program data, technicians diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings and a shut-off valve on the high-side pressure hose, but no EPA 608 low-loss fittings. WO32 EM&V master technicians did not directly observe technicians performing work in the program. WO32 EM&V master technicians found Honeywell THX9321 Prestige 2.0 thermostats installed for each unit. All thermostats were programmed with 55F heating setback and 85F cooling set-forward from 5 PM to 6AM daily and unoccupied weekends. The thermostat is compatible with the Honeywell W7212 digital economizer controller for conventional systems and the W7213 and W7214 economizer modules for heat pump systems. See https://www.forwardthinking.honeywell.com/related_links/thermostats/prestige/68-0311.pdf. Economizers on units at the site were non-functional due to OAS not working or. The wire to connect thermostat terminal A to economizer controller terminal input (N or

OCC) was not connected. If no occupancy output from the thermostat is connected, and no jumper is connected from R to N (or OCC) then the economizer will not function. The thermostat is not an approved thermostat in the utility program. See http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/ProgrammableThermostat_QualifiedProductList.pdf.

3) WO32 EM&V post-observation was performed on 04-30-13 of the 5-ton model 50HJQ006-621HQ, sticker 501-537, RTU HP-W. The economizer controller was disconnected causing dampers to be stuck open. The UC-Davis HVAC maintenance manager provided approval to reinstall controller to evaluate damper operation. With controller reconnected the minimum damper position was closed. Cold spray did not make economizer damper open indicating economizer was not functional due to outdoor air sensor failure. Program database reported technician reprogrammed thermostat, cleaned condenser/evaporator coils, added 48 ounces of R22 refrigerant, and installed machine caps on Schrader valves. Unit is reported as receiving RCA test-in/out incentives in the final program database. The manufacturer provides unit-specific charts of target suction temperature (ST) as a function of outdoor air temperature (OAT) and suction pressure (SP) (50HJQ004-007 Single-Package Rooftop Heat Pump Units, 50hjq-13si 004-007.pdf).[36] The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[37] Temperature split was 27.1°F or 3.7°F above 23.4°F CEC RCA target and outside 20 +/- 2°F program tolerance. Suction temperature was 58.1°F or 16.8 above 41.3°F manufacturer target indicating undercharge. Superheat was 20.9°F or 15.9 above 5°F CEC RCA target at 75.2°F OAT and 53.8°F RWB indicating undercharge. Evaporator saturation temperature (EST) was 37.2°F and below 46 +/- 6°F program tolerance. Low EST and high superheat indicate heat transfer issues, undercharge, or non-condensables. WO32 EM&V measured airflow was 1345 cfm or 269 cfm/ton at total static pressure of 2 inches water column (IWC). Airflow is 33% lower than recommended by manufacturer. Fan-belt pulley was set to 5 turns open or 1108 to 1300 rpm according to manufacturer (depending on standard or high static motor). Low airflow is caused by insufficient blower motor horsepower, low fan speed, or high total static pressure.

4) WO32 EM&V post-observation was performed on 04-30-13 of the 4-ton model 50HJQ005-631HQ, sticker 501-528, RTU HP-E. The economizer outdoor damper was 10% open or 1-finger. Unit did not operate due to failed capacitor (measured capacitance was 0.12 microfarads). UC-Davis maintenance manager provided approval to install new capacitor.

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[36] Manufacturer suction temperature tolerance is +/-5°F.

[37] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

Cold spray did not cause the economizer damper to open indicating the economizer was not functional due to outdoor air sensor failure. Program database reported the technician repaired economizer, reprogrammed thermostat, cleaned evaporator coils, and installed machine caps on Schrader valves. Unit is reported as receiving RCA test-in/out incentives in the final program database. The manufacturer provides unit-specific charts of target ST as a function of OAT and SP (50HJQ004-007 Single-Package Rooftop Heat Pump Units, 50hjq-13si 004-007.pdf). Temperature split was 26.9°F or 0.9°F above 26°F CEC RCA target and outside 20 +/- 2°F program tolerance. Suction temperature was 49.3°F or 1.7 above 47.6°F manufacturer target and within tolerances. Superheat was 13.3°F or 8.3 above 5°F CEC RCA target at 82.5°F OAT and 54.6°F RWB indicating undercharge. EST was 36°F and below 46 +/- 6°F program tolerance. WO32 EM&V measured airflow was 1065 cfm or 266 cfm/ton at total static pressure of 1.7 inches water column (IWC). Airflow was 33% lower than recommended by manufacturer. Low airflow is caused by insufficient blower motor horsepower, low fan speed, or high total static pressure.

5) WO32 EM&V post-observation was performed on 05-1-13 of the 3-ton model 50HJQ004-321HQ, sticker 501-527, RTU HP-N. The economizer damper was 10% open or 1-finger. Cold spray caused the damper to open but the compressor stayed on indicating the economizer was not functional due not being wired for 2-stage cooling which should turn off compressor when economizing on 1st-stage. Program database reported the technician repaired economizer, reprogrammed thermostat, and installed machine caps on Schrader valves. Unit is reported as receiving RCA test-in incentives in the final program database. Since no refrigerant charge measures were reported, the EM&V observations did not include an assessment of RCA. WO32 EM&V measured airflow was 681 cfm or 227 cfm/ton at total static pressure of 0.7 inches water column (IWC). Airflow is 43% lower than 400 cfm/ton recommended by manufacturer. Low airflow is caused by insufficient blower motor horsepower, low fan speed, or high total static pressure. The pulley was found to be turned all the way out (i.e., 6 turns) which provides lowest speed.

6) WO32 EM&V post-observation was performed on 05-1-13 of the 7.5-ton model 50HJQ008-621HQ, sticker 501-530, RTU HP-S. The economizer damper was 10% open or 1-finger. Cold spray caused the damper to open but the compressor stayed on indicating the economizer was not functional due not being wired for 2-stage cooling which should turn off compressor when economizing on 1st-stage. Program database reported the technician repaired economizer, reprogrammed thermostat, cleaned evaporator coils, adjusted refrigerant charge, and installed machine caps on Schrader valves. Unit is reported as receiving RCA test-in/out incentives in the final program database. The manufacturer provides unit-specific charts of target ST as a function of OAT and SP (50HJQ008, 012 Single-Package

Rooftop Heat Pump Units, 50hjq-10si 008-012.pdf).[38] Temperature split was 24.6°F or 2.8°F above 21.8°F CEC RCA target and within tolerances, but outside 20 +/- 2°F program tolerance. Circuit 1 suction temperature was 45.3°F or 9.6 above 35.7°F manufacturer target indicating undercharge. Circuit 1 superheat was 10.4°F or 6.5 above 3.9°F CEC RCA target at 78.2°F OAT and 50.8°F RWB indicating undercharge. Circuit 1 EST was 34.9°F and below 46 +/- 6°F program tolerance. Circuit 2 suction temperature was 46°F or 2.9 above 43.1°F manufacturer target and within tolerances. Circuit 2 superheat was 9.2°F or 5.3 above 3.9°F CEC RCA target at 78.2°F OAT and 50.8°F RWB indicating undercharge. Circuit 2 EST was 36.8°F and below 46 +/- 6°F program tolerance. WO32 EM&V measured airflow was 2608 cfm or 348 cfm/ton at total static pressure of 2 inches water column (IWC). Airflow is 13% lower than recommended but within manufacturer tolerances.

7) WO32 EM&V post-observation was performed on 05-3-13 of the 12.5-ton model 50HJQ014-621AA, sticker 501-536, RTU HP-I. The economizer damper was 10% open or 1-finger. Cold spray caused the damper to open but the compressor stayed on indicating the economizer was not functional due not being wired for 2-stage cooling which should turn off compressor when economizing on 1st-stage. Program database reported the technician conducted maintenance, reprogrammed thermostat, and installed machine caps on Schrader valves. Unit is reported as receiving no incentives in the final program database. Since no refrigerant charge measures were reported, the EM&V observations did not include an assessment of RCA. WO32 EM&V measured airflow was 4300 cfm or 344 cfm/ton at total static pressure of 2 inches water column (IWC). Airflow is 14% lower than recommended but within manufacturer tolerances. Low airflow can be caused by insufficient blower motor horsepower, low fan speed, or high total static pressure.

8) WO32 EM&V post-observation was performed on 05-3-13 of the 7.5-ton model 50HJQ008-621HQ, sticker 501-538, RTU HP-L. The economizer damper was closed. Cold spray caused the damper to open but the compressor stayed on indicating the economizer was not functional due not being wired for 2-stage cooling which should turn off compressor when economizing on 1st-stage. Program database reported the technician adjusted or repaired economizer, reprogrammed thermostat, and installed machine caps on Schrader valves. Unit is reported as receiving no incentives in the final program database. Since no refrigerant charge measures were reported, the EM&V observations did not include an assessment of RCA. WO32 EM&V measured airflow was 2472 cfm or 330 cfm/ton at total static pressure of 1.74 inches water column (IWC). Airflow is 18% lower than recommended by the manufacturer.

[38] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

9) WO32 EM&V post-observation was performed on 05-8-13 of the 10-ton model 50HJQ012-631HQ, sticker 501-519, RTU HP-I1. The economizer damper was closed. Cold spray did cause the damper to open and compressors did not turn off indicating the economizer was not functional due to failed outdoor air sensor. Program database reported the technician tested and found economizer functional, reprogrammed thermostat, adjusted refrigerant charge, and installed machine caps on Schrader valves. Unit is reported as receiving RCA test-in/out incentives in the final program database. The manufacturer provides unit-specific charts of target ST as a function of OAT and SP (50HJQ008, 012 Single-Package Rooftop Heat Pump Units, 50hjq-10si 008-012.pdf). Temperature split was 25.9°F or 6.7°F above 19.2°F CEC RCA target indicating low airflow and outside 20 +/- 2°F program tolerance. Circuit 1 suction temperature was 68.4°F or 40.3 above 28.1°F manufacturer target indicating undercharge. Circuit 1 superheat was 33.9°F or 17.8 above 16.1°F CEC RCA target at 76°F OAT and 62.9°F RWB indicating undercharge. Circuit 1 EST was 34.5°F and below 46 +/- 6°F program tolerance. Circuit 2 suction temperature was 59.9°F or 22.6 above 37.3°F manufacturer target indicating undercharge. Circuit 2 superheat was 22.5°F or 6.4 above 16.1°F CEC RCA target at 76°F OAT and 62.9°F indicating undercharge. Circuit 2 EST was 37.4°F and below 46 +/- 6°F program tolerance. Low EST, high suction temperature, and high superheat indicate heat transfer issues, undercharge, or restrictions. WO32 EM&V measured airflow was 3960 cfm or 396 cfm/ton at total static pressure of 2.14 inches water column (IWC). Airflow is within manufacturer tolerances.

B.3.4 Site MH

1) The ACP program provides incentives to contractors for the following services: 1) basic package (zone and RTU modules, machine fit Schrader caps (without o-rings), thermostat programmable, and economizer changeover check), 2) refrigerant pre-test, 3) refrigerant charge and airflow service, 4) functional economizer test and repair, 5) economizer adjustment, 6) economizer control package, 7) programmable thermostat replacement, and 8) programmable thermostat adjustment.

2) WO32 EM&V post inspections were conducted of work performed in the program. The site has approximately 275 RTUs records submitted for incentives under the program. Ex post EM&V observations were performed of seven (7) units from 08-05-13 to 08-07-13. The following units were evaluated:
   1) 2.5-ton Trane YCC030F1L0BD, S/N M124J6T2H, sticker 647-963, RTU A/C 20,
   2) 6-ton Carrier 48HJS007-651, S/N 3508G30421, sticker 648-020, RTU A/C-1 Boys Locker Room #1,
   3) 4-ton Trane YHC048A4ELA0XC201A1B00300A, S/N 240100361L, sticker 610-903, RTU AC-15,

4) 7.5-ton Trane YHC092A4ELA0WC001A1B00300D, S/N 239100581L, sticker 648-003, RTU AC-12,
5) 5-ton Trane YCH060A4ELA10C201A1B00300B, S/N 240100355L, sticker 610-906, RTU AC-21,
6) 4-ton Carrier 48HJS005-551, S/N 3508G20331, sticker 648-024, RTU A/C-2 Girls Locker Room #1,
7) 5-ton Carrier 48HJS006-541, S/N 3508G20423, sticker 648-023, RTU A/C-3 Girls Locker Room #2.
According to program data, technicians diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings and a shut-off valve on the high-side pressure hose, but no EPA 608 low-loss fittings. WO32 EM&V master technicians did not directly observe technicians performing work in the program.

3) WO32 EM&V post-observation was performed on 08-5-13 of the 2.5-ton Trane model YCC030F1L0BD, sticker 647-963, RTU A/C 20. The economizer minimum damper was closed. Economizer outdoor air setpoint was set between C and D. Testing economizer function found dampers only actuate slightly indicating need for further maintenance work on economizer dampers, linkages, and/or motor. Economizer outdoor air filter completely plugged with dirt, needs cleaning. Air filters were very dirty and dated 7/11/12, but WO32 EM&V was performed on 8/5/13 indicating same filters were installed for more than one year. For EM&V air filters were replaced for refrigerant charge and airflow testing. Electrical control section of RTU was very dirty and in need of cleaning. Contactors showing signs of significant wear and were in need of replacement. Blower motor and blower wheel were significantly dirty. Refrigerant suction pressure was slightly lower and discharge pressure was slightly higher than manufacture target values. The manufacturer provides unit-specific charts of suction pressure and discharge pressure as a function of outdoor air temperature (OAT) and return air wetbulb (RWB) temperature and superheat as a function of OAT and return drybulb (RDB) temperature (see Trane Service Facts YCC030-SF-5B, YCC030F1L0BD, Single Packaged Gas Electric - Convertible 2-½ Ton, YCC030-SF-5B (1).pdf).[39] The CEC RCA protocol provides target temperature split as a function of RWB and return drybulb (RDB) temperature and target superheat (SH) as a function of OAT and RWB temperature.[40] Temperature split was 20.8°F or 0.4°F above 20.4°F CEC RCA target and within CEC tolerance and within 20 +/- 2°F program tolerance. Superheat was 11.7°F or 0.6 above 11.1°F CEC RCA target at 79.3°F OAT and 61.3°F RWB and within tolerance.

[39] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

[40] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

Superheat was 11.7°F or -6.3 below 18°F manufacturer target indicating overcharge. Suction pressure was 67.4 psig or -2.3 below 69.7 psig manufacturer target within tolerance. Discharge pressure was 222.5 psig or 24.7 above 197.8 psig manufacturer target indicating overcharge. Evaporator saturation temperature (EST) was 39.1°F and below 46 +/- 6°F program tolerance. Suction pressure was within manufacturer tolerances, but discharge pressure and superheat were not within manufacturer tolerances.

4) WO32 EM&V post-observation was performed on 08-5-13, of the 6-ton Carrier model 48HJS007-651, sticker 648-020, RTU A/C-1 Boys Locker Room #1. The economizer damper was 20% open (1.25" or 2-fingers). Economizer outdoor air setpoint set between C and D. Testing economizer function found dampers only actuate when testing minimum position, not when testing maximum condition, indicating further maintenance needed. Blower fan belt was old, cracked, squealing, and in need of replacement. Air filters were incorrect size (two 16"x30"x1", should be two 16"x32"x1"). Air filters were very dirty and dated 7/11/12, but WO32 EM&V was performed on 8/5/13 indicating same filters were installed for more than one year. For WO32 EM&V measurements the air filters were replaced for refrigerant charge and airflow testing. The manufacturer provides unit-specific charts of target suction temperature (ST) as a function of outdoor air temperature (OAT) and suction pressure (SP) (see Carrier 48HJ004-007 Single-Package Rooftop Heating/Cooling Standard and Low NOx Units, 48hj-22si.pdf).[41] Temperature split was 25.7°F or 3.8°F above 21.9°F CEC RCA target indicating low airflow and above 20 +/- 2°F program tolerance. Suction temperature was 47.2°F or -3.9 below 51.1°F manufacturer target and within tolerances. Superheat was 3.5°F or -3.3 below 6.8°F CEC RCA target at 90.1°F OAT and 63.2°F RWB and within tolerances. EST was 43.7°F and within 46 +/- 6°F program tolerance. High temperature split indicates low airflow due to cracked and loose fan belt which can cause low superheat and incorrect RCA diagnostics.

5) WO32 EM&V post-observation was performed on 08-6-13 of the 4-ton Trane model YHC048A4ELA, sticker 610-903, RTU AC-15. The economizer damper was closed. Economizer outdoor air setpoint was set between C and D. Economizer damper motor was not working (24 volts coming into motor). Unit was wired to have first stage be economizer but the wiring diagram was not updated to indicate this. Blower fan belt was old, cracked, and in need of replacement. Air filters were dirty and dated 05-07-12, but WO32 EM&V was performed on 8/5/13 indicating same filters were installed for more than one year. Dirty air filters were left installed for the initial WO32 EM&V refrigerant charge and airflow test. Clean air filters were installed for final RCA test. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of OAT and RWB

[41] Manufacturer suction temperature tolerance is +/-5°F.

temperatures (see Trane Service Facts YCH048-SF-2A, YHC048A4ELA, Packaged Gas/Electric 4 Ton Rooftop Units, YHC048-SF-2A.pdf).[42] With dirty air filters the initial temperature split was 23.3°F or 4.3°F above 19°F CEC RCA target indicating low airflow and above 20 +/- 2°F program tolerance. Initial superheat was 20.7°F or 15.6 above 5.1°F CEC RCA target indicating undercharge at 78°F OAT and 56.1°F RWB. Initial superheat was 20.7°F or 15.7 above 5°F manufacturer target indicating undercharge. Initial suction pressure was 61.6 psig or -5.7 below 67.3 psig manufacturer target indicating undercharge. Initial discharge pressure was 207.5 psig or 0.6 above 206.9 psig manufacturer target within tolerance. Subcooling was 18.9°F, EST was 35°F and below 46 +/- 6°F program tolerance, and COA was 20.8°F and within 25 +/- 5°F program tolerance. Discharge pressure was within manufacturer tolerances, but superheat and suction pressure were not within manufacturer tolerances. High superheat, suction pressure, and subcooling indicate heat transfer issues or low airflow due to cracked and loose fan belt. Clean air filters were installed. With clean air filters installed, the final temperature split was 26.1°F or 6°F above 20.1°F CEC RCA target indicating low airflow due to cracked and loose fan belt and above 20 +/- 2°F program tolerance. Final superheat was 2.6°F or -2 below 4.6°F CEC RCA target and within tolerance at 78°F OAT and 53.8°F RWB. Final superheat was 2.6°F or -2.4 below 5°F manufacturer target and within tolerances. Final suction pressure was 61 psig or -4.3 below 65.3 psig manufacturer target and within tolerances. Final discharge pressure was 212 psig or 6.3 above 205.7 psig manufacturer target and within tolerances. Subcooling was 20.1°F, EST was 34.5°F and below 46 +/- 6°F program tolerance, and COA was 22.4°F within 25 +/- 5°F program tolerance. With clean air filters installed superheat, suction pressure, and discharge pressure are within manufacturer tolerances.

6) WO32 EM&V post-observation was performed on 08-6-13 of the 7.5-ton Trane model YHC092A4ELA, sticker 648-003, RTU AC-12. The economizer outdoor damper was closed, but had ½" gap due to weather-stripping falling off. Economizer outdoor air setpoint was set at B. Economizer damper was binding; this may be cause of failing weather-stripping. One circuit board has been removed for some reason, no notes on unit or wiring diagram indicating change. Unit had an 'add a wire' and time delay set to eight minutes added to unit. Unit belt tension too loose and should be tightened. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of OAT and RWB temperatures (see Trane Service Facts YCH092-SF-1, YHC092A4ELA Packaged Gas/Electric 7 1/2 Ton Dual Compressor Rooftop Units, YHC092-SF-1.pdf). Temperature split was 25.3°F or 4.3°F above 21°F CEC RCA target indicating low airflow and above 20 +/- 2°F program tolerance. Circuit 1 superheat was 5.6°F or 0.6 above 5°F CEC RCA target and within

[42] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

tolerance at 93.1°F OAT and 60.2°F RWB. Circuit 1 superheat was 5.6°F or 0.6 above 5°F manufacturer target and within tolerances. Circuit 1 suction pressure was 67.2 psig or -6.9 below 74.1 psig manufacturer target indicating undercharge. Circuit 1 discharge pressure was 232 psig or -12.2 below 244.2 psig manufacturer target indicating undercharge. Circuit 1 EST was 39°F and below 46 +/- 6°F program tolerance. Circuit 2 superheat was 17.8°F or 12.8 above 5°F CEC RCA target indicating undercharge at 93.1°F OAT and 60.2°F RWB. Circuit 2 superheat was 17.8°F or 12.8 above 5°F manufacturer target indicating undercharge. Circuit 2 suction pressure was 71.1 psig or -5.1 below 76.2 psig manufacturer target indicating undercharge. Circuit 2 discharge pressure was 238 psig or -2.9 below 240.9 psig manufacturer target and within tolerances. Circuit 2 EST was 41.7°F and within 46 +/- 6°F program tolerance. Circuit one refrigerant discharge and suction pressure were outside manufacture tolerances and superheat was within manufacturer tolerances indicating heat transfer or airflow issues. Circuit two suction pressure and superheat were outside manufacture tolerances and discharge pressure was within manufacturer tolerances indicating heat transfer or airflow issues. Temperature split was slightly higher than tolerances indicating low airflow.

7) WO32 EM&V post-observation was performed on 08-7-13 of the 5-ton Trane model YHC060A4ELA, sticker 610-906, RTU AC-21. The economizer outdoor damper was 5% open (0.5" open or ½ finger). Economizer outdoor air setpoint was set between C and D. Economizer damper functions properly but when damper fully open compressor still runs. Filters were dirty and replaced during EM&V. Fan belt was cracking and in need of replacement. The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of OAT and RWB temperatures (see Trane Service Facts YCH060-SF-2A, YCH060A4ELA Packaged Gas/Electric 5 Ton Rooftop Units, YHC060-SF-2A.pdf). Temperature split was 23.3°F or 2.3°F above 21°F CEC RCA target indicating low airflow and above 20 +/- 2°F program tolerance. Superheat was 9.6°F or 3.8 above 5.8°F CEC RCA target and within tolerance at 85.6°F OAT and 61°F RWB. Superheat was 9.6°F or 2.2 above 7.4°F manufacturer target and within tolerances. Suction pressure was 64.3 psig or -9.4 below 73.7 psig manufacturer target indicating undercharge. Discharge pressure was 231 psig or 0.6 above 230.4 psig manufacturer target and within tolerances. Subcooling was 16.9°F, EST was 36.9°F and below 46 +/- 6°F program tolerance, and COA was 21.1°F and within 25 +/- 5°F program tolerance. Temperature split, superheat, and discharge pressure were within tolerances, but suction pressure indicated undercharge.

8) WO32 EM&V post-observation was performed on 08-7-13 of the 4-ton Carrier model 48HJS005-551, sticker 648-024, RTU A/C-2 Girls Locker Room #1. The economizer outdoor damper was 10% open (0.75" open or 1 finger). Economizer outdoor air setpoint was set at D. Economizer functions properly; when damper fully open compressor turns off. Blower fan belt was severely cracked and in need of immediate replacement. Air filters were

extremely dirty and replaced during WO32 EM&V observation. Condensate line was broken and condensate draining onto roof. Drain pan was very dirty and needs cleaning. The manufacturer provides unit-specific charts of target suction temperature (ST) as a function of outdoor air temperature (OAT) and suction pressure (SP) (see Carrier 48HJ004-007 Single-Package Rooftop Heating/Cooling Standard and Low NOx Units, 48hj-22si.pdf). Temperature split was 25.5°F or 3.2°F above 22.3°F CEC RCA target indicating low airflow due to cracked and loose fan belt and above 20 +/- 2°F program tolerance. Suction temperature was 43.7°F or -3.5 below 47.2°F manufacturer target and within tolerances. Superheat was 2.8°F or -10.3 below 13.1°F CEC RCA target at 83°F OAT and 63.9°F RWB and indicating overcharge. EST was 40.9°F and within 46 +/- 6°F program tolerance. Suction temperature was within tolerances but superheat was not within tolerances indicating heat transfer issues or low airflow due to cracked and loose fan belt.

9) WO32 EM&V post-observation was performed on 08-7-13 of the 5-ton Carrier model 48HJS006-541, sticker 648-023, A/C-3 Girls Locker Room #2. The economizer damper was 20% open (1.25" open or 2 fingers). Economizer outdoor air setpoint was set between C and D. Economizer does not function; may be due to mixed air sensor being very dirty and in possible need of replacement. Air filters were dirty and replaced during WO32 EM&V observation. Condensate line broken in two places, taped back together rather than being properly repaired. Blower wheel needs cleaning. Fan belt was loose, cracked, and in need of replacement. The manufacturer provides unit-specific charts of target suction temperature (ST) as a function of outdoor air temperature (OAT) and suction pressure (SP) (see Carrier 48HJ004-007 Single-Package Rooftop Heating/Cooling Standard and Low NOx Units, 48hj-22si.pdf). Temperature split was 25.2°F or 4°F above 21.2°F CEC RCA target indicating low airflow and above 20 +/- 2°F program tolerance. Superheat was 21.3°F or 10 above 11.3°F CEC RCA target at 85.7°F OAT and 63.5°F RWB indicating undercharge. Suction temperature was 62.9°F or 25.9 above 37°F manufacturer target outside tolerance indicating undercharge. EST was 41.6°F and within 46 +/- 6°F program tolerance. Temperature split indicated low airflow due to cracked and loose fan belt and suction and superheat temperatures were above manufacturer tolerances indicating undercharge. RCA diagnostics were compromised by low airflow.

B.4 PG&E Statewide

B.4.1 Site CU

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Customer provided a copy of their agreement with the Contractor

defining services to be provided. Agreement requires that customer is responsible for giving full amount of incentive money from PG&E to Contractor in payment for HVAC services performed. Contract provides a one-year warranty.

2) WO32 EM&V post inspections were conducted of work performed in the PG&E program. Detailed EM&V inspections were performed on four units on 11-07-13 and 11-08-13. Ten units had economizers checked.
   1) Bryant 4-ton 580JP05A72A2A0AAA, S/N 1310G10227, PG&E sticker 000 0910, AC 13 classroom 10,
   2) Goodman 4-ton CPG0480703DXXXAA, S/N 810056752, PG&E sticker 000 0911, classroom 11,
   3) Carrier 5-ton 48HJD006-531, S/N 3000G2424762, PG&E sticker 000 0917, AC-20 computer lab, and
   4) Goodman 4-ton CPG0480703DXXXAA, S/N 810056748, PG&E sticker 000 0915, classroom 8.
   Program data records indicate work was performed in December 2012 and May 2013. Contractor was paid incentives for the following measures for all units: coil cleaning, refrigerant test, and replace thermostat. In addition to these measures, some units also received incentives for refrigerant service, economizer test, and decommission economizer. WO32 EM&V master technicians did not directly observe technicians performing work at the site.

3) WO32 EM&V post-observations were performed on 11-07-13 and 11-08-13. Ten (10) units (10 circuits) failed inspections with multiple faults on each unit. All units tested and/or inspected had economizers with new Honeywell W7220 (JADE) digital controllers and sensors that were not installed properly and did not work. All units had very dirty air filters and coils due to agricultural location. All units at site had similar problems with non-functional economizers. Economizers are not working due to incorrect setup and missing "OCC/E-GND" inputs after CQM services were performed. Mixed air temperature (MAT) sensors were incorrectly mounted on the supply blower fan and not installed in proper return air locations. 75% of refrigerant service measures failed inspections and 60% of units (186 out of 311) received refrigerant service. One damper was 100% open (5.25") and others were open 50%. Laboratory, field tests, and other studies show open dampers can increase cooling/heating energy by 8 to 50%. Condenser and evaporator coils were not cleaned and air filters were not changed for 6 to 9 months (air filters were 80% dirty). Dirty condenser/evaporator coils and dirty filters reduce airflow and efficiency (ACCA 180 requires every 3 months). Eight (8) units have down flow economizers on horizontal units and actuators twisting off mounting bracket. WO32 personnel met with technicians on 11-19-13 to explain deficiencies found during EM&V observations. Contractor indicated they were planning to provide a bid for removing existing economizers and installing correct economizers. EM&V follow-up site visits are pending. New PECO Model T4900

programmable thermostats were installed on each unit by the program. The thermostat is compliant with the utility program. The manual for the T4900 thermostat provides instructions for economizer operation and programmable setup. According to the school district maintenance personnel the thermostat was programmed properly with unoccupied heating setback of 65F and unoccupied cooling set-forward of 85F. See http://www.pecomanufacturing.com/assets/docs/installguides/t4900_peco_install_guide.pdf. The manual does not indicate whether or not the thermostat is CEC Title 24 compliant.

4) WO32 EM&V post-observation was performed on 11-7-13 of the 4-ton Bryant 580JP05A72A2A0AAA, sticker 000 0910, AC 13 serving classroom 10. The economizer had the following new parts installed: new Honeywell 7220 Jade Control module, Honeywell C7250A1001 mixed air sensor, and Honeywell C7401F2006/U outdoor air sensors installed. The economizer minimum outdoor air damper position was 10% open (1 finger). The unit also had two outdoor air dampers 50% open. Horizontal economizer installed on vertical unit did not have return air damper installed to block air when economizer is open. Cold spray of economizer with new digital controllers and sensors found to be non-functional due to improper installation. Notched AX35 fan belt tension was slightly loose with proper alignment. The manufacturer provides unit-specific charts of target suction temperature (ST) as a function of outdoor air temperature (OAT) and suction pressure (SP) (Bryant Model 580J*04—12 Nominal 3 to 10 tons with Puron R-410A Refrigerant Service and Maintenance Instructions. sm580j-01.pdf).[43] The CEC RCA protocol provides target temperature split as a function of RWB and return drybulb (RDB) temperature and target superheat (SH) as a function of OAT and RWB temperature.[44] Temperature split was 17°F or -2.5°F below 19.5°F CEC RCA target and within tolerance. Suction temperature was 35.5°F or -0.5 below 36°F manufacturer target and within tolerances. Superheat was 3.1°F or -1.9 below 5°F CEC RCA target at 73.9°F OAT and 50°F RWB and within tolerances. Evaporator saturation temperature (EST) was 32.4°F and below 46 +/- 6°F program tolerance.

5) Post-observations on 11-7-13 of the 4-ton Goodman CPG0480703DXXXAA, sticker 000 0911, classroom 11. The economizer had the following new parts installed: Honeywell 7220 Jade Control module, Honeywell C7250A1001 mixed air sensor, and Honeywell C7401F2006/U outdoor air sensors installed. The economizer minimum outdoor air damper position was closed. One filter was loose, air filters dirty (dated 2-13-13), and air was bypassing. Horizontal economizer installed on vertical unit did not have return air damper installed to block air when economizer is open. Cold spray of economizer with new digital

[43] Manufacturer suction temperature tolerance is +/-5°F.

[44] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

controllers and sensors found to be non-functional due to improper installation. The manufacturer provides unit-specific target superheat of 10 +/- 2°F, subcooling 15 +/- 3°F, and target condenser over ambient (COA) temperature 30 +/- 5°F (Goodman Installation Instructions for Commercial Heating & Cooling 3- ton – 6 ton Package Gas Unit CPG Series. http://www.goodmanmfg.com/Portals/0/pdf/M-Info/IOs/IO-CPG3.pdf, page 18).[45] Temperature split was 13.2°F or -6.3°F below 19.5°F CEC RCA target and below 20 +/- 2°F program tolerance indicating low capacity, plugged air filter, iced coil, low airflow, or low charge. Superheat was 20.1°F or 10.1 above 10 +/- 2°F manufacturer target at 77°F OAT and 50°F RWB indicating undercharge. Subcooling was 2.8°F or -12.2°F below 15 +/- 3°F manufacturer target indicating undercharge. EST was 35.6°F and below 46 +/- 6°F program tolerance. COA was 15.8°F and below manufacturer target of 30 +/- 5°F indicating undercharge, heat transfer issues or restriction.

6) WO32 EM&V post-observation was performed on 11-8-13 of the 5-ton Carrier 48HJD006-531, sticker 000 0917, AC-20 serving computer lab. The economizer had the following new parts installed: Honeywell 7220 Jade Control module, Honeywell C7250A1001 mixed air sensor, and Honeywell C7401F2006/U outdoor air sensors installed. The economizer minimum outdoor air damper position was closed. Fan belt was cracked, contractors were pitted, and 50% of the condenser coil was dirty. Air filters were loose and dirty (dated 2-13-13), and air was bypassing. Horizontal economizer installed on vertical unit did not have return air damper installed to block air when economizer is open. Cold spray of economizer with new digital controllers and sensors found to be non-functional due to improper installation. The manufacturer provides unit-specific charts of target suction temperature as a function of OAT and suction pressure (see Carrier 48HJ004-007 Single-Package Rooftop Heating/Cooling Standard and Low NOx Units, 48hj-22si.pdf). Temperature split was 21.9°F or 3.7°F above 18.2°F CEC RCA target indicating low airflow. Suction temperature was 54.1°F or 18.1 above 36°F manufacturer target indicating undercharge. Superheat was 27.4°F or 22.4 above 5°F CEC RCA target at 69.1°F OAT and 48.2°F RWB indicating undercharge. EST was 26.7°F and below 46 +/- 6°F program tolerance. High temperature split indicates low airflow due to loose and cracked fan belt which can cause incorrect RCA diagnostics. High suction and superheat temperatures and low EST indicate undercharge or heat transfer issues.

7) WO32 EM&V post-observation was performed on 11-8-13 of the 4-ton Goodman CPG0480703DXXXAA, sticker 000 0915, classroom 8. The economizer had the following new parts installed: Honeywell 7220 Jade Control module, Honeywell C7250A1001 mixed air sensor, and Honeywell C7401F2006/U outdoor air sensors installed. The economizer

[45] Manufacturer tolerances are +/-2°F for superheat, +/-3°F for subcooling, +/-5°F for COA.

minimum outdoor air damper position was 80% open (5.25 inches open). The damper motor failed and was stuck 80% open. One filter was loose, air filters were dirty (dated 2-13-13), and air was bypassing. Horizontal economizer installed on vertical unit did not have return air damper installed to block air when economizer is open. Cold spray of economizer with new digital controllers and sensors found to be non-functional due to improper installation. The manufacturer provides unit-specific target superheat of 10 +/- 2°F, subcooling 15 +/- 3°F, and target condenser over ambient (COA) temperature 30 +/- 5°F (Goodman Installation Instructions for Commercial Heating & Cooling 3- ton – 6 ton Package Gas Unit CPG Series. http://www.goodmanmfg.com/Portals/0/pdf/M-Info/IOs/IO-CPG3.pdf). Temperature split was 18.7°F or -0.1°F below 18.8°F CEC RCA target and within 20 +/- 2°F program tolerance. Superheat was 1°F or -9 below 10 +/- 2°F manufacturer target indicating overcharge. Subcooling was 12.6°F or within -2.4°F of 15 +/- 3°F manufacturer target. EST was 37.1°F and below 46 +/- 6°F program tolerance. COA was 21.7°F and below manufacturer target of 30 +/- 5°F indicating under charge. Temperature split is within CEC RCA tolerance, subcooling is within manufacturer tolerance, and superheat is below manufacturer target by -9°F indicating overcharge.

B.4.2 Site CW

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) The PG&E program reported forty one (41) RTUs enrolled across all addresses for the [site name]. Detailed EM&V inspections were performed of two units on 11-15-13.
   1) Lennox 5-ton LGC060S2BS1G, S/N 5604E04380, PG&E Sticker 000 4354, AC 3, at [address 1].
   2) York 7.5-ton D3CG090N16525E, S/N NBDM 007552, PG&E Sticker 000 4361, AC 4, at [address 2].
   Program data records indicate work was performed in February and March 2013. Contractor was paid incentives for the following measures for all units: refrigerant test. In addition to this measure, some units also received incentives for coil cleaning, refrigerant service, economizer test, replace controller/sensor, and adjust thermostat. WO32 EM&V master technicians did not directly observe technicians performing work at the site.

3) WO32 EM&V post-observation was performed on 11-15-13 of the 5-ton LGC060S2BS1G, sticker 000 4354, RTU 3. The factory-installed economizer included a Honeywell C7400A1038 outdoor air enthalpy sensor, Honeywell 99K6401 mixed air sensor, and Honeywell direct coupled actuator (Lennox part # 56M8101). Minimum outdoor air damper

was set to 55% open on control board and actuator was open 60 degrees, and fresh air damper was opened 20%. PG&E program database indicated incentives were paid for economizer controller/sensor replacement but economizer, controls, and sensors look to be original factory equipment. Observed thermostat call for heating but only blower and combustion exhaust fans were running, no furnace operation observed. TXV sensing bulb was not insulated. Unit had alarm codes 56, 82, and 58 (combustion air proof switch 1 is open, main board reset or power outage has occurred, and gas valve 1 not energized two minutes after thermostat call for heat). Evaporator coil was dirty. The AX43 notched v-belt was improperly tensioned and alignment was off by 0.25 inches. Belt deflection was 0.56 inches with 9 lbs force, but deflection should be 0.24 inches with 9 lbs of force (per manufacturer). The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and subcooling temperature as a function of outdoor air temperature (OAT) (Lennox Service Literature, Unit Information, Service Literature LGA/LCA/LGC/LCC L Series 3 to 8 tons, Corp. 9822–L12 Revised 01-2009, 1998 Lennox Industries Inc., 9822h.pdf).[46] The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[47] Temperature split was 19°F or -0.7 below 19.7°F CEC RCA target and within tolerances. Subcooling was 24.6°F or 10.6°F above 14°F manufacturer tolerances indicating overcharge. Suction pressure was 50.8 psig or -20.5 psig below 71.3 psig manufacturer target. Discharge pressure was 180.6 psig or 3.6 psig above 177 psig manufacturer target. Superheat was 18.3°F at 68.1°F OAT and 50°F RWB, evaporator saturation temperature (EST) was 26.6°F and below 46 +/- 6°F program tolerance. Condenser over ambient (COA) was 23.9°F and within 25 +/- 5°F program tolerance. High superheat indicating undercharge, high subcooling indicating overcharge, and low EST indicate possible restriction, heat transfer, and airflow issues due to dirty evaporator and fan belt that was loose and misaligned.

4) WO32 EM&V post-observation was performed on 11-15-13 of the 7.5-ton D3CG090N16525E, sticker 000 4361, RTU 4. The factory-installed economizer included a Honeywell C7400A1038 return air enthalpy sensor, no outdoor air sensor, and Honeywell direct coupled actuator motor and controller (York part # 031-00862). Minimum outdoor air damper was stuck in the closed position and economizer would not open. PG&E program database indicated incentives were paid for economizer controller/sensor replacement but economizer, controls, and sensors look to be original factory equipment. Program database

[46] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, subcooling tolerance is +/-1°F.

[47] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

indicated incentives paid for thermostat adjustment but unit was controlled by an Energy Management System (EMS). Evaporator coil had biological growth in middle section. Compressor 1 contactor had loose wiring causing melting of the insulation. Unit panels had some missing insulation and some stripped fasteners. One condenser fan capacitor had low microfarad reading and should be replaced. Blower wheel was dirty. Fan belt appeared visibly worn, but had proper tension and alignment. Refrigerant charge on both circuits was within manufacturer superheat specifications (York Superheat Charging Table, Courtesy of York Corporation, Unitary Products Group, www.achrnews.com/articles/superheat-charging-curves-for-technicians). Temperature split was 18.1°F or -1.4 below 19.5°F CEC RCA target and within tolerances. Circuit 1 superheat was 4.5°F and at the 4.5°F manufacturer target at 69.7°F OAT and 50°F RWB. Circuit 2 superheat was 5°F or 0.5 above the 4.5°F manufacturer target. Circuit 1 EST was 27°F and below 46 +/- 6°F program tolerance. Circuit 2 EST was 29.6°F and below 46 +/- 6°F program tolerance. Low EST indicates possible heat transfer or low airflow issues that could impact RCA diagnostics.

B.4.3 Site CL

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) EM&V inspections were performed on 11-21-13 of sixteen (16) units.
1) RUUD 8.5-ton RKKB0A102CL22E, S/N 2D6514ADAAF390311757, PG&E sticker 004 2071, RTU 5,
2) RUUD 8.5-ton RKKB-A102CM15E, S/N 2B6514ADAAF270012719, PG&E sticker 004 2064, RTU 1,
3) RUUD 8.5-ton RKKB-A102CM22E, S/N 1Z6514ADAAF270012714, PG&E sticker 004 2065, RTU 10,
4) RUUD 12.5-ton RKKB-A150CM15E, S/N2B6526ADAAF270012698, PG&E sticker 004 2066, RTU 8B,
5) RUUD 8.5-ton RKKB-A102CL22E, S/N 2D6514ADAAF460312999, PG&E sticker 004 2067, RTU 8A,
6) Carrier UNK, S/N UNK, PG&E sticker 004 2068, RTU 9,
7) RUUD 8.5-ton RKKB-A102CL22E, S/N 2D6514ADAAF350305332, PG&E sticker 004 2069, RTU 7,
8) RUUD 8.5-ton RKKB-A102CM15E, S/N 2B6514ADAAF270012720, PG&E sticker 004 2070, RTU 6,
9) Carrier UNK, S/N UNK, PG&E sticker 004 2072, RTU 11,
10) RUUD 5-ton RJKA-A060CL, S/N 5581F01000989, PG&E sticker 004 2073, RTU 12,

11) RUUD 8.5-ton RKKB-A102CM22E, S/N 1Z6514ADAAF270012715, PG&E sticker 004 2063 RTU 2,
12) RUUD 8.5-ton RKKB-A102CM15E, S/N 2B6514ADAAF270012721, PG&E sticker 004 2073, RTU 3,
13) RUUD 12.5-ton RKKB-A150CM15E, S/N 2B6526ADAAF270012697, PG&E sticker 004 2061, RTU 4,
14) Trane 10-ton YHC120A3RMA34C0B0A1B000, S/N 820101522L, PG&E sticker 004 1932, RTU 15,
15) Trane 10-ton YHC120A3RMA34C0B0A1B000BO, S/N 820101514L, PG&E sticker 004 1933, RTU 14,
16) Trane 10-ton YHC120A3RMA34C0B0A1B000B0, S/N 8210158L, PG&E sticker 004 1934, RTU 13.
Program data records indicate work was performed in March 2013. Contractor was paid incentives for the following measures for all units: coil cleaning, refrigerant test, and adjust thermostat. In addition to these measures, some units also received incentives for economizer test, replace damper motor, replace controller/sensor, and renovate linkage. WO32 EM&V master technicians did not directly observe technicians performing work at the site.

3) Observations on 11-21-13 found one cabinet and electrical panel removed and laying on top of the roof. Several other panels were improperly installed with missing screws. There are sixteen (16) units with 31 circuits. All units failed inspections with multiple faults on each unit. Units serving zones 2, 3, 13, and 15 provide intermittent heat (~1 minute on, off, repeat). Some units have damaged condenser fins, cracked fan belts, gas valves turned off, chicken wire economizer filters, or missing filters. Refrigerant oil near Schrader valves indicates no EPA low-loss fittings. Building has EMS but contractor received PG&E incentives for thermostat adjustments. Program requires ACCA 180 inventory based on manufacturer performance objectives to establish unacceptable conditions, indicators, inspection frequencies, and tasks. EM&V observations indicate ACCA 180 maintenance has not been performed. According to the site manager the cooling and heating are controlled by an energy management system (EMS). Thermostat schedules were not adjusted by program technicians.

4) Observations on 11-21-13 of the RUUD 8.5-ton RKKB0A102CL22E, PG&E sticker 004 2071, RTU 5, found new Honeywell C7660A1000 outdoor air sensor, Honeywell W7212A1009 controller, and Belimo AFB24-SR motor. Economizer changeover is set at 68°F (A). Minimum damper position is 10% (1 finger or 0.75 inch). Unit and economizer are controlled by EMS. Economizer damper weather-stripping and seals are coming off damper blades which are very dirty. Economizer was tested with cold spray and not functional. Compressor contactors are pitted. Cabinet panels have missing or stripped screws and 10 screws were missing from economizer hood. Cabinet panels were opening with wind. Fan

belt was making noise, cracked, and loose (1 inch deflection with 4 pounds force), but properly aligned. Condenser fins were bent and evaporator coil was dirty. Electrical control panel wiring needs to be organized and secured.

5) Observations on 11-21-13 of the RUUD 8.5-ton RKKB-A102CM15E, PG&E sticker 004 2064, RTU 1, found new Honeywell C7660A1000 outdoor air sensor, Honeywell W7212A1009 controller, and Belimo AFB24-SR motor. Economizer changeover is set at 68°F (A). Minimum damper position is closed. Unit and economizer are controlled by EMS. Economizer damper blades are very dirty. Economizer was tested with cold spray and not functional. Cabinet panels have missing or stripped screws and opening with wind. Fan belt is cracked in four places and very loose (1 inch deflection with 4 pounds force), and 1/8 inch out of alignment. Condenser and evaporator coils were dirty.

6) Observations on 11-21-13 of the RUUD 8.5-ton RKKB-A102CM22E, PG&E sticker 004 2065, RTU 10, found filter access and electrical door had no screws installed and the panel was ajar. Internal safety panels for electrical section were not installed and laying on the roof. Blower access door missing and or not tightened with screws. Refrigerant oil is covering panel next to Schrader valves indicating no use of EPA 608 low-loss fittings. Gas valve was turned off indicating no heating.

7) Observations on 11-21-13 of the RUUD 12.5-ton RKKB-A150CM15E, PG&E sticker 004 2066, RTU 8B, found filter access panel has one screw holding it shut. Refrigerant oil is covering panel next to Schrader valves indicating no use of EPA 608 low-loss fittings.

8) Observations on 11-21-13 of the RUUD 8.5-ton RKKB-A102CL22E, PG&E sticker 004 2067, RTU 8A, found filter access panel has one screw holding it shut. Refrigerant oil is covering panel next to Schrader valves indicating no use of EPA 608 low-loss fittings.

9) Observations on 11-21-13 of the Carrier UNK, PG&E sticker 004 2068, RTU 9, found missing screws and economizer filter missing.

10) Observations on 11-21-13 of the RUUD 8.5-ton RKKB-A102CL22E, PG&E sticker 004 2069, RTU 7, found filter access and electrical panels open. Refrigerant oil is covering panel next to Schrader valves indicating no use of EPA 608 low-loss fittings.

11) Observations on 11-21-13 of the RUUD 8.5-ton RKKB-A102CM15E, PG&E sticker 004 2070, RTU 6, found economizer air filters broken and laying on the roof. Zip tied chicken wire to cover economizer inlet. Electrical disconnect box is uncovered. Refrigerant oil is covering panel next to Schrader valves indicating no use of EPA 608 low-loss fittings.

12) Observations on 11-21-13 of the Carrier UNK, S/N UNK, PG&E sticker 004 2072, RTU 11, found unit in okay condition but missing many cabinet screws.

13) Observations on 11-21-13 of the RUUD 5-ton RJKA-A060CL, PG&E sticker 004 2073, RTU 12, found return panel not screwed tight and bottom of panel open ½ inch. Other panels were missing numerous screws. Condenser has a large dent and bent fins.

14) Observations on 11-21-13 of the RUUD 8.5-ton RKKB-A102CM22E, PG&E sticker 004 2063 RTU 2, found blower compartment panel was missing all screws except one and filter access and electrical panel were missing all but two screws (barely held in place). Top panel over condenser fans bent upwards. Furnace was short-cycling on 1 minute and off for 2 minutes and repeat. Two of the economizer-damper weather-stripping seals were sitting on a fence outside unit.

15) Observations on 11-21-13 of the RUUD 8.5-ton RKKB-A102CM15E, PG&E sticker 004 2073, RTU 3, found blower compartment panel was missing all screws except one with two other screws stripped or hanging out of panel. Filter access and electrical panel were missing all but one screw (barely held in place). Furnace was short-cycling on 1 minute and off for 2 minutes and repeat. Two of the economizer weather-stripping seals were found sitting on fence outside unit. Refrigerant oil was covering panel next to Schrader valves indicating no use of EPA 608 low-loss fittings.

16) Observations on 11-21-13 of the RUUD 12.5-ton RKKB-A150CM15E, PG&E sticker 004 2061, RTU 4, found filter access panel was missing all screws except one open 1 inch. Furnace was short-cycling on 1 minute and off for 2 minutes and repeat. Refrigerant oil is covering panel next to Schrader valves indicating no use of EPA 608 low-loss fittings.

17) Observations on 11-21-13 of the Trane 10-ton YHC120A3RMA34C0B0A1B000, PG&E sticker 004 1932, RTU 15, found fairly new with dirty economizer filter falling apart. Furnace was short-cycling on 1 minute and off for 2 minutes and repeat.

18) Observations on 11-21-13 of the Trane 10-ton YHC120A3RMA34C0B0A1B000BO, PG&E sticker 004 1933, RTU 14, found fairly new unit with dirty economizer filter falling apart. External ducts were poorly sealed and leaky.

19) Observations on 11-21-13 of the Trane 10-ton YHC120A3RMA34C0B0A1B000B0, PG&E 004 1934, RTU 13, found fairly new with dirty economizer filter falling apart. Furnace was short-cycling on 1 minute and off for 2 minutes and repeat.

B.4.4 Site RU

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Customer provided a copy of their agreement with the Contractor defining the services to be provided. Agreement requires that customer is responsible for giving full amount of incentive money from PG&E to Contractor in payment for HVAC services performed. Contract provides a one-year warranty.

2) WO32 EM&V post inspections were conducted of work performed in the PG&E program. Detailed inspections were performed on two units on 11-05-13 and 11-06-13. An additional six units were checked for economizer measures.
   1) Bryant 12.5-ton 581BEV150224AEAA, S/N 0600G30800, PG&E Sticker 004 2203, AC MPS serving cafeteria/multi-purpose room, and
   2) Bryant 8.5-ton 581BEV102125ADPA, S/N 0600G30283, PG&E Sticker 004 2202, AC 702 serving cafeteria/702.
   Program data records indicate work was performed in June and August 2013. Contractor was paid incentives for the following measures for all units: coil cleaning (all except one unit), refrigerant test, and refrigerant service. In addition to these measures, some units also received incentives for adjust airflow, economizer test, economizer wiring, replace damper motor, replace controller/sensor, renovate linkage, replace thermostat, and adjust thermostat. WO32 EM&V master technicians did not directly observe technicians performing work at the site. All units at site were on EMS and controlled off site.

3) Observations on 11-05-13 and 11-06-13 (3 to 5 months after work was performed), found two (2) units (4 circuits) that failed inspections with multiple faults on each economizer. Units tested had economizers with new digital controllers and sensors that were not installed per manufacturer instructions and did not function. An additional five (5) out of six (6) units checked at the site had new digital economizer controllers and sensors installed under the program but had similar problems with non-functional economizers. Economizers were not working due to incorrect setup and missing “OCC/E-GND” inputs after CQM services were performed. Seventy five percent of refrigerant measures failed inspections and 87% of units (182 out of 210) received refrigerant service with stickers from 3 programs (CQM, ACP, and VSP). Condenser and evaporator coils appeared to be cleaned, but were still covered with dirt. Air filters were changed three months prior to site visit (dated 8/29/13). School district paid extra to have technicians straighten condenser fins due to vandalism with graffiti. Dirty condenser/evaporator coils and dirty filters reduce airflow and efficiency (ACCA 180 requires every 3 months). WO32 master technician met with contractor’s technicians on 11-19-13 to explain issues found during EM&V observations. Ground wire and thermostat

occupancy wire installation requirements were not clearly defined in Version 1 of the economizer manufacturer installation instructions.

4) WO32 EM&V post-observations were performed on 11-05-13 and 11-06-13 of the Bryant 12.5-ton 581BEV150224AEAA, S/N 0600G30800, PG&E Sticker 004 2203, AC MPS. The economizer was retrofitted with new parts including a Honeywell 7220 Jade Control module, Honeywell C7250A1001 mixed air sensor, and Honeywell C7401F2006/U outdoor air sensors. Power exhaust did not operate due to faulty contactor. Condenser and evaporator coils appeared to be cleaned, but some were covered with dirt. Air filters were changed three months prior to site visit (dated 8/29/13). The 5-AMP fuse tripped off after 5-10 minutes of operation, and insufficient time was available to trouble-shoot the problem. Due to the 5 AMP fuse not working unit appears to have not operated properly since the air filters were replaced 3 months ago. School district paid for technician to straighten condenser coil fins that were previously vandalized. Fan belt tension was too tight but belt was properly aligned. Economizer minimum damper position was set to 10% open (2.8V). Economizer dampers on tested units were closed due to ground ("GND") and thermostat occupancy ("OCC") wires not being attached to controller. Default setting is "OCC" so economizer damper does not return to minimum closed position when cooling ("OCC/E-GND" input wires). Cold spray caused damper to open and compressors to stop operating indicating economizer would be functional without other issues. The manufacturer provides charts of suction temperature as a function of suction pressure and outdoor air temperature (OAT) (see Bryant Installation, Start-up and Service Instructions, Single Package Rooftop Gas Heating Electric Cooling Units, 581B DuraPac Plus Series, Sizes 090-150, 7-1/2 to 12-1/2 Tons, ii581b-90-7.pdf).[48] The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[49] Temperature split was 26.4°F or 6.3°F above 20.1°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. **Circuit 1** suction temperature was 54.5°F or 17.5 above 37°F manufacturer target indicating undercharge. Circuit 1 superheat was 20.7°F or 15.7 above 5°F CEC RCA target indicating undercharge, but within to 20 +/- 5°F program tolerance. Circuit 1 subcooling was 13.6°F, evaporator saturation temperature (EST) was 33.8°F and below 46 +/- 6°F program tolerance, and condenser over ambient (COA) was 24.1°F and within 25 +/- 5°F program tolerance. **Circuit 2** suction temperature was 30°F or -4 below 34°F manufacturer target and within tolerance. Circuit 2 superheat was 0.4°F or -4.6 below 5°F CEC RCA target and below 20 +/-

[48] Manufacturer suction temperature tolerance is +/-5°F.

[49] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

5°F program tolerance. Circuit 2 subcooling was 12.6°F, EST was 29.6°F and below 46 +/- 6°F program tolerance, and COA was 23°F and within 25 +/- 5°F program tolerance.

5) WO32 EM&V post-observations were performed on 11-05-13 and 11-06-13 of the Bryant 8.5-ton 581BEV102125ADPA, S/N 0600G30283, PG&E Sticker 004 2202, AC 702. The economizer was retrofitted with new parts including a Honeywell 7220 Jade Control module, Honeywell C7250A1001 mixed air sensor, and Honeywell C7401F2006/U outdoor air sensors. Condenser and evaporator coils appeared to be cleaned, but some were covered with dirt. Air filters were changed three months prior to site visit (dated 8/29/13). Air filters on top rack of unit incorrectly installed and fallen out and 1/3" gap between economizer and sheet metal cabinet causing excessive unintended perimeter leakage. School district paid for technician to straighten condenser coil fins that were previously vandalized. Fan belt tension was too tight and misaligned by 3/16 inch. Economizer dampers were set to 10% open (2.8V). Economizer dampers on tested units were closed due to missing ground ("GND") and thermostat occupancy ("OCC") wire attached. Default setting is "OCC" so economizer damper does not return to minimum closed position when cooling ("OCC/E-GND" input wires). Cold spray caused damper to open and compressors to stop operating indicating economizer would be functional without other issues. The manufacturer provides charts of suction temperature as a function of suction pressure and OAT (see Bryant Installation, Start-up and Service Instructions, Single Package Rooftop Gas Heating Electric Cooling Units, 581B DuraPac Plus Series, Sizes 090-150, 7-1/2 to 12-1/2 Tons, ii581b-90-7.pdf). Temperature split was 24.1°F or 4.2°F above 19.9°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. **Circuit 1** suction temperature was 35.9°F or 7.9 above 28°F manufacturer target indicating undercharge. Circuit 1 superheat was 3.1°F or -1.9 below 5°F CEC RCA target and within tolerances, but below 20 +/- 5°F program tolerance. Circuit 1 EST was 32.8°F and below 46 +/- 6°F program tolerance. **Circuit 2** suction temperature was 29.5°F or 1.5 above 28°F manufacturer target and within tolerance. Circuit 2 superheat was 0.7°F or -4.3 below 5°F CEC RCA target and below 20 +/- 5°F program tolerance. Circuit 2 EST was 28.8°F and below 46 +/- 6°F program tolerance.

B.4.5 Site FF

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) WO32 EM&V post inspections were conducted of work performed in the PG&E program. Detailed EM&V inspections were performed on 11-14-13 on two units.
1) Lennox 40-ton SCA480S2VN1G, S/N 5605C10345, PG&E Sticker 000 6482, AC 2, and

2) Lennox 40-ton SCA480S2VN1G, S/N 5605C07288, PG&E Sticker 000 6484, AC 3. Program data records indicate work was performed in June 2013. Contractor was paid incentives for the following measures: coil cleaning, adjust airflow, refrigerant test, refrigerant service, economizer test, and replace thermostat. WO32 EM&V master technicians did not directly observe technicians performing work at the site.

3) WO32 EM&V post-observation was performed on 11-14-13 of the 40-ton SCA480S2VN1G, sticker 000 6482, RTU 2. Unit thermostat was Honeywell Ultrastat model TB7220U1004 which is an approved thermostat in the utility program. See http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/ProgrammableThermostat_QualifiedProductList.pdf. The Honeywell TB7220 manual provides instructions for economizer operation and 2-stage cooling. See http://www.forwardthinking.honeywell.com/new/63-2635.pdf. Thermostats are located near the ceiling approximately 20 to 25 from the floor and require a lift for access during unoccupied periods. According to site managers, new thermostats were not installed by the program nor were schedules adjusted by program technicians. The 4-circuit unit provides variable volume airflow. The economizer had the following new parts installed: Honeywell C7400A1038 outdoor air enthalpy sensor, Honeywell C770A1006/U mixed air sensor, and Honeywell direct coupled actuator (Lennox part # 56M8101). Cold spray on outdoor air sensor determined that economizer did not work properly. Economizer minimum damper position set at 22.5% on the controller and measured to be 1.125 inches open. Laboratory tests indicate dampers open 1.125 inches introduce 30 to 34% outdoor air. Blower fan was operating 24 hours per day and seven days per week at variable speed. The notched 5VX-850 fan belt properly aligned but improperly tensioned. Fan belt deflection was 0.8 inches with 9 lbs force, but deflection should be 0.42 inches with 9 lbs of force (per manufacturer). Condenser and evaporator were dirty and in need of cleaning. The “power off” alarm was present indicating power to unit was off before the EM&V inspection. The TXV sensing bulbs were not insulated. The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[50] The manufacturer provides charts of target discharge pressure, suction pressure, and approach temperature (liquid minus ambient) based on measurements of outdoor air temperature (OAT), return wetbulb (RWB), and return drybulb (RDB) (Lennox Service Literature, Unit Information, Service Literature SGA/SCA 35, 40, 45, 50 ton, Corp. 0424–L11 Revised 01-2009, 2004 Lennox Industries Inc., 0424e.pdf). The target approach temperature is 7°F +/- 1°F for circuits 1 and 3 and 8°F +/- 1°F for circuits 2 and 4.

[50] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

Temperature split was 25°F or 6.3°F above 18.7°F CEC RCA target and above 20 +/- 2°F program tolerances indicating low airflow.

Circuit 1 approach was 8.7°F or 1.7 above 7°F manufacturer target indicating overcharge, suction pressure was 50.5 psig or -19.7 below 70.2 psig manufacturer target indicating undercharge, discharge pressure was 192 psig or -10 below 202 psig manufacturer target indicating undercharge, superheat was 15°F, and evaporator saturation temperature (EST) was 26.3°F and below 46 +/- 4°F program tolerance. Low EST and inconsistent refrigerant charge diagnostics indicate heat transfer issues or restriction.

Circuit 2 approach was 15.3°F or 7.3 above 8°F manufacturer target indicating overcharge, suction pressure was 57.3 psig or -13.9 below 71.2 psig manufacturer target indicating undercharge, discharge pressure was 219.6 psig or 12.2 above 207.4 psig manufacturer target indicating overcharge, superheat was 14.4°F, and EST was 31.7°F and below 46 +/- 4°F program tolerance. Low EST and inconsistent refrigerant charge diagnostics indicate heat transfer issues, restriction, or non-condensables.

Circuit 3 approach was 14.2°F or 7.2 above 7°F manufacturer target indicating overcharge, suction pressure was 52.9 psig or -15.3 below 68.2 psig manufacturer target indicating undercharge, discharge pressure was 209.6 psig or 13.2 above 196.4 psig manufacturer target indicating overcharge, superheat was 11.5°F, and EST was 28.3°F and below 46 +/- 4°F program tolerance. Low EST and inconsistent refrigerant charge diagnostics indicate heat transfer issues, restriction, or non-condensables.

Circuit 4 approach was 11.9°F or 3.9 above 8°F manufacturer target indicating overcharge, suction pressure was 56.7 psig or -12.5 below 69.2 psig manufacturer target indicating undercharge, discharge pressure was 208.5 psig or 16.2 above 192.3 psig manufacturer target indicating overcharge, superheat was 10.9°F, and EST was 31.3°F and below 46 +/- 4°F program tolerance. Low EST and inconsistent refrigerant charge diagnostics indicate heat transfer issues, restriction, or non-condensables.

4) WO32 EM&V post-observation was performed on 11-14-13 of the 40-ton SCA480S2VN1G, sticker 000 6484, RTU 3. Unit thermostat was Honeywell Ultrastat model TB7220U1004 which is an approved thermostat in the utility program. See http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/ProgrammableThermostat_QualifiedProductList.pdf. The Honeywell TB7220 manual provides instructions for economizer operation and 2-stage cooling. See http://www.forwardthinking.honeywell.com/new/63-2635.pdf. Thermostats are located near the ceiling approximately 20 to 25 from the floor and require a lift for access during unoccupied periods. According to site managers, new thermostats were not installed by the program nor were schedules adjusted by program technicians. The 4-circuit unit provides variable volume airflow. The economizer had the following new parts installed: Honeywell C7400A1038 outdoor air enthalpy sensor, Honeywell C770A1006/U mixed air sensor, and Honeywell direct coupled actuator (Lennox part # 56M8101). Cold spray on outdoor air

sensor determined that the economizer did not work properly. Economizer minimum damper position set at 20% on the controller and measured to be 1 inch open. Laboratory tests indicate dampers open 1 inches introduce 27 to 30% outdoor air. Blower fan was operating 24 hours per day and seven days per week at variable speed. The notched 5VX-850 fan belt was misaligned by 0.875. Fan belt deflection was 1 inch with 9 lbs force, but deflection should be 0.42 inches with 9 lbs of force (per manufacturer). Condenser and evaporator were dirty and required of cleaning. The "power off" alarm was present indicating power to unit was off before the EM&V inspection. The TXV sensing bulbs were not insulated. Two out of six condenser fans failed. Condenser capacitor on fan 3 was disconnected and fan 4 did not operate. Fans 1, 2, 5, and 6 operated. All compressor contactors were discolored with compressor 4 the worst, followed by 2, 3, and 1. Refrigerant charge diagnostic evaluation could not be performed due to failed condenser fans 3 and 4.

B.4.6 Site SV

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) The PG&E program reported sixteen (16) RTUs enrolled. Detailed EM&V observations were performed of two units on 11-22-13.
   1) McQuay 16-ton CUR160ETYC, S/N 5TB8902000, PG&E Sticker 003 9554, MAC 7, and
   2) McQuay 35-ton CUR351ETYC, S/N 5TB8900700, PG&E Sticker 003 9551, MAC 4.
   Program data records indicate work was performed in July 2013. Contractor was paid incentives for the following measures for all units: coil cleaning, refrigerant test, economizer test, and adjust thermostat. In addition to these measures, some units also received incentives for replace economizer damper motor and replace controller sensor. WO32 EM&V master technicians did not directly observe technicians performing work at the site.

3) WO32 EM&V post-observation was performed on 11-22-13 for the 16-ton CUR160ETYC, sticker 003 9554, RTU MAC 7. The economizer was controlled by a thermostatic control that would open the economizer if the outdoor air was below 60°F regardless of a call for cooling leading to the economizer to always be open on cool days (below 60°F). Economizer minimum outdoor air damper position was 7% open or ½ inch open. Return and economizer dampers were very dirty. One condenser fan capacitor had failed, and first contactor was heavily pitted and needed replacement. EM&V observations found that contractor did not adjust thermostat schedule since on-site maintenance personnel control the schedule. On-site management pays for air filter replacement performed every three months. Fan blower wheel was dirty, belt was cracked, tension was loose, and alignment was off by 1/8 inch. TXV was insulated. Outdoor temperature was too cold to perform refrigerant

charge diagnostics. According to the site manager, thermostat schedules were not adjusted by program technicians.

4) WO32 EM&V post-observation was performed on 11-22-13 for the 35-ton CUR351ETYC, sticker 003 9551, RTU MAC 4. The economizer was working properly with outdoor air setpoint of 75°F. Economizer minimum outdoor air damper position was 15% open (1.25 inches or 1.5 fingers). Fan blower contactor was heavily pitted and bottom condenser fan contactor was pitted, both needed replacement. Return and economizer dampers were dirty and needed to be cleaned. PG&E program indicated incentives paid for thermostat adjustment. EM&V observations found that contractor did not adjust thermostat schedule since on-site maintenance personnel control the schedule. On-site management pays for air filter replacement performed every three months. All three blower belts were worn and have different tensions some are too loose. All fan belts are worn and need to be replaced. TXV was insulated. Outdoor temperature was too cold to perform refrigerant charge diagnostics. According to the site manager, thermostat schedules were not adjusted by program technicians.

B.4.7 Site RS

1) Program provides incentives for the following services: 1) coil cleaning, 2) fan maintenance, 3) refrigerant system test, 4) refrigerant system service, 5) economizer test, 6) integrate economizer wiring, 7) replace damper motor, 8) replace controller/sensor, 9) renovate linkage/components, 10) decommission economizer, 11) replace thermostat, and 12) adjust thermostat schedule. Program requires three-year maintenance agreement.

2) WO32 EM&V post inspections were conducted of work performed in the PG&E program. The program reported nineteen (19) RTUs enrolled. Detailed EM&V inspections were performed on 11-20-13 of two units.
1) Trane 20-ton SEHB2004DJ10F22DA4, S/N J87K82818, PG&E Sticker 000 6244, unit 4, and
2) Trane 20-ton SEHB2004DJ10F22DA4, S/N J87H82220, PG&E Sticker 000 6242, unit 2.
Program data records indicate work was performed in October 2012 and February 2013. Contractor was paid incentives for the following measures for all units: coil cleaning, refrigerant test, refrigerant service, and economizer test. In addition to these measures, some units also received incentives for adjust airflow, economizer wiring, replace damper motor, replace controller/sensor, renovate linkage, replace thermostat, adjust thermostat, and decommission economizer. WO32 EM&V master technicians did not directly observe technicians performing work at the site.

3) Observations on 11-20-13 of the 20-ton Trane SEHB2004DJ10F22DA4, S/N J87K82818, PG&E sticker 000 6244, unit 4, found new Honeywell 7220 Jade Control module, Honeywell C7250A1001 mixed air sensor, and Honeywell C7400S1000 outdoor air sensors installed.

Minimum damper position was 2.8V or 10% open, changeover setting was E3S (24 Btu/lb/da), mixed air temperature high 53°F and low 45°F (within range damper opens), and exhaust high 50%. The economizer damper linkage was binding and stuck closed due to age, rust, and friction. During observations, the outdoor conditions were 62°F drybulb, 54.9°F wetbulb, 23.1 Btu/lb/da. Even though this is below the E3S changeover setting, the economizer was unable to open due to the linkage being stuck. The actuator motor attempted to open the linkage during the entire observation, but could not. The condenser coil was corroded and dirty. The evaporator coil was dirty. Both condenser fan contactors were pitted. One thermostat connection in the electrical section was loose due to screw not being tightened and that wire could move freely. The wiring diagram was missing from unit. Belt had signs of wear and tension too loose (alignment could not be checked due to electrical section in way of measurement). RCA check not performed due to low outdoor temperature. According to site manager, a new Honeywell Model TH8320U108 thermostat was installed by the program and this unit is not-compliant with the utility program. The manual for the TH8320U thermostat does not provide instructions for economizer operation. See https://customer.honeywell.com/resources/techlit/TechLitDocuments/68-0000s/68-0280.pdf. The manual does not indicate whether or not the thermostat is CEC Title 24 compliant.

4) Observations on 11-20-13 of the 20-ton Trane SEHB2004DJ10F22DA4, S/N J87H82220, PG&E Sticker, 000 6242, unit 2, found new Honeywell 7220 Jade Control module, Honeywell C7250A1001 mixed air sensor, and Honeywell C7400S1000 outdoor air sensors installed. Minimum damper position was 2.8V or 10% open, changeover setting was E3S (24 Btu/lb/da), mixed air temperature high 53°F and low 45°F (within range damper opens), and exhaust high 50%. Unit 2 had the same problem as unit 4. The economizer damper linkage was binding and stuck closed due to age, rust, and friction. The damper actuator motor did not operate during inspection. The economizer motor was energized during observations, but did not operate. The WO32 master technicians did not have sufficient time available to evaluate the problem. Return damper linkage had missing bolt causing return damper not to move, if damper motor actuated. Outdoor damper linkage was connected. The condenser coil was fairly corroded and dirty, evaporator not as dirty as first unit but could use cleaning. One compressor contactor fairly pitted and the wiring diagram was missing. Belt was in acceptable condition but tension too loose (alignment could not be checked due to electrical section in way of measurement). RCA check not performed due to low outdoor temperature. Ecobee thermostat was installed on unit with following message displayed "There may be a problem with the Furnace. For the past 2 hours the thermostat has been calling for heat, but the room temperature has decreased by 3F." Message indicated furnace was not functional. According to site manager, a new EcoBee Model EMS thermostat was installed by the program and this unit is compliant with the utility program. Manual for the EcoBee provides instructions for economizer operation and 2-stage cooling. The manual does not indicate whether or not the thermostat is CEC Title 24 compliant.

B.5 SDG&E Statewide—Metered Sites

B.5.1 Site EC

1) The SDG&E Statewide Premium Efficiency Cooling Program provided incentives to contractors for the following services: 1) coil cleaning (condenser and evaporator coils), 2) fan maintenance*, 3) refrigerant system test, 4) refrigerant system service, 5) economizer functional test, 6) integrate economizer wiring*, 7) replace damper motor*, 8) replace controllers/sensor, 9) renovate linkage and other components, 10) decommission economizer*, 11) replace thermostat*, 12) adjust thermostat schedule*, 13) minor repairs*, 14) QM completion incentive plus QM incentives (as introduced statewide), 15) maintenance agreement incentive to contractor plus customer incentives.[51]

2) WO32 EM&V pre-observation, technician ride-along, and post-observations were performed of four (4) units from 10-30-12 to 07-26-13. The following units were evaluated:
1) 15-ton Carrier 48HGD016JBD611AG, S/N 1509G10038, sticker SD 153767 (AC-F-1)
2) 15-ton Carrier 48HGD016JBD611AG, S/N 1509G10040, sticker SD 153771 (AC-F-6)
3) 5-ton Carrier 48HJL006-C64SHQ, S/N 1209G50453, sticker SD 153778 (AC-F-13)
4) 10-ton Carrier 48HJD012-C68SHQ, S/N 1409G20814, sticker SD 153768 (AC-F-3)
All units receive monthly maintenance from [site] personnel who replace air filters and wash condensers with water. The participating contractor provides quarterly maintenance including changing filters and washing condensers with water every three months. During EM&V observations of each unit the technician performed the following services: changed air filters, cleaned condensers with water, cleaned evaporator coils with water, chemical, and brush, washed condensate pans, and placed Nu-Calgon Pan Treat tablets in each drain pan. The electrical controls of each unit were also cleaned with a brush. Technician diagnosed refrigerant charge and airflow (RCA) using digital pressure gauge manifold with EPA 608 low-loss fittings, Type-K thermocouple clamps, Type-K thermocouple bead probes, Digital humidity sensors to measure wetbulb air temperatures. The technicians did not purge non-condensables from refrigerant hoses prior to attaching to system on first three units. On last unit AC-F-3 technician purged non-condensables at hose connection to manifold after observing EM&V personnel purging hoses the day before.

3) WO32 EM&V pre-observation was performed on 10-30-12 of the 15-ton TXV Carrier 48HGD016JBD611AG, sticker 153767, RTU AC-F-1. Economizer was not working due to outdoor air sensor not working. Pre-existing note written on unit said 'bad set of thermistors 6/1/11'. The economizer outdoor-air dampers were 10% open (1 finger). Condenser fans

[51] Customer incentives up to $3,836 per eligible unit available for QM service agreement. Incentives paid over 3 years with proof of continuing eligibility and maintenance. https://www.premiumcooling.com/commservices/.

cycled on and off due to bad thermistors. The BX38 notched fan belt was loose and alignment was off by ¼ inch. The manufacturer provides charts of liquid temperature as a function of liquid pressure (see Carrier 48HG014-028 Single-Package Rooftop Heat Pump Units, Installation, Service, and Start-up Instructions, 48hg-2si.pdf).[52] The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[53] Pre-observation temperature split was 23.7°F or 2.7°F above 21°F CEC RCA target and outside 20 +/- 2°F program tolerances. Pre-observation refrigerant charge check found all circuits within manufacturer's liquid line temperature specifications According to the manufacturer, "the TXV (thermostatic expansion valve) is set to maintain between 10 and 15 degrees of superheat at the compressors. The valves are factory set and should not require re-adjustment." Circuit 1 pre-observation superheat was 23.1°F or 15.2 above 7.9°F CEC target at 81.3°F OAT and 59.9°F RWB indicating undercharge. Circuit 2 superheat was 15°F or 7.1 above 7.9°F CEC RCA target indicating undercharge. Circuit 3 superheat was 16.9°F or 9 above 7.9°F CEC RCA target indicating undercharge. Circuit 1 liquid temperature was 81.4°F or 0.1 above 81.3°F manufacturer target. Circuit 2 liquid temperature was 83.7°F or -2.5 below 86.2°F manufacturer target. Circuit 3 liquid temperature was 84.2°F or 1 above 83.2°F manufacturer target. Circuit 1 technician subcooling was 12.2°F and within 1.2 of 11 +/- 4°F program tolerance, evaporator saturation temperature (EST) was 36.7°F and below 46 +/- 6°F program tolerance, condenser over ambient (COA) was 12.3°F and below 25 +/- 5°F program tolerance. Circuit 2 subcooling was 14.6°F or 3.6 above 11°F program target, EST was 40.9°F, and COA was 17°F. Circuit 3 subcooling was 11.2°F and within 0.2 of 11°F program target, EST was 36.7°F, and COA was 14°F.

WO32 EM&V technician observation was performed on 11-15-12 of RTU AC-F-1. Technician did not check the economizer or test the economizer outdoor-air thermistors. Technician greased bearing on motor and outboard side of blower but did not grease inboard blower wheel bearing. Belt alignment was off by 1.4 inch, but was not addressed by technician. Another WO32 EM&V technician observation was performed on 11-27-12. Technician temperature split was 21.8°F or 2.1°F above 19.7°F CEC RCA target and within 20 +/- 2°F program tolerances. Circuit 1 superheat was 12°F or 3.4 above 8.6°F CEC target at 73.5°F OAT and 57.4°F RWB. Circuit 2 superheat was 13.1°F or 4.5 above 8.6°F CEC RCA target. Circuit 3 superheat was 18.7°F or 10.1 above 8.6°F CEC RCA target indicating undercharge. Circuit 1 liquid temperature was 72.7°F or -3.5 below 76.2°F manufacturer target. Circuit 2

[52] Manufacturer liquid temperature tolerance is +/-2°F.

[53] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

liquid temperature was 75.7°F or -3.3 below 79°F manufacturer target. Circuit 3 liquid temperature was 75.8°F or -3.2 below 79°F manufacturer target. Technician used the program subcooling (SC) tolerance of 11°F +/- 4°F. As noted above the manufacturer does not provide target subcooling values. Circuit 1 technician subcooling was 16°F or 5 above 11°F program target, EST was 38.1°F, and COA was 15.2°F. Circuit 2 subcooling was 15.7°F or 4.7 above 11°F program target, EST was 40.2°F, and COA was 17.9°F. Circuit 3 subcooling was 15.6°F or 4.6 above 11°F program target, EST was 38.1°F, and COA was 17.9°F. Technician and did not adjust refrigerant charge on any circuits.

WO32 EM&V post-observation was performed on 11-27-12 of RTU AC-F-1. Post-temperature split measurement was 25.2°F or 6.4 above 18.8°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. The post-observations found all circuits to be within manufacturer liquid line temperature specifications. Circuit 1 liquid temperature was 71.8°F or 0.4 above 71.4°F manufacturer target. Circuit 2 liquid temperature was 73.9°F or -0.7 below 74.6°F manufacturer target. Circuit 3 liquid temperature was 69.8°F or -2.4 below 72.2°F manufacturer target. Circuit 1 superheat was 18.6°F, subcooling was 12.1°F EST was 38.1°F and below 46 +/- 6°F program tolerance, and COA was 12.1°F and below 25 +/- 5°F program tolerance. Circuit 2 superheat was 14.5°F, subcooling was 13.2°F, EST was 41.6°F and COA was 15.3°F and below 25 +/- 5°F program tolerance. Circuit 3 superheat was 23.7°F, subcooling was 14.9°F, EST was 36.7°F and below 46 +/- 6°F program tolerance, and COA was 12.9°F and below 25 +/- 5°F program tolerance. COA values are below tolerances due to low 71.8°F OAT.

4) WO32 EM&V pre-observation was performed on 10-30-12 of the 15-ton Carrier 48HGD016JBD611AG, sticker 153771, RTU AC-F-6. The unit has a TXV expansion device. Economizer was functional and outdoor-air dampers were closed. The BX38 notched fan belt was tensioned too tight, cracked and needing replacement, and alignment was off by ¼ inch. The manufacturer provides charts of liquid temperature as a function of liquid pressure (see Carrier 48HG014-028 Single-Package Rooftop Heat Pump Units, Installation, Service, and Start-up Instructions, 48hg-2si.pdf). Pre-observation temperature split was 24.4°F or 5 above the 19.4°F CEC RCA target indicating low airflow. Circuit 1 pre-observation superheat was 12.6°F or -1.1 below 13.7°F CEC target at 67.7°F OAT and 57.9°F RWB. Circuit 2 superheat was 9.2°F or -4.5 below 13.7°F CEC RCA target. Circuit 3 superheat was 26.6°F or 12.9 above 13.7°F CEC RCA target. Circuit 1 pre-observation liquid temperature was 73.6°F and within 0.2 of 73.4°F manufacturer target. Circuit 2 pre-observation liquid temperature was 81.9°F or 6.1 above 75.8°F manufacturer target. Circuit 3 pre-observation liquid temperature was 73.6°F and within 1.4 of 72.2°F manufacturer target. Circuit 1 subcooling was 12.3°F, EST was 36.7°F and below 46 +/- 6°F program tolerance, and COA was 13.3°F and below 25 +/- 5°F program tolerance. Circuit 2 subcooling was

6.4°F, EST was 38.8°F and COA was 15.7°F and below 25 +/- 5°F program tolerance. Circuit 3 subcooling was 11°F, EST was 35.3°F and below 46 +/- 6°F program tolerance, and COA was 12.1°F and below 25 +/- 5°F program tolerance. COA values are below tolerances due to low 72.6°F OAT.

WO32 EM&V technician observation was performed on 11-27-12 of RTU AC-F-6. The technician greased bearing on motor and inboard and outboard blower wheel bearing. Technician temperature split was 23°F or 4.3°F above 18.7°F CEC RCA target indicating low airflow. Technician used the program SC tolerance of 11°F +/- 4°F. As noted above, the manufacturer does not provide target SC values. Circuit 1 liquid temperature was 66.4°F or -5.0 below 71.4°F manufacturer target. Circuit 2 liquid temperature was 77°F or -4.4 above 72.6°F manufacturer target. Circuit 3 liquid temperature was 70.5°F or -2.9 below 73.4°F manufacturer target. Circuit 1 superheat was 6.9°F, subcooling was 17.5°F, EST was 38.8°F and below 46 +/- 6°F program tolerance, and COA was 16.2°F and below 25 +/- 5°F program tolerance. Circuit 2 superheat was 14.3°F, subcooling was 8.3°F, EST was 38.1°F and COA was 17.4°F and below 25 +/- 5°F program tolerance. Circuit 3 superheat was 11.3°F, subcooling was 15.4°F, EST was 37.4°F and below 46 +/- 6°F program tolerance, and COA was 18.3°F and below 25 +/- 5°F program tolerance. COA values are below tolerances due to low 67.6°F OAT. Technician and did not adjust refrigerant charge on any circuits.

WO32 EM&V post-observation was performed on 11-27-12 of RTU AC-F-6. Post-observation temperature split measurement was 24.1°F or 5.8°F above CEC RCA target indicating low airflow. Circuit 1 post-observation liquid temperature was 72.1°F and within 0.7 of 71.4°F manufacturer target. Circuit 2 post-observation liquid temperature was 81.1°F or 7.3 above 73.8°F manufacturer target indicating undercharge. Circuit 3 post-observation liquid temperature was 75°F or 4.4 above 70.6°F manufacturer target indicating undercharge. Circuit 1 superheat was 11.3°F, subcooling was 11.8°F, EST was 37.4°F and COA was 13.2°F. Circuit 2 superheat was 13.9°F, subcooling was 5.2°F, EST was 40.2°F and COA was 15.6°F. Circuit 3 superheat was 19.2°F, subcooling was 8.1°F, EST was 36.7°F and COA was 12.4°F. COA values are below tolerances due to low 70.7°F OAT.

5) WO32 EM&V pre-observation was performed on 10-19-12 of the 5-ton Carrier 48HJL006-C64SHQ, sticker 153778, RTU AC-F-13. Economizer was not functional due to outdoor air sensor not installed. Economizer outdoor-air dampers were 90% open. Plenum was very dirty and needed cleaning. Pre-observation condensate drain pipe was cut and had gap spilling water onto roof. The A39 standard v-belt tension was too tight and alignment was okay. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and outdoor air temperature (OAT) (see Carrier 48HJ004-007 Single-

Package Rooftop Heating/Cooling Standard and Low NOx Units, 48hj-22si.pdf).[54] Pre-observation temperature split measurement was 19.8°F or 2.3 above 17.5°F CEC RCA target indicating low airflow. Pre-observation suction temperature was 69.8°F or 37.8 above 32°F manufacturer target indicating undercharge. Pre-observation superheat was 31°F or 18.1 above 12.9°F CEC RCA target at 81°F OAT and 63.3°F RWB and above 20 +/- 5°F program tolerance indicating undercharge. EST was 38.8F and below 46 +/- 6°F program tolerance.

WO32 EM&V technician observation was performed on 11-16-12 of RTU AC-F-13. Technician did not check fan belt condition, tension, or alignment. Technician fixed condensate line with new press fit copper collar. Fan belt tension was too tight and not addressed by technician. Technician initial temperature split was 28°F or 6.3 above 21.7°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. Technician initial superheat was 26.4°F or 18.3 above 8.1°F CEC RCA target at 72.2°F OAT and 55.6°F RWB superheat and above 20 +/- 5F program tolerance indicating undercharge. Technician initial suction temperature was 61.7°F or 31.7 above 30°F manufacturer target indicating undercharge. EST was 35.3F and below 46 +/- 6°F program tolerance. Technician added 14 ounces of R22 refrigerant. WO32 EM&V master technicians were unable to obtain final technician measurements.

WO32 EM&V post-observation was performed on 11-27-12 of RTU AC-F-13. Post-observation temperature split was 26.6°F or 4 above 22.6°F CEC RCA target and outside 20 +/-2°F program tolerance indicating low airflow. Post-observation suction temperature was 45.8°F or 19.9 above 25.9°F manufacturer target indicating undercharge. Post-observation superheat was 9.1°F or 4 above 5.1°F CEC RCA target superheat at 76.4°F OAT and 55.4°F RWB and below 20 +/- 5°F program tolerance. Post-observation EST was 36.7°F and below 46 +/- 6°F program tolerance.

6) WO32 EM&V pre-observation was performed on 10-1912 of the 10-ton Carrier 48HJD012-C68SHQ, sticker 153768, RTU AC-F-3. Carrier economizer model CRPWREXH023A01. Economizer was not working due to outdoor air sensor wire and terminal being corroded and not working. Economizer outdoor-air dampers were closed. The A51 standard v-belt tension was too tight, cracking, and should be replaced. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and outdoor air temperature OAT (see Carrier 48HJD/HJE008-014, 48HJF008-012 Single-Package Rooftop Heating/Cooling Units, 48hj-15si.pdf). Pre-observation temperature split was 30.4°F or 12.7 above the 17.7°F CEC RCA target indicating low airflow. Circuit 1 pre-observation suction temperature was 59.2°F or 23.9°F above 35.3°F manufacturer target

[54] Manufacturer suction temperature tolerance is +/-5°F.

indicating undercharge. Circuit 2 pre-observation suction temperature was 61.2°F or 24.1°F above 37.1°F manufacturer target indicating undercharge. Circuit 1 pre-observation superheat was 23.3°F or 5 above 18.3°F CEC RCA target at 77°F OAT and 64.7°F RWB and within 20 +/- 5°F program tolerance. EST was 35.9F and below 46 +/- 6°F program tolerance. Circuit 2 pre-observation superheat was 25.2°F or 6.9 above 18.3°F CEC RCA target and above 20 +/- 5°F program tolerance. EST was 36°F and below 46 +/- 6°F program tolerance.

WO32 EM&V technician observation was performed on 11-27-12 of RTU AC-F-3. Technician cleaned dirty electrical compartment with electric blower. Technician purged non-condensables at hose connection to manifold after observing EM&V personnel purging hoses the day before. Fan belt tension was too tight and not addressed by technician. Technician initial temperature split was 30.6°F or 10.9°F above the 19.7°F CEC RCA target indicating low airflow. Circuit 1 initial suction temperature was 54.3°F or 30.8 above 23.5°F manufacturer target indicating undercharge. Circuit 1 initial superheat was 22°F or 13 above 9°F CEC RCA target at 73.3°F OAT and 57.1°F RWB and within 20 +/- 5°F program tolerance. EST was 32.3°F and below 46 +/- 6°F program tolerance. Circuit 2 suction temperature was 38.2°F or 6.6 above 31.6°F manufacturer target indicating undercharge. Circuit 2 superheat was 3.7°F or -5.3°F below 9.0°F CEC RCA target and below 20 +/- 5°F program tolerance. EST was 34.5°F and below 46 +/- 6°F program tolerance. Technician did not adjust charge. Technician purged non-condensables at hose connection to manifold after observing EM&V personnel purging hoses the day before.

WO32 EM&V post-observation was performed on 11-27-12 of RTU AC-F-3. Post-observation temperature split was 30.1°F or 11.8 above 18.3°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. Circuit 1 post-observation suction temperature was 66.2°F or 34.2 above the 32°F manufacturer target indicating undercharge. Circuit 1 superheat was 36.2°F or 18.2 above 18°F CEC RCA target at 65.7°F OAT and 59.9°F RWB and outside 20 +/- 5°F program tolerance. Circuit 1 EST was 30°F and below 46 +/- 6°F program tolerance. Circuit 2 suction temperature was 62.4°F or 30.4 above 32°F manufacturer target indicating undercharge. Circuit 2 superheat was 31.7°F or 13.7 above 18°F CEC RCA target and outside 20 +/- 5°F program tolerance. Circuit 2 EST was 30.7°F and below 46 +/- 6°F program tolerance. On 11-1-13, the measured airflow was 3626 cfm (362.6 cfm/ton or 90.7% of manufacturer recommended 400 cfm/ton) at 1.01 inches of water column (IWC) total static pressure, fan speed of 865 RPM (5 turns factory setting), and fan power of 1504W. The field-measured total EER* was 10.7 and sensible EER* was EER* 9.7 at 85°F OAT and 57.3°F RWB. The fan speed was adjusted to 5.5 turns or 844 RPM and the measured airflow was 3360 cfm (336 cfm/ton or 84% of manufacturer recommended 400 cfm/ton) at 0.73 IWC total static pressure, and fan power of 1374W. The

field-measured total EER* was 11.5 and sensible EER* was EER* 10 at 85°F OAT and 57.2°F RWB.

B.5.2 Site SD

1) The SDG&E Statewide Premium Efficiency Cooling Program provided incentives to contractors for the following services: 1) coil cleaning (condenser and evaporator coils), 2) fan maintenance*, 3) refrigerant system test, 4) refrigerant system service, 5) economizer functional test, 6) integrate economizer wiring*, 7) replace damper motor*, 8) replace controllers/sensor, 9) renovate linkage and other components, 10) decommission economizer*, 11) replace thermostat*, 12) adjust thermostat schedule*, 13) minor repairs*, 14) QM completion incentive plus QM incentives (as introduced statewide), 15) maintenance agreement incentive to contractor plus customer incentives.[55]

2) WO32 EM&V pre-observation, technician, and post-observations were performed of five (5) units from 10-18-12 to 10-30-13. The following units were evaluated:
   1) 10-ton ICP PGE120H250AA, S/N G080311827, sticker SD 153760, AC #1,
   2) 10-ton Carrier 48HJD012-571, S/N 1105G40625, sticker SD 153759, AC #2,
   3) 10-ton Carrier 48HJD012-571, S/N 5104G11411, sticker SD 153758, AC #3,
   4) 10-ton ICP PGE120H250AA, S/N G074930338, sticker SD 153757, AC #4, and
   5) 7.5-ton ICP PHE090H00AAA, S/N G081220803, sticker SD 153761, AC #8.
   All units receive monthly maintenance from [site] personnel who replace air filters and wash condensers with water. The participating contractor provides quarterly maintenance including changing filters and washing condensers with water every three months. During EM&V observations of each unit the technician performed the following services: changed air filters, cleaned condensers with water, cleaned evaporator coils with water, chemical, and brush, washed condensate pans, and placed Nu-Calgon Pan Treat tablets in each drain pan. The electrical controls of each unit were also cleaned with a brush. Two technicians were observed diagnosing refrigerant charge and airflow (RCA) using digital pressure gauge manifolds with EPA 608 low-loss fittings on one manifold and no low-loss fittings on the other manifold. Both technicians used Type-K thermocouple clamps, and Type-K thermocouple bead probes with wick to measure wetbulb air temperatures. None of the technicians purged non-condensables from refrigerant hoses prior to attaching to system.

3) WO32 EM&V pre-observation was performed on 10-31-12 of the 10-ton ICP PGE120H250AA, sticker 153760, RTU AC #1. Economizer was not functional (model AXB245EMA). Economizer outdoor-air top damper was closed, middle damper was one

[55] Customer incentives up to $3,836 per eligible unit available for QM service agreement. Incentives paid over 3 years with proof of continuing eligibility and maintenance. https://www.premiumcooling.com/commservices/.

finger open (10%), and bottom damper was two fingers open (20%). Average minimum damper position was 10% open (08-17-13). Changeover setpoint was in D position. Compressor 2 had been previously changed but new liquid line drier was not painted at the top and bottom after welding and rust occurring in these areas. Panels were missing several fasteners (10-15). Both compressor contactors showing signs of wear indicating need for replacement. The A47 standard v-belt was cracking and glazed indicating need of replacement. Belt alignment was okay. The manufacturer provides charts of suction temperature as a function of suction pressure and outdoor air temperature (OAT) (Parts List, Tech Labels, Wiring Diagrams PHE072 -- 120 SERIES Package Heat Pump Units, PHE 072-120 51604200200.pdf).[56] The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[57] OAT was 68°F and RWB was 61.5°F. Pre-observation temperature split was 20.3°F or 3.8 above 16.5°F CEC RCA target and within 20 +/- 2°F program tolerance. Circuit 1 pre-observation suction temperature was 59.7°F or 14.3 above 45.4°F manufacturer target indicating undercharge. Circuit 1 superheat was 25.2°F or 5.7 above 19.5°F CEC RCA target and above 20 +/- 5°F program tolerance. Circuit 1 evaporator saturation temperature (EST) was 34.5°F and below 46 +/- 6°F program tolerance. Circuit 2 pre-observation suction temperature was 52.1°F or 6.7 above 45.4°F manufacturer target indicating undercharge. Circuit 2 superheat was 17.6°F or -1.9 below 19.5°F CEC RCA and within 20 +/- 5°F program tolerance. Circuit 2 EST was 34.5°F and below 46 +/- 6°F program tolerance.

WO32 EM&V technician observation was performed on 11-13-12 of RTU #1. Technician replaced the fan belt, but tensioned the belt by hand and did not check alignment. Technician initial temperature split was 30°F or 9.3 above 20.7°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. Initial OAT was 70.9°F and RWB was 51.4°F. Circuit 1 initial suction temperature was 41°F or 17 above 24°F manufacturer target indicating undercharge. Circuit 1 superheat was 10.3°F or 5.6 above 4.7°F CEC RCA target and below 20 +/- 5F program tolerance. Circuit 1 EST was 30.7°F and below 46 +/- 6°F program tolerance. Circuit 2 initial suction temperature was 38.3°F or 10.3 above 28°F manufacturer target indicating undercharge. Circuit 2 superheat was 8.3°F or 3.7 above 4.6°F CEC RCA and below 20 +/- 5°F program tolerance. Circuit 2 EST was 30°F and below 46 +/- 6°F program tolerance. Technician did not make any charge adjustments due to program personnel intervening and telling him not to. The reason was due to the following: 1) superheat tolerance was +/-7°F, 2) airflow might be low due to return register partially

[56] Manufacturer suction temperature tolerance is +/-5°F.

[57] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

closed, and 3) lint in the return duct. During observation the technician noted economizer not working but did not attempt repairs. Technician indicated contractor does not repair economizers. Technician also did not diagnose or repair panels with missing or stripped fasteners. Technician indicated contractor does not require painting over welds so rust may be a problem on filter drier replacements.

WO32 EM&V post-observation was performed on 11-13-12 of RTU #1 after technician completed work. Post-observation temperature split was 27.2°F or 5.2 above 22°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. OAT was 79.5°F and RWB was 53.4°F. Circuit 1 post-observation suction temperature was 46.8°F or 22.8 above 24°F manufacturer target indicating undercharge. Circuit 1 superheat was 13.8°F or 8.8 above 5°F CEC RCA target and below the 20 +/- 5F program tolerance indicating undercharge. Circuit 1 EST was 33°F and below 46 +/- 6°F program tolerance. Circuit 2 suction temperature was 35.6°F or 7.6 above 28°F manufacturer target indicating undercharge. Circuit 2 superheat was 3.3°F or -1.7 below 5°F CEC RCA target and below the 20 +/- 5F program tolerance. Circuit 2 EST was 32.3°F and below 46 +/- 6°F program tolerance.

4) WO32 EM&V pre-observation was performed on 10-18-12 of the 10-ton Carrier 48HJD012-571, sticker 153759, RTU AC #2. Economizer was unplugged and not functional (model 0688-0201-54920). Economizer outdoor-air dampers were 30% open (two inches open), and changeover setpoint was between C and D position (08-17-13). Gas was not connected to RTU. Panels had several stripped and missing fasteners needing new holes and fasteners. Blower contactor showed signs of wear indicating need for replacement. The A54 standard v-belt was misaligned by 1/8 inch, cracking, and too tight indicating need of replacement and tensioning. The manufacturer provides charts of suction temperature as a function of suction pressure and OAT (48HJD/HJE008-014, 48HJF008-012 Single-Package Rooftop Heating/Cooling Units, 48hj-15si.pdf).[58] Pre-observation temperature split was 22.4°F or 6.3 above 16.1°F CEC RCA target indicating low airflow. OAT was 75.8°F and RWB was 65.2°F. Circuit 1 suction temperature was 63.1°F or 24.5 above 38.6°F manufacturer target indicating undercharge at 75.8°F OAT and 65.2°F RWB. Circuit 1 superheat was 26.4°F or 7.5 above 18.9°F CEC RCA target and outside 20 +/- 5°F program target. Circuit 1 EST was 36.7°F and below 46 +/- 6°F program tolerance. Circuit 2 suction temperature was 64.8°F or 11.8 above 53°F manufacturer target indicating undercharge. Circuit 2 superheat was 23.9°F or 5 above 18.9°F CEC RCA target. Circuit 2 EST was 40.9°F and below 46 +/- 6°F program tolerance.

[58] Manufacturer suction temperature tolerance is +/-5°F.

WO32 EM&V technician observation was performed on 11-13-12 and 11-29-12 of RTU #2. Technician noted economizer not working but did not attempt repairs. Technician indicated contractor does not repair economizers. Technician also did not diagnose or repair blower contactor, panels with missing or stripped fasteners, fan belt tension, or belt alignment. Technician wetted wetbulb wick from water in condensate drain line. Technician initial temperature split was 26.2°F or 5.6 above 20.6°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. Initial OAT was 69.2°F and RWB was 51.9°F. Circuit 1 initial suction temperature was 45.3°F or 20.9 above 24.4°F manufacturer target indicating undercharge. Circuit 1 superheat was 13°F or 7.8 above 5.3°F CEC RCA target and below 20 +/- 5F program tolerance. Circuit 1 EST was 32.3°F and below 46 +/- 6°F program tolerance. Circuit 2 initial suction temperature was 42.4°F or 11.8 above 30.6°F manufacturer target indicating undercharge. Circuit 2 superheat was 9.4°F or 4.2 above 5.3°F CEC RCA and below 20 +/- 5°F program tolerance. Circuit 2 EST was 33°F and below 46 +/- 6°F program tolerance. Technician added refrigerant charge to both circuits without a scale approximately 8 ounces to circuit 1 and 24 ounces to circuit 2 (added charge 15 times total on both circuits). Subsequently, technician determined unit was undercharged and added 16 ounces to circuit 1 using a scale. Technician could not get either circuit to pass so he stopped refrigerant services to be continued when his lead technician was on site.

Another WO32 EM&V technician observation was performed on 11-29-12 of RTU #2. WO32 EM&V master technician measured 5°F temperature drop across circuit 1 liquid-line drier indicating restriction and discussed this issue with technician. Technician did not double-check liquid line drier restriction. Technician tested refrigerant charge and found circuit 1 to be overcharged and circuit 2 undercharged. Technician removed charge from circuit 1 and added recovered refrigerant (not new refrigerant) to circuit 2.[59] Technician final temperature split was 20.5°F or 2.8 above 17.7°F CEC RCA target. Final OAT was 66.8°F and RWB was 60.3°F. Circuit 1 final superheat was 17.4°F which is the CEC RCA target and within 20 +/- 5°F program target. Circuit 1 suction temperature was 54.1°F or 10.7 above 43.4°F manufacturer target indicating undercharge. Circuit 1 EST was 36.7°F and below 46 +- 6°F program tolerance. High suction temperature and superheat opposite subcooling and low EST indicate heat transfer issues or restriction for circuit 1. Circuit 2 final superheat was 17.2°F or -0.2 below 17.4°F CEC RCA target and within program target. Circuit 2 suction temperature was 58.1°F and within -1.8 of 59.9°F manufacturer target. Circuit 2 EST was 40.9°F and within 46 +- 6°F program tolerance.

[59] http://www.epa.gov/ozonec./title6/608/608fact.html, 3. Reclamation Requirement: EPA has also established that refrigerant recovered and/or recycled can be returned to the same system or other systems owned by the same person without restriction. If refrigerant changes ownership, it must be reclaimed (i.e., cleaned to the ARI 700-1993 Standard of purity) by an EPA certified refrigerant reclaimer.

WO32 EM&V post-observation was performed on 11-13-12 and 11-29-12, after technician work was completed on RTU #2. Post-observation temperature split was 28.4°F or 7.2 above 21.2°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. at OAT was 73°F and RWB was 54.1°F. Circuit 1 post-observation suction temperature was 47.7°F or 21.4 above 26.3°F manufacturer target indicating undercharge. Circuit 1 superheat was 14.7°F or 9.4 above 5.3°F CEC RCA target and below 20 +/-5°F program tolerance indicating undercharge. Circuit 1 EST was 33°F and below 46 +- 6°F program tolerance. Circuit 2 suction temperature was 41°F or 11.6 above 29.4°F manufacturer target indicating undercharge. Circuit 2 superheat was 8°F or 2.7 above 5.3°F CEC RCA target and below the 20 +/-5°F program tolerance. Circuit 2 EST was 33°F and below 46 +- 6°F program tolerance.

Another WO32 EM&V post-observation was performed on 11-29-12 on RTU #2. Post temperature split was 21.9°F or 4.7 above 17.2°F CEC RCA target indicating low airflow. OAT was 66.3°F and RWB was 60.6°F. Circuit 1 post superheat was 22.5°F and within CEC RCA and program target. Circuit 1 suction temperature was 58.5°F or 17.9 above 40.6°F manufacturer target indicating undercharge. Circuit 1 EST was 36°F and below 46 +- 6°F program tolerance. Circuit 2 superheat was 24.1°F and within CEC RCA and program target. Circuit 2 suction temperature was 61.5°F or 14.2 above 47.3°F manufacturer target indicating undercharge. Circuit 2 EST was 37.4°F and below 46 +- 6°F program tolerance.

5) WO32 EM&V pre-observation was performed on 10-18-12 of the 10-ton Carrier 48HJD012-571, sticker 153758, RTU AC #3. Economizer was unplugged and not functional (model 0688-0201-54920). Economizer outdoor-air dampers were closed and changeover setpoint was between C and D positions (08-17-13). Gas was not connected to the RTU. On 10-18-12, during pre-observations compressor on circuit 2 was not working due to a failed contactor. Panels had several stripped and missing fasteners needing new holes and fasteners and the technician did not replace during observations. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and OAT (48HJD/HJE008-014, 48HJF008-012 Single-Package Rooftop Heating/Cooling Units, 48hj-15si.pdf).[60] Pre-observation temperature split was 8.3°F or -8 below 16.3°F CEC RCA target indicating low capacity due to circuit 2 not working. OAT was 71.6°F and RWB was 63.9°F. Circuit 1 pre-observation suction temperature was 68.5°F or 22.2 above 46.3°F manufacturer target indicating undercharge. Superheat was 30.4F or 10.7 above 19.7F CEC RCA target and

[60] Manufacturer suction temperature tolerance is +/-5°F.

outside 20 +/-5°F program tolerance. EST was 38.1F and below 46 +- 6°F program tolerance.

WO32 EM&V technician observation was performed on 11-14-12 and 11-29-12 of RTU #3. On 11-14-12 the technician noted economizer not working, but did not attempt repairs. Technician indicated contractor does not repair economizers. Technician did not diagnose or repair missing or stripped fasteners, fan belt tension, or belt alignment. Technician installed a new contactor on compressor 2 to enable operation. With both circuits operating, technician temperature split was 27.7°F or 7.2 above 19.3°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. OAT was 73°F and RWB was 61.2°F. Circuit 1 initial suction temperature was 43.7°F or 11.9 above 31.8°F manufacturer target indicating undercharge. Circuit 1 superheat was 9.2°F or 6 below 15.2°F CEC RCA target and below 20 +/- 5F program tolerance indicating overcharge. Circuit 1 EST was 34.5°F and below 46 +- 6°F program tolerance. Circuit 2 initial suction temperature was 47.2°F or -0.9 below 48.1°F manufacturer target. Circuit 2 superheat was 8.4°F or -6.8 below 15.2°F CEC RCA and below 20 +/- 5°F program tolerance indicating overcharge. Circuit 2 EST was 38.8°F and below 46 +- 6°F program tolerance. Technician added 16 ounces of reclaimed refrigerant to circuit 1 and removed 14 ounces from circuit 2.

WO32 EM&V performed another technician observation of final refrigerant test on 11-29-12 of RTU #3. Technician final temperature split was 20.6°F or 4.1 above 16.5°F CEC RCA target and within program tolerance. OAT was 69.8°F and RWB was 61.8°F. Circuit 1 final superheat was 19.8°F or 1.4 above 18.4°F CEC RCA target. Circuit 1 technician final suction temperature was 59.3°F or 5.9 above 53.4°F manufacturer target. Circuit 1 final EST was 39.5°F and below 46 +- 6°F program tolerance. Circuit 2 technician final superheat was 20.4°F or 1.4 above 19°F CEC RCA target. Circuit 2 technician final suction temperature was 62°F or -0.9 below 62.9°F manufacturer target. Circuit 2 final EST was 41.6°F and below 46 +- 6°F program tolerance.

WO32 EM&V post-observation was performed on 11-29-12 of RTU #3. Post-observation temperature split was 21.5°F or 5 above 16.5°F CEC RCA target and within 20 +/- 2°F program tolerance. OAT was 65.1°F and RWB was 61.5°F. Circuit 1 superheat was 21.3°F or 0.1 above 21.2°F CEC RCA target. Circuit 1 suction temperature was 59.4°F or 8.7 above 50.7°F manufacturer target indicating undercharge. Circuit 1 final EST was 38.1°F and below 46 +- 6°F program tolerance. Circuit 2 superheat was 25.7°F or 4.5 above 21.2°F CEC RCA target. Circuit 2 suction temperature was 64.5°F or 10.6 above 53.9°F manufacturer target indicating undercharge. Circuit 2 EST was 38.8°F and below 46 +- 6°F program tolerance.

6) WO32 EM&V pre-observation was performed on 10-31-12 of the 10-ton ICP PGE120H250AA, sticker 153757, RTU AC #4. Economizer was not functional and blades were binding indicating need for service (model AXB245EPA). Economizer outdoor-air dampers were closed and changeover setpoint was in D position (08-17-13). During pre-observation contactor for compressor 2 was found to be in need of replacement. Blower door insulation was coming off and needed repair or replacement. Panels have several stripped and missing fasteners needing new holes and fasteners. The A47 standard v-belt was too tight and cracking, but alignment was acceptable. The manufacturer provides charts of suction temperature as a function of suction pressure and OAT (Parts List, Tech Labels, Wiring Diagrams PHE072 -- 120 SERIES Package Heat Pump Units, PHE 072-120 51604200200.pdf). Pre-observation temperature split was 22.5°F or 4.8 above 17.7°F above CEC RCA target indicating low airflow. OAT was 68.3°F and RWB was 60.4°F. Circuit 1 suction temperature was 47.8°F or 3.1 above 44.7°F manufacturer target. Circuit 1 superheat was 13.3°F or -3.5 below 16.8°F CEC RCA target at 68.3°F OAT and 60.4°F RWB and below 20 +/- 5°F program target. Circuit 1 EST was 34.5°F and below 46 +- 6°F program tolerance. Circuit 2 suction temperature was 46.4°F or 4 within 42.4°F manufacturer target. Circuit 2 superheat was 12.6°F or -4.2 below 16.8°F CEC RCA target and below 20 +/- 5°F program tolerance. Circuit 2 EST was 33.8°F and below 46 +- 6°F program tolerance.

   WO32 EM&V technician observation was performed on 11-14-12 of RTU #4. Technician noted economizer not working but did not attempt repairs. Technician also did not diagnose or repair failing compressor 2, missing blower door insulation, missing or stripped fasteners, or fan belt tension. No RCA was performed on this day.

   WO32 EM&V additional technician observation was performed on 11-29-12 of RTU #4. Technician evaluated refrigerant charge and removed roughly 13 ounces from circuit 1 and 12.8 ounces of refrigerant from circuit 2. WO32 EM&V master technicians were unable to obtain initial technician measurements. Technician final temperature split was 22.7°F or 5 above 17.7°F target indicating low airflow. OAT was 66.7°F and RWB was 59.9°F. Circuit 1 final superheat was 9.7°F or -7.7 below 17.4°F CEC RCA target indicating overcharge. Circuit 1 final suction temperature was 44.2°F or within -4.4 of 48.6°F manufacturer target. Circuit 1 final EST was 34.5°F and below 46 +- 6°F program tolerance. Circuit 2 final superheat was 15.9°F or -0.7 below 16.6°F CEC RCA target. Circuit 2 final suction temperature was 53.3°F or within -5.2 below 58.5°F manufacturer target. Circuit 2 final EST was 37.4°F and below 46 +- 6°F program tolerance.

   WO32 EM&V post-observation was performed on 11-29-12 after technician completed work on RTU #4. Post-observation temperature split was 24.8°F or 7.1 above 17.7°F target indicating low airflow. OAT was 64°F and RWB was 59.8°F. Circuit 1 superheat was 23.8°F or within 4.8 of 19°F CEC RCA target. Circuit 1 suction temperature was 58.3°F or within 3.1

of 55.2°F manufacturer target. Circuit 1 EST was 34.5°F and below 46 +- 6°F program tolerance. Circuit 2 superheat was 12.9°F or -6.1 below 19°F CEC RCA target indicating overcharge. Circuit 2 suction temperature was 45.9°F or within -1.3 below 47.2°F manufacturer target. Circuit 2 EST was 33°F and below 46 +- 6°F program tolerance.

7) WO32 EM&V pre-observation was performed on 10-18-12 of the 7.5-ton ICP PHE090H00AAA, sticker 153761, RTU AC #8. Economizer was unplugged and not functional and was incorrect type for vertical ductwork while unit has horizontal ductwork (model AXB245EPA). Economizer outdoor-air dampers were closed and changeover setpoint was between C and D positions (08-17-13). Compressor 1 contactor was pitted. Blower wheel fins were rusted. The A53 standard v-belt was cracking and alignment was off by 1/8 inch. Panels have several stripped and missing fasteners needing new holes and fasteners. The manufacturer provides charts of suction temperature as a function of suction pressure and OAT (Parts List, Tech Labels, Wiring Diagrams PHE072 -- 120 SERIES Package Heat Pump Units, PHE 072-120 51604200200.pdf).[61] Pre-observation temperature split was 20.9°F or 3.3 above 17.6°F CEC RCA target indicating low airflow. OAT was 75.3°F and RWB was 62°F. Circuit 1 pre-observation suction temperature was 44.6°F or -1 below 45.6°F manufacturer target. Circuit 1 superheat was 7.9°F or -7.4 below 15.3°F CEC RCA target and below 20 +/- 5°F program target. Circuit 1 EST was 36.7°F and below 46 +- 6°F program tolerance. Circuit 2 suction temperature was 37.4°F or 1.4 within 36°F manufacturer target. Circuit 2 superheat was 4.4°F or -10.9 below 15.3°F CEC RCA target and below 20 +/- 5°F program tolerance. Circuit 2 EST was 33°F and below 46 +- 6°F program tolerance.

   WO32 EM&V technician observation was performed on 12-03-12 of RTU #8. During observation the technician noted economizer not working but did not attempt repairs or notice that vertical economizer was installed on unit with horizontal ducts. Technician also did not diagnose or repair failing contactor on compressor 1, rusted blower wheel fins, missing or stripped fasteners, or cracked and failing fan belt. Technician initial temperature split was 21.4°F and 6 above 15.4°F target indicating low airflow. Circuit 1 technician initial suction temperature was 39.3°F or 3.9 above 35.4°F manufacturer target. Circuit 1 superheat was 6.2°F or -13.1 below 19.3°F CEC RCA target at 66°F OAT and 60.6°F RWB and below 20 +/- 5F program tolerance indicating overcharge. Circuit 1 EST was 33.1°F and below 46 +- 6°F program tolerance. Circuit 2 technician initial suction temperature was 43.1°F or -24.7 below 67.8°F manufacturer target indicating overcharge. Circuit 2 superheat was 3.2°F or -16.1 below 19.3°F CEC RCA and below 20 +/- 5°F program tolerance indicating overcharge. Circuit 2 EST was 39.9°F and below 46 +- 6°F program tolerance. Technician removed 13

[61] Manufacturer suction temperature tolerance is +/-5°F.

ounces from circuit 1 and 23 ounces from circuit 2. Afterwards technician stated both circuits were within program specifications and stopped refrigerant test. Technician final temperature split was 19.5°F and 3.4°F above 16.1°F CEC RCA target indicating low airflow. Circuit 1 final superheat was 14.4°F or -4.1 below 18.5°F CEC RCA target at 65°F OAT and 60.4°F RWB and below 20 +/- 5°F program tolerance. Circuit 1 final suction temperature was 47.7°F or 10.8 above 36.9°F manufacturer target indicating undercharge. Circuit 1 final EST was 33.3°F and below 46 +/-6°F program tolerance. Circuit 2 final superheat was 16.7°F or -1.8 below 18.5°F CEC RCA target. Circuit 2 final suction temperature was 56.6°F or -12.1 below 68.7°F manufacturer target indicating overcharge. Circuit 2 final EST was 39.9°F and within program tolerance.

WO32 EM&V post-observation was performed on 12-03-12 after technician work was completed on RTU #8. Post-observation temperature split was 20.9°F or 5°F above 15.9F CEC RCA target at 68.2F OAT and 62.8F RWB and within 20 +/-2°F program tolerance. Circuit 1 post-observation suction temperature was 45.7°F or 11.6 above 34.1°F manufacturer target indicating undercharge. Circuit 1 superheat was 12.7°F or -8.1 below 20.8°F CEC RCA target indicating overcharge and below the 20 +/-5°F program tolerance. Circuit 1 EST was 33°F and below 46 +/- 6°F program tolerance. Circuit 2 suction temperature was 34.5°F or 7 above 27.5°F manufacturer target indicating undercharge. Circuit 2 superheat was 3°F or -17.8 below 20.8°F CEC RCA target and below the 20 +/-5°F program tolerance indicating overcharge. Circuit 2 EST was 31.5°F and below 46 +/- 6°F program tolerance. Suction temperature is opposite superheat for both circuits indicating possible heat transfer issues. Outdoor air temperature was 68.2°F, return drybulb was 70°F, return wetbulb was 62.8°F, and return relative humidity was 68%. These conditions caused high target superheat of 20.8°F which was higher than actual superheat 12.7°F for circuit 1 and 3°F for circuit 2.

WO32 EM&V post-observation was performed again on 10-30-13 of RTU #8. Fan belt had been replaced on 6-28-13 with a new A57 standard belt with proper tension (alignment wasn't checked). Measured airflow was 2392 cfm (319 cfm/ton at 933 rpm and 1 turn) which was 20% lower than manufacturer recommended airflow. As noted above, the vertical unit had a horizontal economizer installed which reduced airflow. Low airflow impacts refrigerant charge diagnostics.

B.5.3 Site TE

1) The SDG&E Statewide Premium Efficiency Cooling Program provided incentives to contractors for the following services: 1) coil cleaning (condenser and evaporator coils), 2) fan maintenance*, 3) refrigerant system test, 4) refrigerant system service, 5) economizer functional test, 6) integrate economizer wiring*, 7) replace damper motor*, 8) replace controllers/sensor, 9) renovate linkage and other components, 10) decommission economizer*, 11) replace thermostat*, 12) adjust thermostat schedule*, 13) minor repairs*,

14) QM completion incentive plus QM incentives (as introduced statewide), 15) maintenance agreement incentive to contractor plus customer incentives.[62]

2) WO32 EM&V pre-observation, technician, and post-observations were performed of four (4) units from 10-17-12 to 08-17-13. The following units were evaluated:
1) 10-ton Carrier 48HJD012-651, S/N 4699G30655, sticker SD 153416 (AC-2)
2) 12.5-ton Carrier 48HJD014-651, S/N 1700G30401, sticker SD 153421 (AC-12)
3) 7.5-ton Carrier 48HJD008-631, S/N 1600G30214, sticker SD 153410 (AC-8), and
4) 12.5-ton Carrier 48HJD014-641, S/N 0300G30682, sticker SD 153419 (AC-13).
All units receive monthly maintenance from [site] personnel who replace air filters and wash condensers with water. The participating contractor provides quarterly maintenance including changing filters and washing condensers with water every three months. During EM&V observations of each unit the technician performed the following services: changed air filters, cleaned condensers with water, cleaned evaporator coils with water, chemical, and brush, washed condensate pans, and placed Nu-Calgon Pan Treat tablets in each drain pan. The electrical controls of each unit were also cleaned with a brush. Technician diagnosed refrigerant charge and airflow (RCA) using digital pressure gauge manifold with EPA 608 low-loss fittings, Type-K thermocouple clamps, Type-K thermocouple bead probes, Digital humidity sensors to measure wetbulb air temperatures. The technicians did not purge non-condensables from refrigerant hoses prior to attaching to system.

This site has architectural screens that cover each packaged unit from being viewed by neighbors above the building. The screens cause condenser outlet air back to recirculate back to the inlet causing high condenser over ambient (COA) temperatures.

3) WO32 EM&V pre-observation was performed on 10-17-12 of the 10-ton Carrier 48HJD012-651, sticker 153416, RTU AC-2. Micrometl model 4682-0301-54930 economizer was unplugged and not working. Economizer outdoor damper was closed with outdoor air setpoint at B position. The A53 standard v-belt was worn, too tight, and alignment was off by 1/3 inch. Compressor 1 had high acid content in the R22 refrigerant.[63] Pre-observation temperature split was 25.9°F or 3.3°F above the 22.6°F CEC RCA target and outside the 20 +/- 2°F program tolerance indicating low airflow. The manufacturer provides charts of suction temperature as a function of suction pressure and outdoor air temperature (OAT) (48HJD/HJE008-014, 48HJF008-012 Single-Package Rooftop Heating/Cooling Units,

[62] Customer incentives up to $3,836 per eligible unit available for QM service agreement. Incentives paid over 3 years with proof of continuing eligibility and maintenance. https://www.premiumcooling.com/commservices/.

[63] https://totaline.com/dl/SECTION%20J%20-%20TOOLS%20AND%20INSTRUMENTS.pdf.

48hj-15si.pdf).[64] The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[65] Circuit 1 pre-observation suction temperature was 59.2°F or 16.1 above 43.1°F manufacturer target indicating undercharge. Circuit 1 superheat was 16.3°F or 11.3°F above 5°F CEC RCA target indicating undercharge at 98.7°F OAT and 61.2°F RWB. Subcooling was 20.5°F and above 11 +/- 4°F program tolerance, evaporator saturation temperature (EST) was 42.9°F and within program tolerance, and condenser over ambient (COA) temperature was 28.7°F and within the 25 +- 5°F program tolerance. High COA (based on 98.7°F OAT) and suction/superheat opposite of subcooling indicates heat transfer issues or non-condensables. Circuit 2 pre-observation suction temperature was 57.6°F or 9 above 48.6°F manufacturer target indicating undercharge. Circuit 2 superheat was 13.3°F or 8.3°F above 5°F CEC RCA target indicating undercharge. Subcooling was 20.5°F and above tolerance, EST was 44.3°F and COA was 29.8°F. High COA (based on 98.7°F OAT) and suction/superheat opposite subcooling indicate heat transfer issues.

WO32 EM&V technician observation was performed on 11-12-12 of RTU AC-2. The technician noted economizer not working and did not attempt repairs. Cabinet panels were missing several fasteners (10-15) and blower wheel needed cleaning. Technician added 5-10 fasteners but did not clean blower wheel during observation. Technician attached refrigerant hoses with low-loss fittings without purging hoses of non-condensables. The technician did not test the unit for acid but the hoses were filled with acidic refrigerant and non-condensables. When the technician subsequently attached the same hoses to other units they became contaminated. Fan belt misalignment was not corrected by the technician. Technician temperature split was 33°F or 12.1°F above the 20.9°F CEC RCA target and above 20 +/- 2°F program target indicating low airflow. Circuit 1 technician superheat (SH) was 27.6°F or 23.3 above 4.3°F CEC RCA target at 72.7°F OAT and 50°F RWB and outside 20 +/- 5°F program target indicating undercharge. Circuit 1 suction temperature was 58.3°F or 40.1 above 18.2°F manufacturer target indicating undercharge. Circuit 1 subcooling was 20°F, EST was 30.7°F and COA was 30.7°F. High COA and suction/superheat opposite of subcooling indicates heat transfer issues or non-condensables. Circuit 2 technician superheat was 7.8°F or 4.3 above 3.5°F CEC RCA target and outside 20 +/- 5°F program target. Circuit 2 suction temperature was 40.1°F or 16.4 above 23.7°F manufacturer target indicating undercharge. Circuit 2 subcooling was 21.1°F, EST was 32.3°F and COA was

[64] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and suction temperature tolerance is +/-5°F.

[65] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

27.3°F. High COA and suction/superheat opposite of subcooling indicates heat transfer issues or non-condensables. Return air temperatures were too low for program so technician stopped test. Technician left unit with stage Y1-Y2 jumper wires installed which would have caused performance issues (both compressors would have operated together). EM&V team informed technician of the issues and technician removed the Y1-Y2 jumper wire. Return ductwork was very dirty and technician prepared a bid for 'high cleaning' of ductwork at this location. Technician indicated a quote would be provided to customer to perform duct cleaning. If approved the contractor planned to let the EM&V team know in order to observe services being performed.

WO32 EM&V post observation was performed of RTU AC-2 on 08-17-13. Cold spray on economizer outdoor air sensor indicated economizer was not functional.

4) WO32 EM&V pre-observation was performed on 10-17-12 of the 12.5-ton Carrier 48HJD014-651, sticker 153421, RTU AC-12. The blower fan wired to operate continuously and economizer was not functional. Micrometl model 4682-0301-54930 economizer outdoor damper was 5% open (½" open) and changeover setpoint at B position. Panels were missing several fasteners (10-15) and holes were stripped. Evaporator coil fins were bent, and evaporator and condenser coils were dirty. The BX48 notched fan-belt was in good condition with proper tension but alignment was off by 1/8 inch. The WO32 EM&V team conducted a follow-up observation on 10-31-13 to measure airflow. Airflow was 379 cfm/ton or 5% less than manufacturer recommended airflow of 400 cfm/ton (4741 cfm at 1060 rpm and 2.5 turns). The manufacturer provides charts of suction temperature as a function of suction pressure and OAT (48HJD/HJE008-014, 48HJF008-012 Single-Package Rooftop Heating/Cooling Units, 48hj-15si.pdf).[66] Pre-observation temperature split was 26.1°F or 3.3 above the 22.8°F CEC RCA target and outside the 20 +/- 2°F program target. Circuit 1 pre-observation suction temperature was 84.7 or 52.7 above 32F manufacturer target indicating undercharge. Circuit 1 superheat was 46.6°F or 41.6°F above 5°F CEC RCA target indicating undercharge at 103.8°F OAT and 64.2°F RWB. Subcooling was -1°F, EST was 38.1°F, and COA was 21.2°F. High suction/superheat and low subcooling indicate heat transfer issues or undercharge. Circuit 2 pre-observation suction temperature was 72.1°F or 22.1 above 50°F manufacturer target indicating undercharge. Circuit 2 superheat was 26.5°F or 21.5°F above 5°F CEC RCA target indicating undercharge. Subcooling was 11.6°F, EST was 45.6°F, and COA was 28°F. High COA and suction/superheat opposite subcooling indicate heat transfer issues or undercharge.

[66] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and suction temperature tolerance is +/-5°F.

WO32 EM&V technician observation was performed on 11-12-12 and 11-28-12 of RTU AC-12. The technician determined that the economizer was not working, but did not attempt or suggest doing any repairs. Technician removed jumper wire on fan to stop continuous operation, but did not address fastener issues. Technician tightened belt and used clean bottle water for wet wick during observation. Technician checked refrigerant charge and airflow on 11-12-12. Technician initial temperature split was 19.5°F or 0.1 above the 19.4°F CEC RCA target. Circuit 1 technician initial superheat was 44.5°F or 28.8 above 15.7°F CEC RCA target at 69.5°F OAT and 60.2°F RWB and above 20 +/- 5°F program target indicating undercharge. Circuit 1 suction temperature was 73.7°F of 43.2 above 30.5°F manufacturer target indicating undercharge. Circuit 2 superheat was 22.2°F or 6.5 above 15.7°F CEC RCA target and within program tolerance. Circuit 2 suction temperature was 62.4°F of 11.6 above 50.8°F manufacturer target indicating undercharge. Technician added 33 ounces to circuit 1 and 8 ounces to circuit 2. Insufficient time was available to perform final measurements. WO32 EM&V technician observation was performed again on 11-28-12 for technician to finish RCA. Technician final temperature split was 18.9°F or 0.7 above the 18.2°F CEC RCA target and within 20 +/- 2°F program tolerance. Circuit 1 technician final superheat was 14.2°F or -3.4 below 17.6°F CEC RCA target and below 20 +/- 5°F program target. Circuit 1 suction temperature was 53.7°F or 0.5 above 53.2°F manufacturer target. Circuit 1 subcooling was 17.8°F, EST was 39.5°F and COA was 33.8°F. Circuit 2 superheat was 18.1°F or 0.5 above 17.6°F CEC RCA target and within program target. Circuit 2 suction temperature was 59.1°F or 6.1 above 53°F manufacturer target indicating undercharge. Circuit 2 subcooling was 24.2°F and above 11 +/- 4°F program tolerance, EST was 40.5°F and COA was 33.8°F. High COA and suction/superheat opposite subcooling indicate heat transfer issues or non-condensables.

WO32 EM&V post-observations were performed on 11-28-12 of RTU AC-12. Post temperature split was 17°F or 2.6 above the 14.4°F CEC RCA target and within 20 +/- 2°F program tolerance. Circuit 1 post-observation suction temperature was 67.8°F or 11 above the 56.8°F manufacturer target indicating undercharge. Circuit 1 superheat was 26.2 or 3.9 above 23.3°F CEC RCA target. Subcooling was 11.7°F, EST was 41.6°F and COA was 21.7°F. Circuit 2 post-observation suction temperature was 63.6°F or 26.6 above the 37°F manufacturer target indicating undercharge. Circuit 2 superheat was 28.3°F or 6.7 above 22.3°F CEC RCA target indicating undercharge. Subcooling was 13.4°F, EST was 35.3°F and COA was 27.6°F. Post observation was performed on 08-17-13 to evaluate economizer. Cold spray on economizer outdoor air sensor indicated economizer was not functional.

5) WO32 EM&V pre-observation was performed on 10-31-12 of the 7.5-ton Carrier 48HJD008-631, sticker 153410, RTU AC-8. A jumper was installed on the blower motor to run continuously. Compressor 1 and 2 also had jumper wires installed so both stages operated

simultaneously with a call for cooling. Micrometl 4682-0201-54930 economizer minimum outdoor air damper position was open 10% open (¾ inch) with changeover setpoint at B position. Economizer is adjacent to sheet metal wall with little clearance for air movement. Gas to unit turned off. Compressor 2 contactor was failing and in need of replacement, but not addressed during observation. The A48 standard v-belt was properly tensioned and aligned. Panels were missing several fasteners (10-15) and another 10-15 were stripped, but technician did not repair during observation. Pre-observation indicated compressor 2 had medium acid, but was not checked by technician during observation. As with first unit checked, technician contaminated other units by hooking up hoses with contaminated acidic refrigerant onto other units during observation. Liquid line drier on first stage had previously been replaced. The manufacturer provides charts of suction temperature as a function of suction pressure and OAT (48HJD/HJE008-014, 48HJF008-012 Single-Package Rooftop Heating/Cooling Units, 48hj-15si.pdf).[67] Pre-observation temperature split was 23.5°F or 3.6 above 19.9°F CEC RCA tolerances and outside 20 +/- 2°F program tolerance. Circuit 1 pre-observation suction temperature was 47.1°F or 7.1 above 40°F manufacturer target indicating undercharge. Circuit 1 superheat was 8.3°F or 0.1°F above 8.2°F CEC RCA at 82.9°F OAT and 61.1°F RWB. EST was 38.8°F and below 46 +/- 6°F program tolerance. Circuit 2 pre-observation suction temperature was 65.5°F or 19.9 above 45.6F manufacturer target indicating undercharge. Circuit 2 superheat was 23.9°F or 15.7°F above 8.2°F CEC RCA at 82.9°F OAT and 61.1°F RWB. EST was 41.6°F and within 46 +/- 6°F program tolerance.

WO32 EM&V technician observation was performed on 11-15-12 and 11-28-12 of AC-8. Technician initial temperature split was 20.1°F or 0.6 above the 19.5°F CEC RCA target and within 20 +/- 2°F program tolerances. Circuit 1 initial suction temperature was 45.8°F or 5.2 above 40.6°F manufacturer target indicating undercharge. Circuit 1 initial superheat was 9.8°F or 1.7 above 8.1°F CEC RCA target at 71°F OAT and 55.5°F RWB and outside 20 +/- 5°F program tolerance. Circuit 1 EST was 36°F and below 46 +/- 6°F program tolerance. Circuit 2 initial suction temperature was 62.4°F or 20.6°F above 41.8°F manufacturer target indicating undercharge. Circuit 2 superheat was 22.9°F or 14.8 above 8.1°F CEC RCA target and within program tolerance. Circuit 2 EST was 39.5°F and within 46 +/- 6°F program tolerance. Technician added 11 ounces of refrigerant to circuit 2, but did not add or remove refrigerant from circuit 1. Technician noted economizer not working but did not attempt repairs. Technician also did not diagnose or repair failed compressor 2 contactors, panels with missing or stripped fasteners, or acid in circuit 2. Technician final temperature split was 20.1°F or 1 above the 19.1°F CEC RCA target and within 20 +/- 2°F program tolerances.

[67] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and suction temperature tolerance is +/-5°F.

Circuit 2 final superheat was 8.1°F or -3.8 below 11.9°F CEC RCA target at 68°F OAT and 56.5°F RWB and within the program tolerance. Circuit 2 final suction temperature was 49.8°F or -3.1°F below 52.9°F manufacturer target and within tolerance. Circuit 2 final EST was 41.6°F and within tolerance.

WO32 EM&V post-observation was performed on 11-28-12 of AC-8. Post temperature split was 25.7°F or 5.8 above 19.9°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. Circuit 1 suction temperature was 43.7°F or -3.7 below 47.4°F manufacturer target. Circuit 1 superheat was 9.2°F or -3.4 below 12.6°F CEC RCA target at 63.1°F OAT and 54.5°F RWB and below 20 +/- 5°F program tolerance. Circuit 1 EST was 34.5F and below 46 +/- 6°F program tolerance. Circuit 2 suction temperature was 65.5°F or 15.5 above 50°F manufacturer target indicating undercharge. Circuit 2 superheat was 30.2°F or 17.6 above 12.6°F CEC RCA target and above 20 +/- 5°F program tolerance indicating undercharge. Circuit 2 EST was 35.3°F and below 46 +/- 6°F program tolerance. Post observation was performed on 08-17-13 to evaluate economizer. Cold spray on economizer outdoor air sensor indicated economizer was not functional.

6) WO32 EM&V pre-observation was performed on 10-17-12 of the 12.5-ton Carrier 48HJD014-641, sticker 153419, RTU AC-13. Micrometl model 4682-0301-54930 economizer was not functional due to stuck and rusted linkage. Economizer outdoor damper was 5% open (½" open) and changeover setpoint was at D position. Gas to unit was shut off. Condensate line was not properly sealed and leaking onto roof. Cabinet panels were missing several fasteners (10-15) and 20-30 were stripped. The BX48 notched v-belt was properly tensioned but misaligned by ¼ inch. The manufacturer provides charts of suction temperature as a function of suction pressure and OAT (48HJD/HJE008-014, 48HJF008-012 Single-Package Rooftop Heating/Cooling Units, 48hj-15si.pdf).[68] Pre-observation temperature split was 24.1°F or within -0.1 of 24.2°F CEC RCA target but outside 20 +/- 2°F program tolerance. Circuit 1 pre-observation suction temperature was 59.9°F or 4.9 above 55°F manufacturer target. Circuit 1 superheat was 11.8°F or 6.8 above 5°F CEC RCA target at 100°F OAT and 61.8°F RWB and below program tolerance. Circuit 1 subcooling was 5.3°F and below 11 +/- 4F program tolerance, EST was 48.1°F and within 46 +/- 6°F program tolerance, and COA was 33.1°F and outside 25 +/- 5°F program tolerance. High COA, high superheat, and low subcooling indicate possible heat transfer issues or non-condensables for circuit 1. Circuit 2 pre-observation suction temperature was 79.2°F or 23.1 above 56.1°F manufacturer target indicating undercharge. Circuit 2 superheat was 31.7°F or 26.7 above 5°F CEC RCA target and above 20 +/- 5°F program tolerance indicating undercharge. Circuit

[68] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and suction temperature tolerance is +/-5°F.

2 subcooling was 6.8°F, EST was 47.5°F, and COA was 32.6°F. High COA, suction temperature, and superheat, and low subcooling indicate possible heat transfer issues or non-condensables for circuit 2.

WO32 EM&V technician observation was performed on 11-15-12 of AC-13. The technician did not check refrigerant charge due to return ductwork and plenum being dirty, but wrote up a bid for 'high cleaning' of ductwork. Technician noted economizer not working but did not attempt repairs. Technician did not diagnose or repair condensate line leak, belt alignment, or panels with missing or stripped fasteners. Technician indicated he would call EM&V staff to observe high cleaning when scheduled and perform refrigerant charge testing. No call was received.

WO32 EM&V post observation was performed of RTU AC-13 on 08-17-13. Cold spray on economizer outdoor air sensor indicated economizer was not functional.

B.5.4 Site SE

1) The SDG&E Statewide Premium Efficiency Cooling Program provided incentives to contractors for the following services: 1) coil cleaning (condenser and evaporator coils), 2) fan maintenance*, 3) refrigerant system test, 4) refrigerant system service, 5) economizer functional test, 6) integrate economizer wiring*, 7) replace damper motor*, 8) replace controllers/sensor, 9) renovate linkage and other components, 10) decommission economizer*, 11) replace thermostat*, 12) adjust thermostat schedule*, 13) minor repairs*, 14) QM completion incentive plus QM incentives (as introduced statewide), 15) maintenance agreement incentive to contractor plus customer incentives.[69]

2) WO32 EM&V pre-observation, technician, and post-observations were performed on two (2) units on 8-15-13:
1) Trane R410A Model 4YCC3048A3075AB, S/N 09503HOH9H, Sticker SD143181, RTU 1, and
2) Trane R22 Model YCC048F3M0BD, S/N M422M3Y1H, Sticker SD153787, RTU 2.
An additional post observation was conducted on 10-31-13. The participating contractor provides maintenance services according to the program including changing filters and washing condensers with water every three months. During EM&V observations of each unit the technician performed the following services: changed air filters, cleaning condenser and evaporator coils with water pre-rinse, chemical cleaners, and final rinse from inside out per manufacturer, pulled blower out and cleaned it (when needed), sanded refrigerant suction and liquid lines prior to attaching clamp-on thermocouples, and purged hoses of non-condensables prior to attaching to system. Technician diagnosed refrigerant charge and airflow (RCA) using digital pressure gauge manifold with EPA 608 low-loss fittings, Type-K

[69] Customer incentives up to $3,836 per eligible unit available for QM service agreement. Incentives paid over 3 years with proof of continuing eligibility and maintenance. https://www.premiumcooling.com/commservices/.

thermocouple clamps, Type-K thermocouple bead probes, Digital humidity sensors to measure wetbulb air temperatures. Technician hooked up refrigerant hoses and purged non-condensables with di minimis refrigerant from system.

3) WO32 EM&V pre-observation was performed on 9-25-12 of the 4-ton R410A Trane 4YCC3048A3075AB, S/N 09503HOH9H, sticker SD143181, RTU 1. No economizer or outdoor air dampers were installed. Unit was equipped with a TXV expansion device and direct-drive blower motor. Unit did not have a discharge pressure service valve. Air filter was dirty and plugged, condenser and evaporator coils were dirty and condensate drain was plugged. The manufacturer provides unit-specific charts for liquid pressure as a function of liquid temperature and target subcooling of 12F, and unit-specific charts of suction pressure as a function of outdoor air temperature (OAT) and return wetbulb (RWB) temperature (see Trane Service Facts 4YCC3048A-SF-3C.pdf, page 7, 12°F target subcooling).[70] The manufacturer refrigerant charge charts require minimum evaporator airflow of 400 cfm/ton, 50% relative humidity, superheat greater than 5°F, and steady system operation before measurements are taken. The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[71] Pre-observation temperature split was 26.3 or 5.9 above 20.4°F CEC RCA target and above 20 +/- 2°F program target indicating low airflow. Pre-observation subcooling was 17.5°F or 5.5 above 12°F manufacturer target and within 14 +/- 4°F program tolerance. Pre-observation suction pressure was 114 psig or -13.3 psig below 127.3 psig manufacturer target at 85°F OAT and 59°F RWB indicating undercharge. Superheat was 9.2°F, evaporator saturation temperature (EST) was 38.1°F, and condenser over ambient (COA) was 17.5°F. Based on subcooling the unit was overcharged, and based on suction pressure the unit was undercharged indicating heat transfer issues or restriction.

   WO32 EM&V technician observation was performed on 08-15-13 of the 4-ton R410A RTU 1 (Sticker SD143181). The technician repaired a plugged condensate drain during observations. Technician initial temperature split which was 22.4°F and within 2.5 of the 19.9°F CEC RCA target specification. Technician initial subcooling was 9.7°F and within the 12°F manufacturer target and 11 +/- 4°F program target. Technician initial suction pressure was 118.2 psig or -9.8 psig below 128 psig manufacturer target indicating undercharge at 85.7°F OAT and 59°F RWB. Technician did not adjust refrigerant charge and no final measurements were taken.

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[70] Assumed manufacturer subcooling temperature tolerance is +/-3°F and suction pressure tolerance is +/5 psig.

[71] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

WO32 EM&V post-observation was performed on 8-15-13 of RTU 1. Post-observation temperature split was 24.1°F or 4.4 above 24.1°F CEC RCA target indicating low airflow. Post-observation suction pressure was 128.1 psig or -8.9 below 137 psig manufacturer target indicating undercharge at 92°F OAT and 62.6°F RWB. Subcooling was 11.9°F and within 12°F manufacturer target tolerance. Superheat was 30.2°F and above 20 +/- 5°F program tolerance, EST was 44.2°F and within 46 +/- 6°F program tolerance, and COA was 17.8°F and below 25 +/- 5°F program tolerance. Low suction pressure and COA indicate possible heat transfer issues.

4) WO32 EM&V pre-observation was performed on 9-25-12 of the 4-ton R22 Trane YCC048F3M0BD, S/N M422M3Y1H, Sticker SD153787, RTU 2. No economizer or outdoor air dampers were installed. Unit was equipped with a non-TXV and direct-drive blower motor. Air filter was dirty and plugged, condenser and evaporator coils were dirty, bottom half of evaporator coil was covered with ice, and condensate drain was plugged. The manufacturer provides unit-specific charts for target discharge pressure and suction pressure as functions of OAT and RWB temperature, and unit-specific charts for superheat temperature as a function of OAT and return drybulb temperature (see Trane Service Facts YCC048-SF-10B.pdf).[72] Pre-observation temperature split was 25.7°F or 5.5 above 20.2°F target and above 20 +/- 2°F program target indicating low airflow. Pre-observation superheat was 2.4°F and within 2.6 of 5°F manufacturer tolerance but below 20 +/- 5°F program tolerance. Suction pressure was 57 psig or -12 psig below 69 psig manufacturer target indicating undercharge at 85°F OAT and 57.2°F RWB. Discharge pressure was 244 psig or 14 psig above 230 psig target indicating overcharge. Pre-observation EST was 31.5°F (due to coil icing) and suction temperature was 34°F (due to icing). Suction pressure was opposite discharge pressure due to coil icing heat transfer issues or possible restriction.

   WO32 EM&V technician observation was performed on 08-15-13 of the 4-ton RTU 2 (Sticker SD 153787). The technician repaired a plugged condensate drain during observations. Evaporator was iced up and unit appeared to be low on refrigerant or restricted. Technician did not perform a refrigerant leak test. Technician temperature split was 11.8°F and -3.4 below 15.2°F CEC RCA target and below 20 +/- 2°F program tolerance indicating low cooling capacity, plugged air filter, iced coil, or low charge. Technician evaluated refrigerant charge for the non-TXV system using the program superheat method (based on the CEC RCA protocol). Technician initial superheat was 84°F or 68.6°F greater than 15.4°F CEC RCA target and greater than 20°F +/- 5°F program tolerance indicating undercharge (i.e.,

[72] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

due to refrigerant leak). Technician discharge pressure was 190 psig or -65 psig below 255 psig manufacturer target and suction pressure was 26 psig or -57 psig below 83 psig manufacturer target indicating undercharge. Ice formation on evaporator caused low temperature split (11.8°F), low capacity, low suction pressure (26 psig), low evaporator saturation temperature (2.3°F), and low discharge pressure (190 psig). Technician determined unit was undercharged and added 99 ounces (factory charge is 102 ounces). Technician final superheat was 5.5°F and within 0.5 of 5°F CEC RCA target and 5°F manufacturer target at 87°F OAT and 71.2°F return drybulb, but below program target of 20°F +/- 5°F. Technician final suction pressure was 61.4 psig or -12.9 psig below 74.3 psig manufacturer target indicating undercharge. Discharge pressure was 254.5 psig or 9.5 psig above 245 psig manufacturer target indicating overcharge.

WO32 EM&V post-observation was performed on 8-15-13 of RTU 2. Post-observation temperature split was 22.7°F or 3.9 above 18.8°F CEC RCA target and above 20 +/- 2°F program tolerance. Post-observation suction pressure was 60 psig or -14.3 below 74.3 psig manufacturer target at 87°F OAT and 59.3°F RWB indicating undercharge. Discharge pressure was 249 psig or 24 above 225 psig target indicating overcharge. Superheat was 2.9°F and within -2.1 of 5°F manufacturer target. EST was 33.8°F and below 46 +/- 6°F program tolerance. Delta suction pressure was opposite delta discharge pressure and relatively low EST indicate low airflow, low refrigerant charge, restriction or heat transfer issues.

Another WO32 EM&V post-observation was performed on 10-31-13 of RTU 2. The evaporator coil was iced up again due to low airflow, low refrigerant charge, or restriction. Ice block on coil was five inches thick beyond the coil surface on inlet and outlet. Unit appeared to have a refrigerant leak.

B.5.5 Site SN

1) The SDG&E Statewide Premium Efficiency Cooling Program provided incentives to contractors for the following services: 1) coil cleaning (condenser and evaporator coils), 2) fan maintenance*, 3) refrigerant system test, 4) refrigerant system service, 5) economizer functional test, 6) integrate economizer wiring*, 7) replace damper motor*, 8) replace controllers/sensor, 9) renovate linkage and other components, 10) decommission economizer*, 11) replace thermostat*, 12) adjust thermostat schedule*, 13) minor repairs*, 14) QM completion incentive plus QM incentives (as introduced statewide), 15) maintenance agreement incentive to contractor plus customer incentives.[73]

[73] Customer incentives up to $3,836 per eligible unit available for QM service agreement. Incentives paid over 3 years with proof of continuing eligibility and maintenance. https://www.premiumcooling.com/commservices/.

2) Technician and EM&V post-observations were performed on two (2) units on 8-13-13:
1) Carrier Model 50JX-048-311, S/N 0403G31263, Sticker SD147143, RTU 1, and
2) Carrier Model 50JX-030-301, S/N 1203G41134, Sticker SD136301, RTU 2.
Both units were replaced with new units: 1) 4-ton Arcoaire, PHD348000K000C1, S/N C133431789, and 2) 3-ton Arcoaire, PHD336000K000C1, S/N C125112854.
The participating contractor provides maintenance services according to the program including changing filters and washing condensers with water every three months. During EM&V observations of each unit the technician performed the following services: changed air filters, cleaning condenser and evaporator coils with water pre-rinse, chemical cleaners, and final rinse from inside out per manufacturer, pulled blower out and cleaned it (when needed), sanded refrigerant suction and liquid lines prior to attaching clamp-on thermocouples, and purged hoses of non-condensables prior to attaching to system. Technician diagnosed refrigerant charge and airflow (RCA) using digital pressure gauge manifold with EPA 608 low-loss fittings, NTC thermistors clamps, NTC thermistors bead probes, Digital humidity sensors to measure wetbulb air temperatures. Technician hooked up refrigerant hoses and purged non-condensables with di minimis refrigerant from system.

3) WO32 EM&V pre-observation was performed on 9-24-12 of the 4-ton 50JX-048-311, S/N 0403G31263, Sticker SD147143, RTU 1. No economizer was installed, but unit has fresh-air dampers which were 30% open (3 fingers). Unit was equipped with a non-TXV expansion device and direct-drive blower motor. Wrong air filter was installed, suction Schrader valve was leaking, blower motor contactor was pitted, blower and condenser fan motor capacitors needed replacement (low capacitance), cabinet fasteners were missing, duct work was cracking, condenser and evaporator coils were dirty and fins were decaying, no condensate p-trap was installed, condensate drain was plugged, blower compartment was wet with moisture. The manufacturer provides unit-specific charts of suction temperature as a function of suction pressure and outdoor air temperature (OAT) (see Carrier 50JX024-060 Single-Package Rooftop Heat Pump Units, Installation, Service, and Start-up Instructions, 50tjx-1si.pdf).[74] The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[75] Pre-observation temperature split was 18.6°F and within 1.6°F of the 17°F CEC RCA target and within 20 +/- 2°F program tolerance. Pre-observation suction temperature was 43°F or -6.3°F below 49.3°F manufacturer target indicating overcharge. Refrigerant superheat was 0.1°F or -22.2°F below 22.3°F CEC RCA target value at 82°F OAT and 69.1°F RWB and below 20 +/- 5°F program tolerance indicating overcharge. Pre-observation evaporator saturation temperature (EST) was 42.9°F and within 46 +/- 6°F program tolerance. On 7-25-13, EM&V personnel measured 400 cfm make-up outdoor

[74] Manufacturer suction temperature tolerance is +/-5°F.

[75] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

airflow using anemometer traverse in the fresh-air supply duct. This represents approximately 25 to 30% outdoor airflow if the unit provides 300 to 400 cfm/ton. EM&V personnel were unable to measure evaporator airflow. WO32 EM&V technician observation was performed on 8-13-13 of RTU 1. Technician checked contactors and capacitors and indicated contactors and capacitors needed to be replaced. Technician cleaned condenser and evaporator coils with water pre-rinse, chemical cleaners, and final rinse from inside out per manufacturer. Technician did not diagnose or adjust fresh-air damper which was open 30% (3 fingers). Technician added new screws to panels, pulled and clean blower, sanded refrigerant suction and liquid lines prior to attaching clamp-on thermocouples, and purged hoses of non-condensables prior to attaching to system. Technician initial temperature split was 20.5°F or 2.9 above 17.6°F CEC RCA target and within the 20 +/-2°F program tolerance. Technician evaluated refrigerant charge for the non-TXV system using the superheat method (based on the CEC RCA protocol). Technician initial superheat was -2.9°F or -17.6°F below 14.7°F CEC RCA target at 76°F OAT and 62°F RWB and below 20 +/- 5°F program tolerance indicating overcharge. Technician initial suction temperature was 44°F or -17 below 61°F manufacturer target indicating overcharge. Technician determined unit was overcharged and removed 27.8 ounces (factory charge is 162 ounces). Final technician temperature split was 12°F or -6.7 below 18.7°F CEC RCA target and below program tolerance indicating low capacity, plugged or dirty air filter, or low charge. Final superheat was 12°F or -2.7 below 14.7°F CEC target and below 20 +/- 5°F program tolerance. Technician final suction temperature was 45°F or 11°F above 34°F manufacturer target indicating undercharge. Technician final EST was 33°F and below 46 +/- 6°F program tolerance. Low EST and superheat opposite subcooling indicate heat transfer issues or restriction.

WO32 EM&V post observation was performed on 8-13-13 of RTU 1. Post-observation temperature split was 18.2°F and within 0.6°F of 17.6°F CEC RCA target and within 20 +/- 2°F program tolerance. Post-observation superheat was 5.8°F or -8.2°F below 14°F CEC RCA target at 76.6°F OAT and 61.7°F RWB and below 20 +/- 5°F program tolerance indicating overcharge. Post-observation suction temperature was 41.8°F or 6.9°F above 34.9°F manufacturer target indicating undercharge. Post-observation EST was 36°F and below 46 +/- 6°F program tolerance. Superheat diagnostic opposite suction temperature diagnostic indicate possible heat transfer issues or restriction. EM&V personnel found a new unit installed on 3-13-14, Arcoaire, 4-ton model PHD348000K000C1, S/N C133431789.

4) WO32 EM&V pre-observations were performed on 9-24-12 of the 2.5-ton Carrier 50JX-030-301, S/N 1203G41134, Sticker SD136301, RTU 2. No economizer or fresh-air dampers were installed. Unit was equipped with a non-TXV expansion device and direct-drive blower motor. Air filters were missing, blower motor contactor was pitted, transformer tap needed to be moved (230V needed to be set at 208V for proper contactor voltage operation), cabinet

fasteners were missing, duct work was cracking, condenser and evaporator coils were dirty and fins were decaying, condensate drain was plugged, blower compartment was wet with moisture. Manufacturer provides charts for target suction temperature as functions of suction pressure and outdoor temperature (see Carrier 50JX024-060 Single-Package Rooftop Heat Pump Units, Installation, Service, and Start-up Instructions, 50tjx-1si.pdf). Pre-observation temperature split was 14.5°F or -0.7°F below 15.2°F CEC RCA target and below 20 +/- 2°F program tolerance. Pre-observation suction temperature was 45°F or -13.9°F below 58.9°F manufacturer target indicating overcharge. Superheat was 0.7°F or -14.9°F below 15.6°F CEC RCA target at 79°F OAT and 64.2°F RWB and below the 20 +/- 5°F program tolerance indicating overcharge. EST was 44.3°F and within 46 +/- 6°F program tolerance.

WO32 EM&V technician observation was performed on 8-13-13 of RTU 2. Technician checked contactors and capacitors, cleaned condenser and evaporator coils with water pre-rinse, chemical cleaners, and final rinse from inside out per manufacturer. Technician added new screws to panels, pulled and clean blower, fixed condensate line, sanded refrigerant suction and liquid lines prior to attaching clamp-on thermocouples, and purged hoses of non-condensables prior to attaching to system. Technician initial temperature split was 17.1°F and within -0.8 of 17.9°F CEC RCA target. Technician evaluated refrigerant charge for non-TXV system using superheat method (based on the CEC RCA protocol). Technician initial superheat was 50.1°F or 30.9°F above 19.2°F CEC RCA target at 73°F OAT and 64.3°F RWB and above 20 +/- 5°F program tolerance indicating undercharge. Technician initial suction temperature was 69°F or 37°F above 32°F manufacturer target indicating undercharge. The technician determined unit was undercharged and added 32.5 ounces (factory charge is 102 ounces). Technician added refrigerant to RTU 2, which was reclaimed from RTU 1.[76] Technician final temperature split was 24.4°F or 5.6°F above 18.8°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. Technician final superheat was 13.8°F and within -1.4°F of 15.2°F CEC RCA target, but outside program target superheat of 20 +/- 5°F. Technician final suction temperature was 54°F or -0.2 below 54.2°F manufacturer target. Technician final EST was 40.2°F and within 46 +/- 6°F program tolerance.

WO32 EM&V post observation was performed on 8-13-13 of RTU 2. Post-observation temperature split was 11.8°F or -5.4°F below the 17.2°F CEC RCA target and below 20 +/- 2°F program tolerance indicating low capacity, plugged air filter, iced coil, low airflow, or undercharge. Post-observation suction temperature was 40.3°F or 8.3°F above 32°F manufacturer target indicating undercharge. Superheat was 8°F or -6.5°F below 14.5°F CEC RCA target at 74°F OAT and 61.2°F RWB and below the 20 +/- 5°F program tolerance

[76] http://www.epa.gov/ozone/title6/608/608fact.html, 3. Reclamation Requirement: EPA has also established that refrigerant recovered and/or recycled can be returned to the same system or other systems owned by the same person without restriction. If refrigerant changes ownership, it must be reclaimed (i.e., cleaned to the ARI 700-1993 Standard of purity) by an EPA certified refrigerant reclaimer.

indicating overcharge. Post-observation EST was 32.3°F and below 46 +/- 6°F program tolerance. Low EST and suction temperature diagnostic opposite superheat indicates heat transfer issues or restriction. EM&V personnel found a new unit installed on 3-13-14, Arcoaire, 3-ton, model PHD336000K000C1, S/N C125112854.

B.5.6 Site SP

1) The SDG&E Statewide Premium Efficiency Cooling Program provided incentives to contractors for the following services: 1) coil cleaning (condenser and evaporator coils), 2) fan maintenance*, 3) refrigerant system test, 4) refrigerant system service, 5) economizer functional test, 6) integrate economizer wiring*, 7) replace damper motor*, 8) replace controllers/sensor, 9) renovate linkage and other components, 10) decommission economizer*, 11) replace thermostat*, 12) adjust thermostat schedule*, 13) minor repairs*, 14) QM completion incentive plus QM incentives (as introduced statewide), 15) maintenance agreement incentive to contractor plus customer incentives.[77]

2) Technician and EM&V post-observations were performed on two (2) units from 9-24-12 to 8-14-13:
1) York Model B2HZ060A25A, S/N N1F0033662, Sticker SD107501, RTU 1, and
2) Trane Model WCC036F300BF, S/N 31824111H, Sticker SD148514, RTU 2.
The Trane unit at this site was replaced by Arcoaire, PH0336000H000C1, S/N C134504407.
Technician diagnosed refrigerant charge and airflow (RCA) using digital pressure gauge manifold with EPA 608 low-loss fittings, NTC thermistors clamps, NTC thermistors bead probes, Digital humidity sensors to measure wetbulb air temperatures. Technician hooked up refrigerant hoses and purged non-condensables with di minimis refrigerant from system.

3) WO32 EM&V pre-observations on 9-24-12 of the 5-ton York B2HZ060A25A, Sticker SD107501, RTU 1. The unit is equipped with a TXV expansion device and direct-drive blower motor and uses R410A refrigerant. The unit does not have an economizer or outdoor air dampers. The air filter was dirty, condenser and evaporator coils were dirty, condensate drain was missing a p-trap, and blower door insulation was coming off covering motor. The manufacturer did not provide refrigerant charge specifications. Refrigerant charge for the TXV system was evaluated using the measured superheat temperature which was 15.3°F or 6.3F above 9°F manufacturer target at 90°F outdoor air temperature (OAT) and 64°F return wetbulb (RWB) (York Superheat Charging Table, Courtesy of York Corporation, Unitary Products Group, www.achrnews.com/articles/superheat-charging-curves-for-technicians). Pre-observation temperature split was 30.2 or 7.4°F above 22.8°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. The CEC RCA protocol provides

[77] Customer incentives up to $3,836 per eligible unit available for QM service agreement. Incentives paid over 3 years with proof of continuing eligibility and maintenance. https://www.premiumcooling.com/commservices/.

target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature. Pre-observation subcooling was 2.1°F or -7.9°F below 10°F CEC RCA and below 11°F +/- 4°F program tolerance indicating undercharge. Evaporator saturation temperature (EST) was 47°F and within 46 +/- 6°F program tolerance. Condenser over ambient (COA) was 17.1°F and below 25 +/- 5°F program tolerance. High superheat, low subcooling, and low COA indicate undercharge.

WO32 EM&V technician observation was performed on 08-14-13 of the 5-ton York B2HZ060A25A, Sticker SD107501, RTU 1. Technician cleaned the condenser and evaporator coils with water pre-rinse, chemical cleaners, and final rinse from inside out per manufacturer. Technician removed loose insulation from blower door. Technician sanded refrigerant suction and liquid lines prior to attaching clamp-on thermocouples, and purged hoses of non-condensables prior to attaching to system. Technician initial temperature split was 20.2°F or 2 above the 18.2°F CEC RCA target and within 20 +/- 2°F program tolerance. Technician evaluated refrigerant charge for the TXV system using the CEC RCA default 10°F target subcooling. Technician initial subcooling was 4.3°F or -5.7°F below 10°F CEC RCA target and below 11°F +/- 4°F program tolerance. Technician initial superheat was 19.1°F or 6.5°F above 12.6°F manufacturer target at 80°F OAT and 62.4°F RWB. Technician determined unit was undercharged and added 32.2 ounces (factory charge is 184 ounces). Technician final temperature split was 21.6°F or 2.9 above 18,7°F CEC RCA target and within program target. Technician final subcooling was 8.8°F or -1.2°F below 10°F CEC RCA target and within 11°F +/- 4°F program target. Technician final superheat was 15.4°F or 3.1°F above 12.3°F manufacturer target at 80°F OAT and 62.2°F RWB.[78] Final EST was 40.3°F and within 46 +/- 6°F program tolerance. Final COA was 19°F and below 25 +/- 5°F program tolerance.

WO32 EM&V post-observation of RTU 1 was performed on 08-14-13. Post-observation temperature split was 23.5°F or 5.8 above 17.7°F CEC RCA target and above the 20 +/- 2F program tolerance indicating low airflow. Post-observation superheat was 12°F or -2.7°F below 14.7°F manufacturer target at 86.1°F OAT and 66.6°F RWB. Post-observation subcooling was 4.5°F or -5.5°F below 10°F CEC RCA target and below 11°F +/- 4°F program target. EST was 44.5°F and within 46 +/- 6°F program tolerance. COA was 12.9°F and below 25 +/- 5°F program tolerance.

4) WO32 EM&V pre-observation was performed on 9-24-12 of the 3-ton Trane Model WCC036F300BF, S/N 31824111H, Sticker SD148514, RTU 2. The unit is equipped with a

[78] Source: www.achrnews.com/articles/superheat-charging-curves-for-technicians. Courtesy of York Corporation, Unitary Products Group.

non-TXV expansion device and direct-drive blower motor and uses R22 refrigerant. The unit does not have an economizer or outdoor air dampers. The air filter was dirty, condenser and evaporator coils were dirty, condensate drain was missing a p-trap, and blower door insulation was missing. The manufacturer provides unit-specific charts for target superheat, discharge pressure, and suction pressure as functions of OAT and RWB (see Trane Service Facts WCC036F100BF Single Packaged Heat Pump Convertible 3 Ton, WCC036-SF-5B.pdf). [79] Pre-observation temperature split was 31.6 or 6.5°F above 25.1°F CEC RCA target indicating low airflow due to evaporator coil ice build-up. Pre-observation superheat was 6.6°F or -6.6°F below the 13.2°F manufacturer target at OAT 84.5°F OAT and 53.6°F RWB indicating overcharge. Pre-observation suction pressure was 54 psig or -11 psig below 65 psig manufacturer target and discharge pressure was 222 psig or -8 psig below 230 psig manufacturer target indicating undercharge. EST was 29.2F and below 46 +/- 6F program tolerance. Low EST, low superheat, and low suction pressure indicate heat transfer issues, undercharge, or restriction.

WO32 EM&V technician observation was performed on 8-14-13, for the pre-existing 3-ton Trane Model WCC036F300BF, S/N 31824111H, Sticker SD148514, RTU 2. Technician cleaned condenser and evaporator coils with water pre-rinse, chemical cleaners, and final rinse from inside out per manufacturer. Technician used same set of gauges for both units. (RTU 2 uses R22 and RTU 1 uses 410A), and blew out hoses and manifold with CO2 between units. Technician added new screws to panels, sanded refrigerant suction and liquid lines prior to attaching clamp-on thermocouples, and purged hoses of non-condensables prior to attaching to system. Technician initial temperature split was 25.1°F and 6 above 19.1°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. OAT was 77°F and RWB was 57°F. Technician initial superheat was 5.3°F and within 0.3 of 5.7°F CEC RCA target and 5°F manufacturer target, but below 20°F +/- 5°F program tolerance. Technician initial suction pressure was 55 psig or -6 psig below 61 psig manufacturer target and discharge pressure was 190 psig or -20.5 psig below 210 psig target indicating undercharge. Technician determined unit was properly charged and did not require charge adjustment (factory charge is 131 ounces). Technician final temperature split was 25.1°F or 6 above 19.1°F CEC RCA target and above 20 +/- 2°F indicating low airflow. Technician final superheat was 5.3°F or -0.4 below 5.7°F manufacturer target at 77°F OAT and 57°F RWB. Technician final suction pressure was 55 psig or -6 psig below 61 psig manufacturer target and discharge pressure was 190 psig or -20.5 psig below 210 psig target indicating undercharge.

WO32 EM&V post-observation of RTU 2 was performed on 08-14-13. Post-observation temperature split was 26.9°F or 8.4 above 18.5°F CEC RCA target and above 20 +/- 2°F program tolerance indicating low airflow. Post-observation superheat was 20.5°F or 10.4 above 10.1°F manufacturer target at 82.6°F OAT and 63.7°F RWB indicating undercharge.

[79] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

Post-observation suction pressure was 63 psig or -9 psig below 72 psig manufacturer target and discharge pressure was 221 psig or -14 psig below 235 psig target indicating undercharge. Post-observation EST was 36°F and below 46 +/- 6°F program tolerance.

B.5.7 Site SS

1) The SDG&E Statewide Premium Efficiency Cooling Program provided incentives to contractors for the following services: 1) coil cleaning (condenser and evaporator coils), 2) fan maintenance*, 3) refrigerant system test, 4) refrigerant system service, 5) economizer functional test, 6) integrate economizer wiring*, 7) replace damper motor*, 8) replace controllers/sensor, 9) renovate linkage and other components, 10) decommission economizer*, 11) replace thermostat*, 12) adjust thermostat schedule*, 13) minor repairs*, 14) QM completion incentive plus QM incentives (as introduced statewide), 15) maintenance agreement incentive to contractor plus customer incentives.[80]

2) Technician and EM&V post-observations were performed on one (1) unit from 07-25-13 to 04-10-14. The site had only one unit.
1) Carrier 5-ton Model 50TFQ006-A-511, S/N 2006G40554, SDG&E Sticker 152794 (HP 6 or RTU 1).
The participating contractor provides maintenance services according to the program including changing filters and washing condensers with water every three months. During EM&V observations of each unit the technician performed the following services: changed air filters, cleaning condenser and evaporator coils with water pre-rinse, chemical cleaners, and final rinse from inside out per manufacturer, pulled blower out and cleaned it (when needed), sanded refrigerant suction and liquid lines prior to attaching clamp-on thermocouples, and purged hoses of non-condensables prior to attaching to system. Technician diagnosed refrigerant charge and airflow (RCA) using digital pressure gauge manifold with EPA 608 low-loss fittings, Type-K thermocouple clamps, Type-K thermocouple bead probes, Digital humidity sensors to measure wetbulb air temperatures. Technician hooked up refrigerant hoses and purged non-condensables with di minimis refrigerant from system.

3) WO32 pre-observation was performed on 7-25-13 of the 5-ton Carrier 50TFQ006-A-511, sticker 152794, RTU 1. The unit was equipped with a non-TXV expansion device and A41 standard v-belt-driven blower motor. The unit did not have an economizer. The fresh-air vent was open 75%, air filter was dirty, blower motor contactor was worn and pitted, plenum was dirty, cabinet fasteners were missing, condenser and evaporator coils were dirty, and condensate drain was plugged. The manufacturer provides charts of target suction

[80] Customer incentives up to $3,836 per eligible unit available for QM service agreement. Incentives paid over 3 years with proof of continuing eligibility and maintenance. https://www.premiumcooling.com/commservices/.

temperature as a function of outdoor air temperature (OAT) and suction pressure (SP) (see Carrier 50TFQ004-007 Single-Package Rooftop Heat Pump Units, Installation, Service, and Start-up Instructions, 50tfq-1si.pdf).[81] The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[82] Pre-observation temperature split was 16.6°F or -0.2 below 16.8°F CEC RCA target. OAT was 74°F and RWB was 67.5°F. Pre-observation suction temperature was 81.3°F or 45.3°F above 36°F manufacturer target indicating undercharge. Pre-observation superheat was 52.9°F or 28.1 above 24.8°F CEC RCA target at 74°F OAT and 67.5°F RWB and above 20 +/- 5°F program tolerance indicating undercharge. Pre-observation evaporator saturation temperature (EST) was 28.4°F and below 46 +/- 6°F program tolerance.

WO32 EM&V technician observation was performed on 08-12-13 of the 5-ton RTU 1 (Sticker SD 152794). Fresh-air vent was open 75%. The technician cleaned condenser and evaporator with a water pre-rinse, chemical cleaners, and final rinse from inside to outside. The technician repaired and/or straightened bent fins on the condenser coil. The technician also pulled the blower out and cleaned it, sanded refrigerant suction and liquid lines prior to attaching clamp-on thermocouples, and purged hoses of non-condensables prior to attaching to the system. Technician initial temperature split was 19°F or 2 above 17°F CEC RCA target. OAT was 75°F and RWB was 68.8°F. Technician initial superheat was 35.8°F or 9.9 above 25.9°F CEC RCA target and above 20°F +/- 5°F program target indicating undercharge. Technician initial suction temperature was 82°F or 10.5 above 71.5°F manufacturer target indicating undercharge. Initial EST was 46.2°F and within 46 +/- 6°F program tolerance. High suction temperature and high superheat indicate heat transfer issues or undercharge. Based on high superheat the technician added 24.5 ounces (factory charge is 128 ounces). Technician final temperature split was 23.6°F or 4.1 above 19.5°F CEC RCA target and above 20°F +/- 2°F program target indicating low airflow. OAT was 75°F and RWB was 64.1°F Technician final superheat was 15.7°F or -2.3 below 18°F CEC RCA target and within 20°F +/- 5°F program target. Final suction temperature was 65.7°F or -12.3 below 78°F manufacturer target indicating overcharge (based on 84 psig suction pressure and 75°F OAT). Final EST was 50°F and within 46 +/- 6°F program tolerance.

WO32 EM&V post-observation was performed on 8-12-13 of 5-ton RTU 1. Post-observation temperature split was 23.9°F or 5.3 above 18.6°F CEC RCA target and above 20 +/- 2°F

[81] Manufacturer suction temperature tolerance is +/-5°F.

[82] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

program tolerance indicating low airflow. Post-observation suction temperature was 55.3°F or 6.4 above 48.9°F manufacturer target indicating undercharge. Post-observation superheat was 17.1°F or 2.3 above 14.8°F CEC RCA target at 78.1°F OAT and 62.6°F RWB and within 20 +/- 5°F program tolerance. EST was 38.1°F and below 46 +/- 6°F program tolerance.

Another WO32 EM&V post-observation was conducted on 04-08-14 of the 5-ton unit (sticker 152794 and RTU 1). The measured airflow with closed outdoor air damper was 1451 cfm (290 cfm/ton) at 0.56 inches of water column (IWC) total static pressure with 656W fan power. The belt-driven fan speed was 1023 RPM (3.5 turns). The factory setting is 1060 rpm and 3 turns. The unit ran continuously due to condenser being very dirty. The unit had high discharge pressure of 316.2 psig. The measured existing efficiency was 7.2 EER* total and 6.0 EER* sensible at 84.1°F OAT and 63.8°F RWB. The 5-ton unit was only delivering 44,525 Btu per hour of cooling which was 27.8% less than 61,708 Btu per hour cooling capacity the manufacturer specifies at 84.1°F OAT and 63.8°F RWB and 1,500 cfm.[83] Refrigerant was recovered and 106.25 ounces was weighed out indicating undercharge by 21.75 ounces or -17%. According to the program database the technician added 24.5 ounces. With 128 ounce factory charge and dirty condenser, the CEC RCA superheat protocol and manufacturer suction temperature protocol diagnosed correct charge. Efficiency improved to 7.8 EER* total and 6.8 EER* sensible (+8%) at 85.9°F OAT and 67.8°F RWB. Cooling capacity increased by 11% to 49,553 Btu per hour and total power increased by 2.8% with factory charge. The building owner has a maintenance contractor who changes filters and cleans coils and notifies the property manager and tenant of any problems requiring repairs. The tenant is required to hire a contractor to make repairs. It appears that the SDG&E statewide program contractor is not the only contractor providing maintenance services at the site. The tenant contractor cleaned and degreased the condenser coil. With factory charge and clean condenser the discharge pressure decreased from 325.6 psig to 253.8 psig and total power decreased to 5280 W (-15%). Efficiency increased to 10.2 EER* total and 8.4 EER* sensible at 86.2°F OAT and 65.2°F RWB which is a 41% improvement from undercharge. Cooling capacity increased to 53,717 Btu per hour which is within 6.3% of the 57,358 Btu per hour cooling capacity specified by the manufacturer at 86.2°F OAT and 65.2°F RWB and 1,500 cfm.[84] With factory charge and clean condenser the measured superheat was 20.2°F or 7°F above 13.2F manufacturer target but within the 20 +/- 5°F program tolerance. The CEC RCA delta superheat was 7°F indicating "false alarm" undercharge. The suction temperature was 61.3°F or 13.4°F above 47.9°F manufacturer

[83] 50HJQ004---016, 50TFQ004---012, 50HEQ003---006, Single Package Rooftop, Standard and High Efficiency Heat Pump Units, Product Data, Carrier Corp. S 7310 W. Morris St. S Indianapolis, IN 46231, Edition Date: 3/09, 50h-t-11pd.pdf

[84] Ibid

target indicating “false alarm” undercharge. The manufacturer does not provide recommended airflow values for checking refrigerant charge. Increasing airflow would likely increase superheat and suction temperatures which would tend to reinforce the "false alarm" undercharge diagnostic. The site was visited a third time on 04-10-14 to measure airflow, power, and EER. The final measured field efficiency was 10.3 EER* at 77.8°F OAT and 60.1°F RWB.

B.6 SDG&E Local Program

B.6.1 Site CB

1) The SDG&E Premium Cooling Efficiency local program provided incentives for the following Tier 1 services: 1) condenser coil cleaning, 2) refrigerant system test, and 3) refrigerant system service. The program also provided incentives for the following Tier 2 services: 4) economizer repair, 5) suction line insulation, 6) evaporator coil cleaning, 7) condenser coil fin combing, and 8) duct wrap.[85]

2) The observed site has five (5) non-TXV RTUs and one TXV RTU. All have one circuit. The non-TXV RTUs include two 2-ton RTUs and two 3-ton RTUs. The TXV unit is 3-tons and received incentives for refrigerant test only. Two of the non-TXV RTUs received incentives for refrigerant tests and adjustments. One non-TXV RTU received incentives for refrigerant test only plus evaporator/condenser coil cleaning. One received incentives for refrigerant test and adjustment plus evaporator/condenser coil cleaning, and one received incentives for refrigerant test and adjustment plus condenser coil cleaning. Work was performed in October 2011. The EM&V team conducted observations on 2-14-14, 2-21-14, 3-12-14, 4-22-14 and 5-12-14 of six (6) units.
   1) 2-ton Carrier 50SZ-024-301, S/N 1506G31381, SDG&E Sticker 146550, RTU D-2,
   2) 3-ton Carrier 50HJQ004-321, S/N 0806G20488, SDG&E Sticker 151593, RTU F-1,
   3) 3-ton Carrier 50HJQ004-321, S/N 1906G40655, SDG&E Sticker 146549,
   4) 2.5-ton ICP PH330000K000C1, S/N C101769899, SDG&E Sticker 151590,
   5) 2-ton Carrier 50SZ-024-301, S/N 1506G31382, SDG&E Sticker 151591,
   6) 3-ton Carrier 50HJQ004-521, S/N 2306G50556, SDG&E Sticker 151592.
   According to program data, technicians diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings and a shut-off valve on the high-side pressure hose, but no EPA 608 low-loss fittings. WO32 EM&V master technicians did not directly observe technicians performing work in the program.

[85] Duct wrap incentives are only applicable to pre-1992 buildings (limited to exposed ducts in unconditioned space) with customer co-payment. Program does not pay incentives for check, clean, and/or replace air filter, check/adjust airflow, lubricate serviceable bearings, or inspect/adjust unit for proper operation.

3) WO32 EM&V post-observation was performed on 2-21-14 of the 2-ton Carrier model 50SZ-024-301, sticker 146550 (unit D-2). The pre-existing indoor fan set at the low-horsepower factory default. Minimum outdoor air (OA) damper was closed (fresh-air only, no economizer). WO32 EM&V technicians measured airflow on 3-12-2014. The measured airflow was 526.5 cfm (263 cfm/ton) and external static pressure (ESP) was 0.31 inches of water (IWC). Airflow was 34% less than manufacturer recommendation of 400 cfm/ton. The manufacturer provides unit-specific charts of target suction temperature (ST) as a function of outdoor air temperature (OAT) and suction pressure (SP) (Carrier 50SZ Single Packaged Heat Pump Units, Installation, Start-up, and Service Instructions, 8-05, 50sz-1si.pdf).[86] The manufacturer recommends "indoor airflow (cfm) must be within the normal operating range of the unit." The manufacturer provides tables of fan speed versus airflow (cfm) and external static pressure (ESP inches of water column, IWC). The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[87] Temperature split was 23.9F or 5.9°F above 18°F CEC RCA target and outside 20 +/- 2°F program tolerance. Suction temperature was 36.2°F or -12.2 below 48.4°F manufacturer target indicating undercharge. Superheat was 0°F or -11.4 below 11.4°F CEC RCA target at 71.8°F OAT and 57.6°F RWB. Evaporator saturation temperature (EST) was 36.2°F and below 46 +/- 6°F program tolerance. Low superheat and low EST indicate undercharge, heat transfer issues, ice on evaporator coil, or liquid line restriction.

   WO32 EM&V post-observation was performed again on 2-21-14 of unit D-2. According to the program database the technician added 42 ounces. Refrigerant in RTU D-2 was recovered and weighed and the circuit was found to be undercharged by 12 ounces or -9.4%. The unit was evacuated to 500 microns and a leak test was performed with unit holding at or below 1000 microns for 20 minutes. Therefore, the as-found undercharge condition was not due to refrigerant leaks. After the 128 ounce factory charge was weighed into RTU D-2 and with 263 cfm/ton airflow, the manufacturer protocol and CEC RCA protocol both diagnosed "false alarm" overcharge, i.e., remove charge to achieve required target ST (manufacturer) or SH (CEC RCA). WO32 EM&V post-observation was conducted on 3-12-2014 to measure airflow. Measured airflow was 526 cfm or 263 cfm/ton at low speed and ESP of 0.31 IWC. Airflow was 34% less than manufacturer recommendation of 400 cfm/ton. The manufacturer installation instructions provide the following requirement regarding airflow. "Do not operate the unit at a cooling airflow that is less than 350 cfm for each 12,000 Btuh of

[86] Manufacturer suction temperature tolerance is +/-5°F.

[87] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

rated cooling capacity. Evaporator coil frosting may occur at airflows below this point."[88] The measured ESP was 0.31 IWC and the manufacturer indicates that airflow should be 820 cfm at 0.30 IWC at 230 Volts, and 738 cfm or 369 cfm/ton at 208 Volts (manufacturer instructions Table 5). After weighing in factory charge on 2-21-14, temperature split was 23.5°F or 6 above 17.5°F CEC RCA target indicating low airflow. Superheat was 8.9°F or -7.1 below 16°F CEC RCA target at 67.1°F OAT and 58.6°F RWB indicating "false alarm" overcharge. Suction temperature was 45.5°F or -9.2°F below 54.7°F manufacturer target indicating "false alarm" overcharge. EST was 36.6°F and below 46 +/- 6°F program tolerance.

WO32 EM&V third post-observation was conducted on 4-22-2014. The RTU D-2 fan setting was increased to medium and the measured airflow was 670 cfm or 335 cfm/ton at 0.42 IWC. After 15 minutes of operation, temperature split was 21.4°F or 3.9 above 17.5°F CEC RCA target (outside +/- 3°F tolerance), but within 20 +/-2°F program tolerance. Superheat was 9.9°F or -3.7 below 13.6°F CEC RCA target at 70.6°F OAT and 58.6°F RWB indicating correct charge. Suction temperature was 49.9°F or -8.4°F below 58.3°F manufacturer target indicating overcharge. After 15 minutes of operation the manufacturer protocol diagnosed "false alarm" overcharge and CEC RCA protocol diagnosed correct charge. After 30 minutes of operation, temperature split was 21.2°F or 3.9 above 17.3°F CEC RCA target (outside +/- 3°F tolerance), but within 20 +/-2°F program tolerance. Superheat was 7.3°F or -5.4 below 12.7°F CEC RCA target at 69.7°F OAT and 57.9°F RWB indicating overcharge. Suction temperature was 46.4°F or -10.9°F below 57.3°F manufacturer target indicating overcharge. After 30 minutes of operation the manufacturer protocol and CEC RCA protocol diagnosed "false alarm" overcharge. With 27% percent more airflow at medium speed RCA diagnostics are closer, but ST and SH diverge from the target as the unit operates for a longer period of time. At medium the final EST was 39.1°F.

WO32 EM&V fourth post-observation was conducted on 5-12-2014. The RTU D-2 fan setting was increased to high. At the high setting the measured airflow was 922 cfm (461 cfm/ton) at 0.55 IWC or 75% greater than low setting. After 15 minutes of operation with 461 cfm/ton, temperature split was 20.3°F or 1.6 above 18.7°F target and within +/-3°F tolerance. Superheat was 6.4°F or 1.3 above 5.1°F CEC RCA target at 83°F OAT and 58°F RWB indicating correct charge. Suction temperature was 48.1°F or -3.6°F below 51.7°F manufacturer target indicating correct charge. After 15 minutes of operation the manufacturer protocol and CEC RCA protocol diagnosed correct charge. After 30 minutes of operation with 461 cfm/ton, temperature split was 20.5°F or 1.2 above 19.3°F target and within +/-3°F tolerance. Superheat was 1.5°F or -4 below 5.5°F CEC RCA target at 81°F OAT

[88] See page 20. Carrier Corporation. 2007. 50SZ Comfort Single–Packaged Heat Pump System With R-22 Refrigerant Single and Three Phase 2-5 Nominal Tons (Sizes 024-060). S 7310 W. Morris St., Indianapolis, IN 46231. 50sz-05si.pdf.

and 57.7°F RWB indicating correct charge. Suction temperature was 43°F or -9.6°F below 52.6°F manufacturer target indicating "false alarm" overcharge. After 30 minutes of operation the manufacturer protocol diagnosed "false alarm" overcharge, and CEC RCA protocol diagnosed correct charge. EST was 41.5°F and within 46 +/- 6°F program tolerance. High blower motor setting provides 75% more airflow and requires 49% more fan power than low setting. RCA diagnostics are closer, but ST and SH diverge from the target as the unit operates for a longer period of time. EM&V research findings at this site indicate that airflow influences diagnostics. Measured airflow is 39% lower than recommended and indicated by the manufacturer at low, 35% lower at medium, and 15% higher at the high setting. Technicians might measure ESP and at 0.3 IWC technicians might assume airflow is 820 cfm or 410 cfm/ton based on manufacturer installation instructions. Based on incorrect information and either manufacturer or CEC RCA protocols, the technicians would remove charge to achieve the target ST or SH. Field evaluation data indicates temperature split measurements provide reasonable indications of proper airflow. Efficiency improves as airflow increases. At low setting total EER* was 13.8 and sensible EER* was 8.9 at 67.1°F OAT and 69°F RDB and 58.6°F RWB. At medium setting total EER* was 14.4 and sensible EER* was at 70.6°F OAT and 69.1°F RDB and 58.6°F RWB 9.56. At high setting total EER was 16 and sensible EER* was 11.47 at 72.7°F OAT and 67°F RDB and 56.7°F RWB.

4) Observations on 2-14-14 of the 3-ton Carrier model 50HJQ004-321, sticker 151593, unit F-1, found the pre-existing belt-driven fan speed was 921 RPM (3 turns) which is the factory setting. The fresh-air OA damper position is open approximately 10% (½") when blower fan was operating and closed when fan is not operating. Damper is for fresh-air only with no economizer. The position of the OA damper varies due to a missing guide pin. The OA damper was fixed to closed position during EM&V testing. The existing airflow was 951 cfm (317 cfm/ton) at 921 rpm (3 turns), and 0.69 IWC ESP. Airflow was 21% less than manufacturer recommendation of 400 cfm/ton. Temperature split (TS) was 21.6°F or 4.8°F above 16.8°F CEC RCA target and outside +/-3°F tolerance indicating low airflow. Low airflow can cause issues with RCA diagnostics. The manufacturer protocol provides target suction temperature as a function of OAT and SP (Carrier 50HJQ004-007 Single-Package Rooftop Heat Pump Units, Installation, Start-up, and Service Instructions, 12-03, 50hjq-13si.pdf). Superheat was 15.6°F or 3.9 above 11.7°F CEC RCA target at 67°F OAT and 55.6°F RWB indicating correct charge. Suction temperature was 47.1°F or 19.6°F above 27.5°F manufacturer target indicating undercharge. EST was 31.5°F and below 46 +/- 6°F program tolerance. Refrigerant was recovered and weighed and unit was found to be undercharged by 54.25 ounces or -28.2%. According to the program database the technician removed 42 ounces. The CEC RCA protocol misdiagnosed the undercharge fault. After evacuation to 500 microns held for 20 minutes, the 192 ounce factory charge was weighed into the unit. Temperature split was 22.8°F or 5.5°F above 17.3°F CEC RCA target and outside +/-3°F tolerance indicating low airflow. Superheat was 7.3°F or -5.3 below 12.6°F CEC RCA target at 68°F OAT and 56.9°F RWB indicating overcharge. Suction temperature was 40.3°F or 8.8°F above 31.5°F manufacturer target indicating undercharge. EST was 33°F and below 46 +/-

6°F program tolerance. The CEC RCA protocol diagnosed a slight overcharge, and the manufacturer protocol diagnosed undercharge. Neither protocol provides correct diagnostics with the factory charge which could be caused by low airflow (317 cfm/ton). More tests would need to be performed to evaluate issues with the protocols.

B.6.2 Site CV

1) The SDG&E Premium Cooling Efficiency local program provided incentives for the following Tier 1 services: 1) condenser coil cleaning, 2) refrigerant system test, and 3) refrigerant system service. The program also provided incentives for the following Tier 2 services: 4) economizer repair, 5) suction line insulation, 6) evaporator coil cleaning, 7) condenser coil fin combing, and 8) duct wrap.[89]
   According to program data, technicians diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings and a shut-off valve on the high-side pressure hose, but no EPA 608 low-loss fittings. WO32 EM&V master technicians did not directly observe technicians performing work in the program.

2) The observed site has five non-TXV RTUs: two 20-ton units with two-circuits each, two 4-ton, and one 6-ton unit. Incentives were paid for the following measures: 1) condenser coil cleaning 2) refrigerant system test, and 3) refrigerant system service. Work was performed in September 2011. The EM&V team conducted observations on 2-12-14, 2-15-14, 4-21-14, and 5-13-14. EM&V inspections were performed on one unit (RTU 1). The following units had program stickers at the site.
   1) Trane 20-ton YCD241C4LCBA, S/N Z35101043D, SDG&E Sticker 143426, RTU 1,
   2) Trane 20-ton YCD241C4LCBA, S/N Z35101134D, SDG&E Sticker 143427, RTU 2,
   3) Trane 4-ton YHC048A4RMA0C2B, S/N Z29100616L, SDG&E Sticker 143428,
   4) Trane 6-ton, YCD074C46CBE, S/N Z35100611D, SDG&E Sticker 143429, and
   5) Trane 6-ton, UNK, S/N Z30100049L, SDG&E Sticker 150620.
   According to program data, technicians diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings and a shut-off valve on the high-side pressure hose, but no EPA 608 low-loss fittings. WO32 EM&V master technicians did not directly observe technicians performing work in the program.

3) WO32 EM&V post-observation was performed on 2-12-14 of the 20-ton Trane model YCD241C4LCBA sticker 143426, RTU 1. The blower fan was operating 24 hours per day and 7 days per week with the OA damper stuck closed. The economizer was non-functional. The B81 standard v-belt was loose and pre-existing airflow was 7656 cfm (383 cfm/ton) with fan power of 3482W. Airflow was 4.3% less than 400 cfm/ton recommended by the

[89] Duct wrap incentives are only applicable to pre-1992 buildings (limited to exposed ducts in unconditioned space) with customer co-payment. Program does not pay incentives for check, clean, and/or replace air filter, check/adjust airflow, lubricate serviceable bearings, or inspect/adjust unit for proper operation.

manufacturer. The measured baseline application energy efficiency ratio (EER*) was 9.8 at 77.3°F OAT and 68°F RDB and 53.8°F RWB.[90] The manufacturer provides unit-specific charts of suction pressure, discharge pressure, and superheat as a function of outdoor air temperature (OAT) and return air wetbulb (RWB) temperature (Trane Service Facts YC*241-SF-3B, YCD241C4LCBA, Packaged Gas/Electric 20 Ton Rooftop Units with Micro-Electronic Controls, YC_241-SF-3B.pdf).[91] The manufacturer refrigerant charge charts require minimum evaporator airflow of 400 cfm/ton, 50% relative humidity, superheat greater than 5°F, and steady system operation before measurements are taken. The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[92] Temperature split was 22.4°F or 3.1 above 19.3°F CEC RCA target. Circuit 1 suction pressure was 57.3 psig or -7.7 below 65 psig manufacturer tolerance indicating undercharge. Circuit 1 discharge pressure was 210.3 psig or 6.3 above 204 psig manufacturer target and within tolerance. Circuit 1 superheat was 28.2°F or 25.2 above 3°F manufacturer target indicating undercharge. Circuit 1 evaporator saturation temperature (EST) was 31.7°F and below 46 +/- 6°F program tolerance. Circuit 2 suction pressure was 60.2 psig or -4.8 below 65 psig manufacturer target and within tolerance. Circuit 2 discharge pressure was 216.3 psig or 12.3 above 204 psig manufacturer target indicating overcharge. Circuit 2 superheat was 25.4°F or 22.4 above 3°F manufacturer target indicating undercharge. Circuit 2 EST was 33.9°F and below 46 +/- 6°F program tolerance. Circuit 1 superheat and suction pressure indicated undercharge and low EST indicated heat transfer issues or restriction. Circuit 2 discharge pressure indicated overcharge, superheat indicated undercharge, and low EST indicated heat transfer issues or restriction. Refrigerant in both circuits was recovered and weighed. Circuit 1 was overcharged by 28.5 ounces or 8.1%. According to the program database the technician previously added 50 ounces to circuit 1. Circuit 2 was overcharged by 70 ounces or 20%. According to the program database the technician previously added 45 ounces to circuit 2. After recovery, each circuit was evacuated to 500 microns, held for 20 minutes below 1000 microns, whereupon the factory charge was carefully weighed into each circuit.

WO32 EM&V post-observation was performed on 2-15-14 of the 20-ton Trane model YCD241C4LCBA sticker 143426, RTU 1. On 4-21-14 a new BX81 notched fan belt was installed and the tension and alignment were adjusted per manufacturer specifications.

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[90] Total delivered cooling capacity in British thermal units per hour (Btuh) divided by total electric power (Watts).

[91] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

[92] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

Airflow was measured at 9127 cfm (456 cfm/ton) with fan power of 5035W (airflow was 19% higher than 2-12-14). With factory charge and 19% greater airflow, the application EER* increased by 8.1% to 10.6 at 74.4°F OAT and 69.8°F RDB and 60.1°F RWB. Temperature split was 16.1°F or -1.6 below 17.7°F CEC RCA target. Circuit 1 suction pressure was 54.1 psig or -16.9 below 71 psig manufacturer tolerance indicating undercharge. Circuit 1 discharge pressure was 194.5 psig or -16.5 below 211 psig manufacturer target indicating undercharge. Circuit 1 superheat was 40.6°F or 31.1 above 9.5°F manufacturer target indicating undercharge and 30.4°F above the 10.2°F CEC RCA target indicating undercharge. Circuit 1 EST was 29.2°F and below 46 +/- 6°F program tolerance. Circuit 2 suction pressure was 61.5 psig or -9.5 below 71 psig manufacturer target indicating undercharge. Circuit 2 discharge pressure was 195 psig or -16 below 211 psig manufacturer target indicating undercharge. Circuit 2 superheat was 34°F or 24.5 above 9.5°F manufacturer target indicating undercharge and 23.8°F above the 10.2°F CEC RCA target indicating undercharge. Circuit 2 EST was 34.9°F and below 46 +/- 6°F program tolerance. With increased airflow and factory charge the manufacturer and CEC RCA protocols indicated “false alarm” undercharge.

Another WO32 EM&V post-observation was performed on 04-21-14. The condenser was cleaned to determine if diagnostics would improve. Temperature split was 14.9°F or -0.5 below 15.4°F CEC RCA target. Circuit 1 suction pressure was 54.8 psig or -16.2 below 71 psig manufacturer target indicating undercharge. Circuit 1 discharge pressure was 195.9 psig or -15.1 below 211 psig manufacturer target indicating undercharge. Circuit 1 superheat was 40.4°F or 29.9 above 10.5°F manufacturer target and 27.9°F above the 12.5°F CEC RCA target indicating undercharge. Circuit 1 EST was 29.8°F and below 46 +/- 6°F program tolerance. Circuit 2 suction pressure was 51.5 psig or -19.5 below 71 psig manufacturer target indicating undercharge. Circuit 2 discharge pressure was 201 psig or -10 below 211 psig manufacturer target and within tolerances. Circuit 2 superheat was 41.2°F or 30.7 above 10.5°F manufacturer target and 28.7°F above the 12.5°F CEC RCA target indicating undercharge. Circuit 2 EST was 27.1°F and below 46 +/- 6°F program tolerance. With 19% greater airflow, factory charge, and clean condenser, the manufacturer and CEC RCA protocols provide "false alarm" undercharge diagnostics even though both circuits had correct factory charge of 348.8 ounces. With clean condenser, the EER increased by 3.3% to 11.0 at 77.2°F OAT and 68.2°F RDB and 60.6°F RWB. The EM&V findings indicate that the manufacturer and CEC RCA protocols do not provide accurate diagnostic information for this unit. Increasing airflow and cleaning the condenser coil did not improve diagnostics.

Another WO32 EM&V post-observation was performed on 5-13-14. The airflow was measured after the fan belt was broken in. The airflow was 8582 cfm (429 cfm/ton) with fan power of 5035W. Temperature split was 20.6°F or -0.7 below 21.3°F CEC RCA target. Circuit 1 suction pressure was 60 psig or -4 below 64 psig manufacturer target and within tolerance. Circuit 1 discharge pressure was 246.9 psig or 7.9 above 239 psig manufacturer

target and within tolerance. Circuit 1 superheat was 32.6°F or 29.6 above 3°F manufacturer target and 27.6°F above the 5°F CEC RCA target indicating undercharge. Circuit 1 EST was 33.8°F and below 46 +/- 6°F program tolerance. Circuit 2 suction pressure was 64.4 psig or 0.4 above 64 psig manufacturer target and within tolerance. Circuit 2 discharge pressure was 251.2 psig or 12.2 above 239 psig manufacturer target indicating overcharge. Circuit 2 superheat was 29.9°F or 26.9 above 3°F manufacturer target and 24.9°F above the 5°F CEC RCA target indicating undercharge. Circuit 2 EST was 37°F and below 46 +/- 6°F program tolerance. CEC RCA protocols indicated "false alarm" undercharge. Manufacturer protocols indicate correct charge based on suction and discharge pressure and undercharge based on superheat. The manufacturer target superheat is 3°F at 51°F indoor wetbulb and 91°F condenser entering air temperature. Manufacturer states the following: "Do not add refrigerant if the superheat is less than 5 F." Pressures are close to correct and superheat is high due to low RWB conditions. The EM&V findings indicate that the manufacturer and CEC RCA protocols do not provide accurate diagnostic information for this unit based on superheat only. Unit-specific suction and discharge pressures appear to provide more accurate diagnostic information.

4) Observations of the 20-ton Trane YCD241C4LCBA, S/N Z35101134D, SDG&E Sticker 143427, RTU 2, found the B81 standard v-belt was worn and glazed with loose tension. Due to belt slippage the airflow was too low to measure and refrigerant charge could not be tested. WO32 EM&V master technicians installed a new BX81 notched v-belt with proper tension and alignment per the manufacturer. Additional evaluation tests could not be performed due to lack of time.

B.6.3 Site DM

1) The SDG&E Premium Cooling Efficiency local program provided incentives for the following Tier 1 services: 1) condenser coil cleaning, 2) refrigerant system test, and 3) refrigerant system service. The program also provided incentives for the following Tier 2 services: 4) economizer repair, 5) suction line insulation, 6) evaporator coil cleaning, 7) condenser coil fin combing, and 8) duct wrap.[93]

2) The observed site has two 4-ton RTUs. The EM&V team conducted ride-along technician observations on 4-11-13. EM&V inspections were performed on North Unit 1.
   1) Trane 4-ton WCC048F300BH, S/N 5062YJ92H, SDG&E Sticker SD 155496, RTU 1.

[93] Duct wrap incentives are only applicable to pre-1992 buildings (limited to exposed ducts in unconditioned space) with customer co-payment. Program does not pay incentives for check, clean, and/or replace air filter, check/adjust airflow, lubricate serviceable bearings, or inspect/adjust unit for proper operation.

Technician diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings no EPA 608 low-loss fittings. Technicians did not have refrigerant in hoses and did not purge non-condensables. Could not disconnect high side and purge to low side due to not having EPA 608 low-loss fittings.

3) WO32 EM&V technician observation was performed on 4-11-13 of the 4-ton Trane model WCC048F300BH sticker 155496, North Unit 1. No economizer was installed and fresh-air damper vent was open 37% (1.5 inches). Technician used electrical tape to secure suction and liquid sensors. Technician took outdoor air temperature reading on side of unit by electrical section and away from condenser coil. Technician brushed the evaporator coil to remove dirt and debris from the outdoor air damper. Water was unavailable on the rooftop so the technician connected a hose to the front of the building to rinse the condenser coils with water. Condenser and evaporator coils were not cleaned per manufacturer instructions with water pre-rinse, chemical cleaners, and final rinse from the inside out. Technician did not check contactors, capacitors, fan speed, or damper position. Technician performed RCA test with the fresh air damper open and dirty air filter installed. Delta temperature split was within tolerances. The manufacturer provides charts and target values for suction and discharge pressure based on outdoor air temperature (OAT), return wetbulb (RWB), and return drybulb (RDB) and charts of superheat based on RDB and OAT (Trane Service Facts WCC048-SF-5B, WCC048F100BG, Single Packaged Heat Pump Convertible 4 Ton, WCC048-SF-5B.pdf).[94] The manufacturer refrigerant charge charts require minimum evaporator airflow of 400 cfm/ton, 50% relative humidity, superheat greater than 5°F, and steady system operation before measurements are taken. The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[95] The technician used VSP equipment to evaluate RCA. Technician initial temperature split was 17.7°F and equal to 17.7°F CEC RCA target. Technician initial superheat was 20.2°F or 9.2 above the 11°F CEC RCA target at 77°F OAT and 60.4°F RWB indicating undercharge. Technician initial superheat was 20.2°F or 14.6°F above the 5.6°F manufacturer target at 77°F OAT and 70°F RDB indicating undercharge and within 20 +/- 5°F program tolerance. Initial suction pressure was 60 psig or -9.9 psig below 69.9 psig manufacturer target indicating undercharge (+/- 5°F tolerance). Initial discharge pressure was 155 psig or -41.9 psig below 196.9 psig manufacturer target indicating undercharge (+/- 10°F tolerance). Technician added 18 ounces to unit.

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[94] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

[95] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

Technician final measurement was made without air filter installed. Technician final temperature split was 22.2°F or 3.5 above 18.7°F CEC RCA target indicating low airflow. Technician final superheat was 6°F or -1.5 below 7.5°F CEC RCA target at 77°F OAT and 58.4°F RWB and outside 20 +/- 5°F program tolerance. Technician final superheat was 6°F or 0.4 above 5.6°F CEC RCA target at 77°F OAT and 70°F RDB. Final suction pressure was 65 psig or -3.3 psig below 68.3 psig manufacturer target but within +/-5°F manufacturer tolerance. Final discharge pressure was 185.5 psig or -7.5 psig below 193 psig manufacturer target and within +/- 10°F tolerance. Final evaporator saturation temperature (EST) was 37.4°F and below 46 +/- 6°F program tolerance. IOU program inspector indicated final measurement would need to be performed again with clean air filter installed. Technician deleted data for job after inspector informed him that job would need to be performed again. Building maintenance personnel indicated that contractor did not have permission to perform services on units.

B.6.4 Site FT

1) The SDG&E Premium Cooling Efficiency local program provided incentives for the following Tier 1 services: 1) condenser coil cleaning, 2) refrigerant system test, and 3) refrigerant system service. The program also provided incentives for the following Tier 2 services: 4) economizer repair, 5) suction line insulation, 6) evaporator coil cleaning, 7) condenser coil fin combing, and 8) duct wrap.[96]

2) The observed site has two (2) non-TXV RTUs. All have one circuit. The EM&V team conducted observations on 4-12-13, 1-13-14, 1-14-14, and 1-22-14.
1) 3-ton Trane WCC036F300BG, S/N 5362N8B14, SDG&E Sticker 155798, RTU 3,
2) 2.5-ton Trane WCC030F100BH, S/N 54023F11H, SDG&E Sticker 155797, RTU 2.
Technician diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings no EPA 608 low-loss fittings. Technicians did not have refrigerant in hoses and did not purge non-condensables. Could not disconnect high side and purge to low side due to not having EPA 608 low-loss fittings.

3) WO32 EM&V technician observation was performed on 4-12-13 of the 3-ton Trane model WCC036F300BG, sticker 155798 (South Unit 3). No economizer was installed and fresh-air damper vent was open 37.5% (1.5 inches). Technician did not have EPA 608 low-loss fitting on refrigerant hoses. Technician used black electrical tape to secure suction and liquid sensors. Technician brushed the evaporator coil to remove dirt and debris from the outdoor air damper. Water was unavailable on the roof top so technician connected a hose to the front of the building to rinse condenser coils with water. Condenser and evaporator coils were not cleaned per manufacturer instructions with water pre-rinse, chemical cleaners, and

[96] Duct wrap incentives are only applicable to pre-1992 buildings (limited to exposed ducts in unconditioned space) with customer co-payment. Program does not pay incentives for check, clean, and/or replace air filter, check/adjust airflow, lubricate serviceable bearings, or inspect/adjust unit for proper operation.

final rinse from inside out. Technician did not check contactors, capacitors, fan speed, or damper position. Technician performed RCA test with fresh-air damper open and dirty air filter installed. Delta temperature split was within tolerances. The manufacturer provides charts and target values for suction and discharge pressure based on outdoor air temperature (OAT), return wetbulb (RWB), and return drybulb (RDB) and charts of superheat based on RDB and OAT (Trane Service Facts WCC036-SF-6A, WCC036F300BF, Single Packaged Heat Pump Convertible 3 Ton, WCC036-SF-6A.pdf).[97] The manufacturer refrigerant charge charts require minimum evaporator airflow of 400 cfm/ton, 50% relative humidity, superheat greater than 5°F, and steady system operation before measurements are taken. The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[98] Technician temperature split was 18.5°F or -0.6 below 19.1°F CEC RCA target. Technician superheat was 51.7°F or 42.7 above the 9°F CEC RCA target and 43.2°F above 8.5°F manufacturer target at 72.5°F OAT and 57°F RWB. Initial suction pressure was 40.4 psig or -18.8 psig below 59.2 psig manufacturer target indicating undercharge. Discharge pressure was 165.1 psig or -33 psig below 198.1 psig manufacturer target indicating undercharge. Superheat was 51.7°F or 43.2 above 8.5°F manufacturer target indicating undercharge. Technician determined unit was undercharged and added 63 ounces (43% of 131 ounce factory charge). Technician final measurement was made with a clean air filter installed. Technician temperature split was 25.8°F or 6.3 above 19.5°F CEC target indicating low airflow. Technician final superheat was 8.7°F or 0.6 above the 8.1°F CEC RCA target and 0.1°F above 8.6°F manufacturer target. Final suction pressure was 60 psig or 1.8 psig above 58.2 psig manufacturer target. Discharge pressure was 197 psig or -0.3 psig below 197.3 psig manufacturer target. Final evaporator saturation temperature (EST) was 33.8°F and below 46 +/- 6°F program tolerance.

WO32 EM&V post-observation was performed on 1-13-14 of the 3-ton Trane South Unit 3. The outdoor air fresh-air damper vent was open 37.5% (1.5 inches). The unit was diagnosed as properly charged based on the CEC RCA superheat protocol and properly charged based on manufacturer suction pressure, discharge pressure, and superheat protocol. Temperature split was 24.3°F or 3.2 above 21.1°F CEC RCA target. Superheat was 3.5°F or -1.5 below 5°F CEC RCA target at 75.9°F OAT and 52°F RWB. Superheat was 3.5°F or -3.5°F below 7°F manufacturer target at 75.9°F OAT and 70.5°F RDB. Suction pressure was 61.2 psig or 4.6 psig above 56.6 psig manufacturer target. Discharge pressure was 201.6 psig or -5.6 psig below 207.2 psig manufacturer target. EST was 34.7°F and below 46 +/- 6°F program tolerance.

WO32 EM&V post-observation was performed on 1-14-14 of the 3-ton Trane South Unit 3. The outdoor fresh-air damper was fully 100% open. The unit was diagnosed as properly charged based on the CEC RCA superheat protocol and properly charged based on

[97] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

[98] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

manufacturer suction pressure and discharge pressure, but overcharged based on manufacturer superheat protocol. Temperature split was 28.7°F or 1.6 above 27.1°F CEC RCA target. Superheat was 3°F or -2 below 5°F CEC RCA target at 85.8°F OAT and 53.4°F RWB. Superheat was 3°F or -14°F below 17°F manufacturer target at 85.8°F OAT and 82.4°F return drybulb (RDB).[99] Suction pressure was 68.9 psig or 5.4 psig above 63.5 psig manufacturer target. Discharge pressure was 242.6 psig or 2 psig above 240.6 psig manufacturer target. EST was 40.2°F and within 46 +/- 6°F program tolerance.

Another WO32 EM&V post-observation was performed on 1-14-14 approximately 20 minutes later of the 3-ton Trane South Unit 3. The outdoor air damper was fully closed and sealed with plastic. The unit was diagnosed as properly charged based on the CEC RCA superheat protocol. The unit was diagnosed as properly charged based on the manufacturer suction and discharge pressure protocols and diagnosed as overcharged based on manufacturer superheat. Temperature split was 25°F or 1 above 24°F CEC RCA target. Superheat was 2.8°F or -2.2 below 5°F CEC RCA target at 85.5°F OAT and 53.6°F RWB. Superheat was 2.8°F or -7.7°F below 10.5°F manufacturer target at 85.5°F OAT and 77.4°F RDB indicating overcharge. Suction pressure was 67.3 psig or 3.7 psig above 63.6 psig manufacturer target. Discharge pressure was 236.7 psig or -3 psig below 239.7 psig manufacturer target. EST was 39.1°F and below 46 +/- 6°F program tolerance.

Another WO32 EM&V post-observation was performed on 1-22-14. Refrigerant was recovered and weighed and the unit was found to contain 139 ounces and overcharged by 8 ounces or 6.1%. The unit was evacuated to 500 microns and a leak test was performed with unit holding at or below 1000 microns for 20 minutes. After the 131 ounce factory charge was weighed in with damper fully open, the manufacturer protocol diagnosed proper charge and the CEC RCA superheat protocol diagnosed a slight overcharge. Temperature split was 25.4°F or 3.4 above 22°F CEC RCA target. Superheat was 11.5°F or 5.9 above 5.6°F CEC RCA target at 73°F OAT and 54.5°F RWB. Superheat was 11.5°F or -1.7°F below 13.2°F manufacturer target at 73°F OAT and 74°F RDB. Suction pressure was 60.3 psig or 3 psig above 57.3 psig manufacturer target. Discharge pressure was 198.8 psig or 0.1 psig above 198.7 psig manufacturer target. EST was 34°F and below 46 +/- 6°F program tolerance.

Another WO32 EM&V post-observation was performed on 1-22-14 of the 3-ton Trane South Unit 3. With factory charge and damper closed, the manufacturer protocol diagnosed proper charge based on suction and discharge pressure and superheat. The CEC RCA superheat protocol diagnosed proper charge and low airflow. Temperature split was 24.6°F or 4 above 20.6°F CEC RCA target. Superheat was 2.7°F or -2.3 below 5°F CEC RCA target at 72°F OAT and 52.3°F RWB. , Superheat was 2.7°F or -6.5°F below 9.2°F manufacturer target at 72°F OAT and 70.3°F RDB. Suction pressure was 58.5 psig or 3.7 psig above 54.8 psig manufacturer target. Discharge pressure was 195.8 psig or 0.7 psig above 195.1 psig manufacturer target. EST was 32.7°F and below 46 +/- 6°F program tolerance.

[99] Manufacturer target superheat is a function of return drybulb and which requires much higher target superheat than the CEC RCA protocol with low indoor humidity conditions (i.e., low return wetbulb).

4) WO32 EM&V technician observation was performed on 4-12-13 of the 2.5-ton Trane model WCC030F100BH, sticker 155797 (North Unit 2). No economizer was installed and fresh-air damper vent was open 100% (4 inches). Technician did not have EPA 608 low-loss fitting on refrigerant hoses. Technician used black electrical tape to secure suction and liquid sensors. Technician brushed the evaporator coil to remove dirt and debris from the outdoor air damper. Water was unavailable on the roof top so technician connected a hose to the front of the building to rinse condenser coils with water. Condenser and evaporator coils were not cleaned per manufacturer instructions with water pre-rinse, chemical cleaners, and final rinse from inside out. Technician did not check contactors, capacitors, fan speed, or damper position. Technician performed RCA test with fresh-air damper fully open and dirty air filter installed. The manufacturer provides charts and target values for suction and discharge pressure based on OAT, RWB, and RDB and charts of superheat based on OAT and RDB (Trane Service Facts WCC030-SF-2B, WCC030F100BG, Single Packaged Heat Pump Convertible 2-1/2 Ton, WCC030-SF-2B.pdf).[100] The manufacturer refrigerant charge charts require minimum evaporator airflow of 400 cfm/ton, 50% relative humidity, superheat greater than 5°F, and steady system operation before measurements are taken. Technician initial temperature split was 22.5°F or 4.3 above 18.2°F CEC RCA target. The technician used VSP equipment and determined that the unit was undercharged based on initial superheat of 31.5°F or 16 above the 15.5°F CEC RCA target at 67.9°F OAT and 58.9°F RWB. Initial superheat of 31.5°F was 19.8°F above 11.7°F manufacturer target at 67.9°F OAT and 70.2°F RDB. Initial suction pressure was 54.3 psig or -4.1 psig below 58.4 psig manufacturer target, and discharge pressure was 170.3 psig or 12.4 psig above 157.9 psig manufacturer target. The technician added 20.2 ounces to the unit. Technician final measurement was made with a clean air filter installed. Technician final temperature split was 24.7°F or 6.5 above 18.2°F CEC RCA target indicating low airflow. Technician final superheat was 20.6°F or 5.1 above the 15.5°F CEC RCA target at 67.6°F OAT and 59°F RWB. Final superheat was 20.6°F or 8.7°F above 11.9°F manufacturer target at 67.6°F OAT and 70.2°F RDB. Final suction pressure was 58.3 psig and equal to 58.3 psig manufacturer target, and discharge pressure was 193.4 psig or 36.4 psig above 157 psig manufacturer target.

   WO32 EM&V post-observation was performed on 1-14-14 of the 2.5-ton Trane North Unit 2. With damper fully closed and 80.9°F OAT the manufacturer protocol diagnosed overcharge based on superheat and undercharge based on suction pressure. The CEC RCA protocol diagnosed undercharge based on superheat. Temperature split was 40.3°F or 13.6 above 26.7°F CEC RCA target. Superheat was 14.7°F or 9.7 above 5°F CEC RCA target at 80.9°F OAT and 56.3°F RWB indicating undercharge. Superheat was 14.7°F or -5.8°F below 20.5°F

[100] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

manufacturer target at 80.9°F OAT and 83.4°F RDB indicating overcharge. Suction pressure was 54.8 psig or -9.2 psig below 64 psig manufacturer target indicating undercharge. Discharge pressure was 186.2 psig or 1.2 psig above 185 psig manufacturer target. EST was 29.8°F and below 46 +/- 6°F program tolerance. Low EST and manufacturer superheat diagnostic opposite suction pressure diagnostic indicate issues with heat transfer, coil icing, or restriction.

WO32 EM&V post-observation was performed on 1-14-14 of the 2.5-ton Trane North Unit 2 with the damper fully open 100%. Temperature split was 28.6°F or 3.7 above 24.9°F CEC RCA target. Superheat was 4.7°F or -0.3 below 5°F CEC RCA target at 77.6°F OAT and 51.7°F RWB within tolerance. Superheat was 4.7°F or -10.2°F below 14.9°F manufacturer target at 77.6°F OAT and 77.5°F RDB indicating overcharge. Suction pressure was 61.1 psig or 1.1 psig above 60 psig manufacturer target and within tolerance. Discharge pressure was 181 psig or 1 psig above 180 psig manufacturer target and within tolerance. EST was 34.6°F and below 46 +/- 6°F program tolerance. Low EST and low superheat indicate undercharge or issues with heat transfer, coil icing, or restriction. On 1-22-14 refrigerant was recovered and weighed and the unit was found to contain 101 ounces and undercharged by 19 ounces or 16%. The unit was evacuated to 500 microns and a leak test was performed with unit holding at or below 1000 microns for 20 minutes. The 120 ounce factory charge was weighed in, but insufficient time was available to evaluate refrigerant charge.

B.6.5 Site QB

1) The SDG&E Premium Cooling Efficiency local program provided incentives for the following Tier 1 services: 1) condenser coil cleaning, 2) refrigerant system test, and 3) refrigerant system service. The program also provided incentives for the following Tier 2 services: 4) economizer repair, 5) suction line insulation, 6) evaporator coil cleaning, 7) condenser coil fin combing, and 8) duct wrap.[101]

2) The observed site has two (2) non-TXV RTUs. All have one circuit. The EM&V team conducted observations on 4-12-13, and 1-14-14.
1) 3-ton Trane WCC036F300BG, S/N 5442KW41H, SDG&E Sticker 155799, RTU 4,
2) 4-ton Trane WCC048F300BH, S/N 5384YGP2H, SDG&E Sticker 155800, RTU 5.
Technician diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings no EPA 608 low-loss fittings. Technicians did not have refrigerant in hoses and did not purge non-condensables. Could not disconnect high side and purge to low side due to not having EPA 608 low-loss fittings.

[101] Duct wrap incentives are only applicable to pre-1992 buildings (limited to exposed ducts in unconditioned space) with customer co-payment. Program does not pay incentives for check, clean, and/or replace air filter, check/adjust airflow, lubricate serviceable bearings, or inspect/adjust unit for proper operation.

3) WO32 EM&V technician observation was performed on 4-12-13 of the 3-ton Trane model WCC036F300BG, sticker 155799 (North Unit 4). No economizer was installed and fresh-air damper vent was open 100% (4 inches). Technician did not have EPA 608 low-loss fitting on refrigerant hoses. Technician used black electrical tape to secure suction and liquid sensors and Armaflex insulation tape over the sensor. Technicians brushed the evaporator coil to remove dirt and debris from the outdoor air damper. Water was unavailable on the roof top so technicians connected a hose to the front of the building to rinse condenser coils with water. Condenser and evaporator coils were not cleaned per manufacturer instructions with water pre-rinse, chemical cleaners, and final rinse from inside out. Technicians did not check contactors, capacitors, fan speed, or damper position. Technician performed RCA test with fresh-air damper open and dirty air filter installed. The manufacturer provides charts and target values for suction and discharge pressure based on outdoor air temperature (OAT), return wetbulb (RWB), and return drybulb (RDB) and charts of superheat based on RDB and OAT (Trane Service Facts WCC036-SF-6A, WCC036F300BF, Single Packaged Heat Pump Convertible 3 Ton, WCC036-SF-6A.pdf).[102] The manufacturer refrigerant charge charts require minimum evaporator airflow of 400 cfm/ton, 50% relative humidity, superheat greater than 5°F, and steady system operation before measurements are taken. The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[103] Technician initial temperature split was 22.5°F or 3.7 above 18.8°F CEC RCA target. Technician superheat was 29.5°F or 16.4 above 13.1°F CEC RCA target and 19.6°F above 9.9°F manufacturer target at 73.5°F OAT and 59.6°F RWB. Initial suction pressure was 59.6 psig or -2.3 psig below 61.9 psig target and within manufacturer tolerance. Discharge pressure was 172.8 psig or -29.7 psig below 202.5 psig manufacturer target indicating undercharge. Evaporator saturation temperature (EST) was 33.5°F and below 46 +- 6°F program tolerance. Technician determined unit was undercharged and added 8 ounces of R22 refrigerant. Technician final measurement was made without air filter installed. Technician temperature split was 24°F or 5.3 above 18.7°F CEC RCA target indicating low airflow. Technician final superheat was 10.4°F or 0.5 above the 9.9°F CEC RCA target and 2.6°F above the 7.8°F manufacturer target at 73.5°F OAT and 58.2°F RWB. Final suction pressure was 61.6 psig or 0.8 above the 60.8 psig manufacturer target. Discharge pressure was 185.3 psig or -16.5 psig below 201.8 psig manufacturer target indicating undercharge. EST was 35°F and below 46 +- 6°F program tolerance.

   WO32 EM&V post-observation was performed on 1-14-14 of the 3-ton North Unit 4. The economizer damper was found fully open. RCA was evaluated with damper fully open and damper fully closed and sealed. With dampers fully open the temperature split was 26.5°F or 1.5 above 25°F CEC RCA target and within tolerance. Superheat was 3.2°F or -1.8 below 5°F CEC RCA target at 84.7°F OAT and 56.3°F RWB and within tolerance. Superheat was -

[102] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and superheat temperature tolerance is +/-5°F.

[103] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

10.9°F below 14.1°F manufacturer target at 84.7°F OAT and 79.8°F RDB indicating overcharge. Suction pressure was 67 psig and equal to the 67 psig manufacturer target and within tolerance. Discharge pressure was 226.8 psig or -7.2 psig below 234 psig manufacturer target and within tolerance. EST was 38.8°F and below 46 +- 6°F program tolerance. CEC RCA superheat protocol indicated proper charge. Manufacturer superheat protocol indicated overcharge while suction and discharge pressure protocol indicated proper charge.

With dampers fully closed and sealed the temperature split was 27.6°F or 4.1 above 23.5°F CEC RCA target and within tolerance. Superheat was 3.4°F or -1.6 below 5°F CEC RCA target at 84.3°F OAT and 57.2°F RWB and within tolerance. Superheat was -8.8°F below 12.2°F manufacturer target at 84.3°F OAT and 78.2°F RDB indicating overcharge. Suction pressure was 64 psig or -2 psig below 6 psig manufacturer target and within tolerance. Discharge pressure was 221 psig or -9 psig below 230 psig manufacturer target and within tolerance. EST was 36.7°F and below 46 +- 6°F program tolerance. CEC RCA superheat protocol indicated proper charge. Manufacturer superheat protocol indicated overcharge while suction and discharge pressure protocol indicated proper charge.

4) WO32 EM&V technician observation was performed on 4-12-13 of the 4-ton Trane model WCC048F300BH, sticker 155800 (South Unit 5). No economizer was installed and fresh-air damper vent was open 100% (4 inches). Technician did not have EPA 608 low-loss fitting on refrigerant hoses. Technician used black electrical tape to secure suction and liquid sensors and Armaflex insulation tape over the sensor. Technicians brushed the evaporator coil to remove dirt and debris from the outdoor air damper. Water was unavailable on the roof top so technicians connected a hose to the front of the building to rinse condenser coils with water. Condenser and evaporator coils were not cleaned per manufacturer instructions with water pre-rinse, chemical cleaners, and final rinse from inside out. Technicians did not check contactors, capacitors, fan speed, or damper position. Technician performed RCA test with fresh-air damper fully open and dirty air filter installed. The manufacturer provides charts and target values for suction and discharge pressure based on outdoor air temperature (OAT), return wetbulb (RWB), and charts of superheat based on OAT and return drybulb (RDB) (Trane Service Facts WCC030-SF-2B, WCC030F100BG, Single Packaged Heat Pump Convertible 2-1/2 Ton, WCC030-SF-2B.pdf). The manufacturer refrigerant charge charts require minimum evaporator airflow of 400 cfm/ton, 50% relative humidity, superheat greater than 5°F, and steady system operation before measurements are taken. The CEC RCA protocol provides target temperature split as a function of RWB and

RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[104] Technician initial temperature split was 20.5°F or 1.7 above 18.8°F CEC RCA target and within tolerance. Technician superheat was 9.3°F or -7 below 16.3°F CEC RCA target and -4.1°F below 13.4°F manufacturer target at 69.3°F OAT and 59.6°F RWB. Initial suction pressure was 70.7 psig or 5.1 psig below 65.6 psig manufacturer target and within tolerance. Discharge pressure was 173.8 psig or -3.3 psig below 177.1 psig manufacturer target and within tolerance. EST was 41.4°F and within 46 +- 6°F program tolerance, The technician did not adjust refrigerant charge. Technician final measurement was made with a clean air filter installed. Technician temperature split was 22.4°F or 3.6 above 18.8°F CEC RCA target indicating low airflow. Technician final superheat was 16.1°F or 1.1 above the 15°F CEC RCA target and 4.3°F above the 11.8°F manufacturer target at 71.3°F OAT and 59.7°F RWB. Final suction pressure was 70 psig or 3.3 above the 66.7 psig manufacturer target. Discharge pressure was 184.8 psig or 3 psig above 181.8 psig manufacturer target indicating overcharge. EST was 40.9°F and within 46 +- 6°F program tolerance.

WO32 EM&V post-observation was performed on 1-14-14. The unit was evaluated with damper fully open and dampers fully closed and sealed. With dampers fully open the temperature split was 22.8°F or -0.9 below 23.7°F CEC RCA target and within tolerance. Superheat was 11.6°F or 6.6 above 5°F CEC RCA target at 84.3°F OAT and 55.4°F RWB indicating undercharge. Superheat was 0.7°F above 10.9°F manufacturer target at 84.3°F OAT and 77.2°F RDB and within tolerance. Suction pressure was 74.3 psig or 5 above 69.3 psig manufacturer target and within tolerance. Discharge pressure was 211.5 psig or 7.4 psig above 204.1 psig manufacturer target and within tolerance. EST was 43.9°F and within 46 +- 6°F program tolerance. CEC RCA superheat protocol indicated undercharge. Manufacturer protocol indicated proper charge.

With dampers closed and sealed the temperature split was 23.8°F or 0.5 above 23.3°F CEC RCA target and within tolerance. Superheat was 11.4°F or 6.4 above 5°F CEC RCA target at 84.3°F OAT and 55.8°F RWB indicating undercharge. Superheat was 0.9°F above 10.5°F manufacturer target at 84.3°F OAT and 76.9°F RDB and within tolerance. Suction pressure was 72.4 psig or 2.7 psig above 69.7 psig manufacturer target and within tolerance. Discharge pressure was 209.6 psig or 4.4 psig above 205.2 psig manufacturer target and within tolerance. EST was 42.5°F and within 46 +- 6°F program tolerance. CEC RCA superheat protocol indicated undercharge. Manufacturer protocol indicated proper charge.

[104] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

B.6.6 Site ST

1) The SDG&E Premium Cooling Efficiency local program provided incentives for the following Tier 1 services: 1) condenser coil cleaning, 2) refrigerant system test, and 3) refrigerant system service. The program also provided incentives for the following Tier 2 services: 4) economizer repair, 5) suction line insulation, 6) evaporator coil cleaning, 7) condenser coil fin combing, and 8) duct wrap.[105]

2) The observed site has five 10-ton two-circuit TXV RTUs. Incentives were paid for the following measures: 1) economizer repair (damper lubricated), 2) refrigerant charge test, adjustment and evaporator/condenser coil cleaning (4 of 5 both circuits), and 3) condenser coil fin straightening (2 units). Work was performed in January and February 2011.The EM&V team conducted observations on 1-23-14, 1-24-14, 1-28-14, 1-29-14 and 2-11-14.
1) Lennox LGA120HH1Y, S/N 5600B08598, SDG&E Sticker 141615, RTU 1,
2) Lennox LGA120HH1Y, S/N 5600B08597, SDG&E Sticker 141616, RTU 3,
3) Lennox LGA120HH1Y, S/N 5600B08596, SDG&E Sticker 141617, RTU 2,
4) Lennox LGA120HH1Y, S/N 5600B08595, SDG&E Sticker 141618, RTU 4, and
5) Lennox LGA120HH1Y, S/N 5600B08599, SDG&E Sticker 141619, RTU 5.
According to program data, technicians diagnosed refrigerant charge and airflow (RCA) using verification service provider (VSP) equipment with standard hose fittings and a shut-off valve on the high-side pressure hose, but no EPA 608 low-loss fittings. WO32 EM&V master technicians did not directly observe technicians performing work in the program.

3) WO32 EM&V post-observation was performed on 1-24-14 of the 10-ton Lennox LGA120HH1Y, S/N 5600B08598, sticker 141615, RTU 1. The unit was inoperable due to failure of the main control board. Economizer minimum outdoor air damper position was closed. Evaporator and condenser coils were dirty and TXV sensing bulbs were uninsulated, and condensate drain was cut. EM&V master technicians were unable to evaluate refrigerant charge and airflow (RCA) due to the unit not working.

4) WO32 EM&V post-observation was performed on 1-24-14 of the 10-ton LGA120HH1Y, S/N 5600B08597, sticker 141616, RTU 3. The economizer damper was closed, evaporator and condenser coils were dirty, TXV sensing bulbs were uninsulated, condensate drain was cut, and economizer filter was falling apart. Cold spray test of sensor indicated economizer was not functional. According to the program database technicians removed 7 ounces (4%) from both circuits. The manufacturer provides charts of target discharge pressure (DP), suction pressure (SP), and approach temperature (AT – liquid minus ambient temperature) based on measurements of outdoor air temperature (OAT), return wetbulb (RWB), and return drybulb (RDB) (Lennox, Service Literature, Unit Information LGA/LCA/LHA 7.5 / 8.5 / 10 / 12.5 ton, Corp. 9901–L1, Revised 03–2006, Supersedes Corp. 9803–L4, 1999 Lennox

[105] Duct wrap incentives are only applicable to pre-1992 buildings (limited to exposed ducts in unconditioned space) with customer co-payment. Program does not pay incentives for check, clean, and/or replace air filter, check/adjust airflow, lubricate serviceable bearings, or inspect/adjust unit for proper operation.

Industries Inc., http://www.hvacc.net/pdf/lennox/LGA_9901c.pdf).[106] According to the manufacturer, "WARNING–Do not exceed nameplate charge under any condition. The unit is factory charged and should require no further adjustment. If the system requires charge, reclaim the charge, evacuate the system, and add required nameplate charge. NOTE – System charging is not recommended below 60°F. In temperatures below 60°F, the charge must be weighed into the system. Steady system operation is required before measurements are taken." The CEC RCA protocol provides target temperature split as a function of RWB and RDB temperature and target superheat (SH) as a function of OAT and RWB temperature.[107] Post-observation temperature split was 23.4°F or 3.7°F above 19.7°F CEC RCA target indicating slightly low airflow. Circuit 1 subcooling was 111.9°F or 1.9 above 10°F program target, and circuit 2 subcooling was 13.9°F or 3.9 above 10°F program target. Circuit 1 approach was 5.8°F or -1.2°F below 7°F manufacturer target indicating overcharge at 71°F OAT and 54.2°F RWB. Circuit 2 approach was 6.5°F or -0.5 below 7°F manufacturer target indicating overcharge (+/-1°F tolerance). Circuit 1 suction pressure was 59.3 psig or -16.4 below 75.7 psig manufacturer target indicating undercharge. Circuit 2 suction pressure was 59.5 psig or -15.1 psig below 74.6 psig manufacturer target indicating undercharge (+/-5 psig tolerance). Circuit 1 discharge pressure was 185 psig at the 185 psig target, and circuit 2 discharge pressure was 191 psig or 1 psig above 190 psig manufacturer target (+/-10 psig tolerance). Evaporator saturation temperature (EST) was 33.3 and 33.4°F respectively for circuits 1 and 2. Condenser over ambient (COA) was 17.7 and 20.4°F respectively for circuits 1 and 2. Low suction pressure and low EST indicate heat transfer issues. The evaluation did not have time to perform additional work on RTU 3.

5) WO32 EM&V post-observation was performed on 1-24-14 of the 10-ton Lennox LGA120HH1Y, S/N 5600B08598, sticker 141617, RTU 2. Economizer damper was closed, evaporator and condenser coils were dirty, TXV sensing bulbs were uninsulated, condensate drain cut, and economizer filter falling apart. EM&V master technicians were unable to evaluate refrigerant charge and airflow (RCA) due to the unit not working.

6) WO32 EM&V post-observation was performed on 1-23-14 of the 10-ton LGA120HH1Y, S/N 5600B08595, sticker 141618, RTU 4. Economizer damper was closed, evaporator coil was dirty, TXV sensing bulbs were uninsulated, condensate drain was cut, and economizer filter was falling apart. Cold spray test of sensor indicated economizer was not functional. According to the program database technicians added 8 ounces to circuit 1 (4% of factory charge) and 11 ounces to circuit 2 (6% of factory charge). The manufacturer provides charts

[106] Manufacturer suction pressure tolerance is +/-5 psig, discharge pressure tolerance is +/-10 psig, and approach temperature tolerance is +/-1°F.

[107] California Energy Commission (CEC). 2008. Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Appendix RA3 - Residential Field Verification and Diagnostic Test Protocols. Effective January 1 2010.

of target DP, SP, and AT based on measurements of OAT, RWB, and RDB (http://www.hvacc.net/pdf/lennox/LGA_9901c.pdf). Post-observation temperature split was 25.4°F or 4.7 above 20.7°F CEC RCA target and outside 20 +/- 2°F program tolerance indicating low airflow. Circuit 1 subcooling was 16.9°F or 6.9 above 10°F program tolerance. Circuit 2 subcooling was 15.8°F or 5.8 above 10°F program tolerance. Circuit 1 approach was 4.7°F or -2.3°F below 7°F manufacturer target indicating overcharge at 69°F OAT and 54.3°F RWB. Circuit 2 approach was 6°F or -1 below 7°F manufacturer target indicating overcharge. Circuit 1 suction pressure was 59.8 psig or -15.6 below 75.4 psig manufacturer target indicating undercharge (+/-5 psig tolerance). Circuit 2 suction pressure was 60.8 psig or -13.5 psig below 74.3 psig manufacturer target indicating undercharge (+/-5 psig tolerance). Circuit 1 discharge pressure was 184.9 psig or 6.5 psig above 178.4 psig manufacturer target (+/-10 psig tolerance). Circuit 2 discharge pressure was 185.4 psig or 1.1 psig above 184.3 psig manufacturer target. EST was 33.6 and 34.4°F respectively for circuits 1 and 2. COA was 21.6 and 21.8°F respectively for circuits 1 and 2. Low suction pressure and low EST indicate heat transfer issues. On 1-29-14, the measured airflow was 3429 cfm (343 cfm/ton) at 0.84 inches of water column (IWC) total static pressure, fan speed of 959 RPM (3 turns factory setting), and fan power of 1835W. The field-measured EER* was 9.5 EER* at 77.1°F OAT. The evaluation did not have time to recover refrigerant charge or perform additional work on RTU 4.

7)

WO32 EM&V post-observation was performed on 1-23-14 of the 10-ton Lennox LGA120HH1Y, S/N 5600B08599, sticker 141619, RTU 5. Economizer minimum outdoor air damper position was closed, evaporator coil was dirty, TXV sensing bulbs were uninsulated, condensate drain was cut, economizer filter was falling apart, fan speed at 2 turns, and one of two condenser fans failed. Cold spray test of sensor indicated economizer was not functional. According to the program database technicians added 13 ounces to circuit 1 (7% of factory charge) and 12 ounces to circuit 2 (6.5% of factory charge). The manufacturer provides charts of target DP, SP, and AT based on measurements of OAT, RWB, and RDB (http://www.hvacc.net/pdf/lennox/LGA_9901c.pdf). Post-observation temperature split was 21.4°F or 1.3°F above 20.1°F CEC RCA target indicating slightly low airflow. Circuit 1 post-observation subcooling was 19.9°F or 9.9 above 10°F CEC RCA target. Circuit 2 post-observation subcooling was 25.8°F or 15.8 above 10°F CEC RCA target. Circuit 1 approach was 24.9°F or 17.9°F above 7°F manufacturer target indicating undercharge at 73°F OAT and 53.7°F RWB. Circuit 2 approach was 21.8°F or 14.8 above 7°F manufacturer target indicating overcharge. Circuit 1 suction pressure was 63.2 psig or -12.8 psig below 76 psig manufacturer target indicating undercharge. Circuit 2 suction pressure was 65.6 psig or -9.3 psig below 74.9 psig manufacturer target indicating undercharge. Circuit 1 discharge pressure was 267.2 psig or 76.7 psig above 190.5 psig target indicating undercharge. Circuit 2 discharge pressure was 277 psig or 80.6 psig above 196.4 psig manufacturer target (+/-10 psig tolerance) indicating undercharge. EST was 36.2 and 37.9°F respectively for circuits 1

and 2. COA was 44.8 and 47.6°F respectively for circuits 1 and 2. Low suction pressure, low EST, and high COA indicate heat transfer issues due to one failed condenser fan (one was still working) and possible non-condensables.

WO32 EM&V post-observation was performed again on 1-28-14 of RTU 5 (sticker 141619). Measured airflow was 3422 cfm (342 cfm/ton) at 0.93 inches of water column (IWC) total static pressure, fan speed of 1023 RPM (2 turns), and fan power of 2322W. The factory setting is 3 turns or 959 RPM. Refrigerant was recovered and weighed out of both circuits. Circuit 1 was undercharged by 4.5 ounces (2.5%) and circuit 2 was undercharged by 2 ounces (1%).

WO32 EM&V post-observation was performed again on 1-29-14 of RTU 5 (sticker 141619). The failed condenser fan was replaced with a new fan by the WO32 master HVAC evaluation technicians. After installing the new condenser fan, the COA dropped to 15.8°F on circuit 1 and 19.6°F on circuit 2 at 77.6°F OAT and 56.3°F RWB. With both condenser fans operating and factory charge the CEC RCA protocol diagnosed correct charge. Circuit 1 subcooling was 10.9°F or 0.9 above 10°F target and within 11 +/- 4°F program tolerance. Circuit 2 subcooling was 13.7°F or 3.7F above 10°F target and within 11 +/- 4°F program tolerance. Temperature split was 19.9°F or -0.2°F below 20.1°F CEC RCA target and within 20 +/- 2°F program tolerance. Circuit 1 discharge pressure was 200 psig or -5 below 205 psig manufacturer target. Circuit 2 discharge pressure was 206.1 psig or -4.4 below 210.5 psig manufacturer target. Circuit 1 suction pressure was 62.1 psig or -15.7 below 76.8 psig manufacturer target. Circuit 2 suction pressure was 62.4 psig or -13.3 below 75.7 psig manufacturer target. Circuit 1 approach was 4.9°F or -2.1 below 7°F manufacturer target (tolerance is +/-1°F). Circuit 2 approach was 5.9°F or -1.1 below 7°F manufacturer target. EST was 35.3°F for circuit 1 and 35.6°F for circuit 2. Low suction pressure, low EST, and low approach temperature indicate heat transfer issues for both circuits. With both condenser fans operating and factory charge the field-measured efficiency increased by 33% from 6.7 EER* (72.5°F OAT) to 8.9 EER* (77.6°F OAT). On 2-11-14 the fan speed was adjusted to 3 turns (factory setting) or 959 RPM. The airflow was 3235 cfm (324 cfm/ton) and fan power was 1844W (20.6%). Temperature split was 20.9 or 0.8°F above 20.1°F CEC RCA target and within 20 +/- 2°F program tolerance indicating proper airflow. With 3 turns the field-measured efficiency increased by to 9.9 EER* (77.6°F OAT) a 10.5% increase from 2 turns and 48% increase from the as found 6.7 EER* (72.5°F OAT).

C. Residential Quality Installation Test Results by Site

Table 3: Site Information And Airflow Results

Site ID	Part/ Non-Part	IOU	CZ	Served Area (ft^2)	AHU CFM (Cooling)	Tonnage Installed	CFM/Ton	External Static Pressure (Cooling, IWC)
1	P	SCE	9	1859	1213	4	303	1.11
2	P	SCE	10	2552	1509	5	302	1.45
3	P	SCE	10	2124	1361	4	340	0.70
4	P	SCE	10	2520	1392	4	348	1.40
5	P	SCE	10	2150	1526	4	381	1.14
6	P	SCE	10	2117	1332	4	333	1.40
7	P	SCE	10	1106	1112	4	278	1.55
8	P	SCE	10	1970	1383	5	277	0.70
9	P	SCE	10	1988	1089	3	363	0.80
10	P	SCE	15	1680	1137	5	227	0.96
11	P	SCE	10	3290	1522	5	304	0.89
12	P	SCE	15	1213	977	3	326	0.50
13	P	SCE	10	2669	1433	5	287	0.92
14	P	SCE	10	1620	1033	3	344	1.19
15	P	SCE	10	1121	1183	3	394	0.53
16	P	SCE	10	1556	943	3	314	0.91
17	P	SCE	10	2825	1312	5	262	1.43
18	P	SCE	14	1200	859	3	344	0.33
19	P	SCE	9	1437	936	2	468	0.80
20	P	SCE	15	1540	927	3	309	0.65
21	P	SCE	10	1313	1109	3	370	0.73
22	P	SCE	9	1840	-	4	-	0.76
23	P	SCE	10	1704	1045	3	348	0.60
24	P	SCE	10	2360	1283	5	257	0.85
25	P	SCE	8	2200	1296	4	370	1.15
26	P	SCE	10	1904	1431	4	358	0.87
27	P	SCE	10	1832	1448	4	362	1.24
28	P	SCE	10	1910	1285	3	428	0.68
29	P	SCE	8	1753	888	3	296	0.51
30	P	SCE	10	2441	1516	4	379	1.20
31	P	SCE	8	2099	436	3	145	0.80
32	P	SCE	14	1986	656	3	219	0.66

Site ID	Part/ Non-Part	IOU	CZ	Served Area (ft^2)	AHU CFM (Cooling)	Tonnage Installed	CFM/Ton	External Static Pressure (Cooling, IWC)
33	P	SCE	10	1471	959	3	320	0.75
34	P	SCE	10	2015	1409	3	470	1.20
35	P	SCE	9	2219	1565	4	391	0.79
36	P	SCE	8	1580	857	3	286	1.04
37	P	SCE	10	2999	1347	5	269	1.27
38	P	SCE	8	1144	1175	3	392	0.75
39	P	SCE	8	1583	1009	2	505	1.01
40	P	SCE	10	1905	1190	4	297	1.52
41	P	SCE	9	1797	1162	4	290	0.90
42	P	SCE	15	1716	1893	5	379	1.60
43	P	SCE	13	1661	1531	4	437	0.50
44	P	SCE	15	1476	1515	4	379	1.24
45	P	SCE	14	2802	956	4	239	1.04
46	P	SCE	10	1871	1112	3	371	0.35
47	P	SCE	9	1314	969	3	323	0.62
48	P	SCE	9	1732	1072	3	357	0.79
49	P	SCE	9	1022	1276	3	425	0.52
50	P	SCE	15	1974	1487	4	372	1.42
51	NP	SDG&E	10	2610	830	3	314	0.48
52	NP	SDG&E	10	2784	999	4	250	-
53	NP	SDG&E	10	1470	617	3	473	-
54	NP	SDG&E	10	2660	704	4	215	-
55	NP	SDG&E	10	3150	1400	5	224	0.60
56	NP	SDG&E	9	1480	954	3	247	-
57	NP	SDG&E	10	1352	1410	3	293	-
58	NP	SDG&E	10	1413	1781	5	379	-
59	NP	SDG&E	10	1386	1254	4	295	-
60	NP	SDG&E	10	2755	894	4	211	-
61	NP	SCE	10	1165	1076	5	272	-
62	NP	SCE	13	1252	1138	3	309	-
63	NP	SCE	10	1594	1478	4	346	-
64	NP	SCE	10	1488	998	4	250	-
65	NP	SCE	9	1880	723	3	280	-
66	NP	SCE	8	2096	786	3	199	0.84
67	NP	SCE	9	1518	873	3	285	0.72
68	NP	SCE	14	2000	756	3	176	-
69	NP	SCE	9	1625	1237	5	-	0.89

Site ID	Part/ Non-Part	IOU	CZ	Served Area (ft^2)	AHU CFM (Cooling)	Tonnage Installed	CFM/Ton	External Static Pressure (Cooling, IWC)
70	NP	SCE	9	740	1152	4	247	0.64
71	NP	SCE	10	2865	920	3	232	0.08
72	NP	SCE	13	1584	772	3	280	0.48
73	NP	SCE	13	1641	700	3	413	0.54
74	NP	SCE	9	1200	1238	3	223	0.42
75	NP	SCE	9	1080	884	3	-	-
76	NP	SCE	8	1716	1027	4	250	-
77	NP	SCE	10	2250	1160	5	370	-
78	NP	SCE	14	1080	742	3	332	-
79	NP	PG&E	13	2282	1418	3	222	-
80	NP	PG&E	13	1434	-	2	358	-
81	NP	PG&E	13	1928	-	4	280	-
82	NP	PG&E	12	1125	-	-	291	-
83	NP	PG&E	11	2026	795	4	405	0.19
84	NP	PG&E	12	1421	634	3	329	0.07
85	NP	PG&E	13	1526	750	3	197	0.31
86	NP	PG&E	12	800	817	3	224	0.12
87	NP	PG&E	12	1600	1385	4	307	0.03
88	NP	PG&E	13	1065	981	4	252	0.06
89	NP	PG&E	12	-	669	3	318	0.18
90	NP	PG&E	12	1850	1138	4	241	0.42
91	NP	PG&E	12	1274	1572	3	262	-
92	NP	PG&E	11	2000	807	4	470	-
93	NP	PG&E	12	2400	1512	5	247	0.76
94	NP	PG&E	12	1414	928	3	524	-
95	NP	PG&E	12	1204	855	2	309	0.63
96	NP	PG&E	11	3992	2026	5	356	-
97	NP	PG&E	12	2622	1111	5	302	-
98	NP	PG&E	12	1642	1433	4	202	-
99	NP	PG&E	11	1870	1769	5	570	1.26
100	NP	PG&E	13	1663	690	4	354	.537

Table 4: Duct Leakage And Infiltration

Site ID	Leakage To Outside, CFM_{25}	Leakage To Outside, CFM_{50}	Leakage To Outside (CFM_{25}), % of Nominal Airflow	Total Duct Leakage, CFM (25Pa)	Total Duct Leakage, CFM (50Pa)	Total Duct Leakage (CFM_{25}), % of Nominal Airflow	Infiltration (-25Pa)	Infiltration (-50Pa)
1	185	285	11.6%	269	579	16.8%	2152	3241
2	73	113	3.7%	128	200	6.4%	1334	1947
3	87	137	5.4%	127	193	7.9%	1184	1834
4	142	206	8.9%	225	339	14.1%	1589	2589
5	153	239	9.6%	214	332	13.4%	1396	2132
6	117	169	7.3%	158	241	9.9%	1356	2080
7	121	180	7.6%	139	211	8.7%	1756	2715
8	161	-	8.1%	603	-	11.3%	7804	-
9	25	40	2.1%	136	223	11.3%	1436	2275
10	159	238	8.0%	174	287	8.7%	1727	2676
11	33	49	1.7%	92	144	4.6%	2813	4290
12	151	242	12.6%	235	361	19.6%	3720	5663
13	160	250	8.0%	267	400	13.4%	1588	2463
14	-	-	-	136	208	11.3%	886	1350
15	78	118	6.5%	98	153	8.2%	851	1342
16	76	120	6.3%	146	231	12.2%	738	1124
17	136	205	6.8%	250	378	12.5%	1756	2764
18	186	292	18.6%	251	380	25.1%	757	1213
19	89	137	11.1%	173	271	21.6%	1223	1807
20	156	248	13.0%	170	275	14.2%	873	1339
21	106	161	8.8%	120	183	10.0%	964	1419
22	59	79	4.2%	170	333	12.1%	1370	2250
23	29	43	2.4%	155	252	12.9%	895	1374
24	116	179	5.8%	216	363	10.8%	1675	2739
25	100	156	7.1%	215	334	15.4%	1552	2473
26	78	120	4.9%	105	163	6.6%	965	1428
27	348	442	21.8%	476	650	29.8%	1455	2214
28	88	129	7.3%	127	199	10.6%	1050	1639
29	128	184	10.7%	173	269	14.4%	1283	2005
30	72	104	4.5%	144	242	9.0%	2449	3795
31	87	126	7.3%	158	249	13.2%	940	1410
32	87	140	7.3%	118	184	9.8%	1568	2539
33	45	70	3.8%	111	178	9.3%	936	1375
34	69	112	5.8%	116	181	9.7%	827	1237

Site ID	Leakage To Outside, CFM_{25}	Leakage To Outside, CFM_{50}	Leakage To Outside (CFM_{25}), % of Nominal Airflow	Total Duct Leakage, CFM (25Pa)	Total Duct Leakage, CFM (50Pa)	Total Duct Leakage (CFM_{25}), % of Nominal Airflow	Infiltration (-25Pa)	Infiltration (-50Pa)
35	45	72	2.8%	100	152	6.3%	2816	4186
36	157	245	13.1%	229	342	19.1%	1193	1844
37	79	130	4.0%	214	332	10.7%	2607	4355
38	97	162	8.1%	133	220	11.1%	1310	2076
39	124	192	15.5%	143	224	17.9%	1145	1741
40	67	110	4.2%	120	200	7.5%	1134	1801
41	-	-	-	450	798	-	2365	3730
42	208	315	10.4%	275	430	13.8%	2226	3244
43	138	224	9.9%	178	297	12.7%	1046	1637
44	-	-	-	284	363	-	-	-
45	29	60	1.8%	290	477	18.1%	1687	2655
46	65	105	5.4%	81	133	6.8%	721	1117
47	-	227	-	218	352	18.2%	1390	2142
48	45	70	3.8%	55	84	4.6%	1325	2035
49	34	53	2.8%	87	134	7.3%	577	887
50	167	265	10.4%	265	415	16.6%	1389	2116
51	43	77	4.3%	86	136	15.1%	608	888
52	-	-	-	-	-	6.6%	1406	2158
53	279	412	27.9%	353	578	18.7%	348	827
54	-	-	-	904	-	-	2212	3473
55	435	498	21.8%	497	807	11.7%	4649	7271
56	99	150	8.3%	112	176	-	1224	1858
57	177	267	14.8%	219	393	27.9%	1441	2250
58	284	439	14.2%	414	648	17.3%	2931	4715
59	31	47	1.9%	242	395	-	-	-
60	64	102	4.0%	187	284	-	-	-
61	-	-	-	-	-	24.5%	-	-
62	-	-	-	208	330	15.4%	-	-
63	98	151	6.1%	143	225	10.9%	801	1269
64	42	64	2.6%	105	165	14.0%	714	1111
65	119	191	9.9%	163	251	-	3058	4733
66	149	232	12.4%	243	369	-	948	1515
67	28	44	2.3%	37	58	17.3%	615	1012
68	268	402	22.3%	277	434	-	1072	1661
69	112	176	5.6%	128	199	26.0%	1626	2661

Site ID	Leakage To Outside, CFM_{25}	Leakage To Outside, CFM_{50}	Leakage To Outside (CFM_{25}), % of Nominal Airflow	Total Duct Leakage, CFM (25Pa)	Total Duct Leakage, CFM (50Pa)	Total Duct Leakage (CFM_{25}), % of Nominal Airflow	Infiltration (-25Pa)	Infiltration (-50Pa)
70	180	271	12.9%	208	311	35.3%	1268	1952
71	42	70	3.5%	87	130	35.8%	910	1394
72	126	209	12.6%	154	248	10.5%	1090	1629
73	73	116	7.3%	105	161	5.1%	1605	2517
74	24	38	2.0%	61	93	9.9%	647	978
75	261	433	21.8%	566	866	11.0%	270	402
76	87	131	6.2%	390	608	-	2769	4323
77	586	932	29.3%	715	1052	8.9%	934	1450
78	-	-	-	-	-	8.6%	1360	2081
79	179	260	14.9%	224	351	7.5%	1322	2115
80	24	37	3.0%	90	128	-	454	743
81	226	342	14.1%	415	632	24.9%	1551	2358
82	335	667	-	428	710	3.1%	1981	3032
83	418	618	26.1%	551	782	13.5%	1620	2607
84	599	-	49.9%	-	-	14.9%	3728	5385
85	120	196	10.0%	168	266	12.3%	1589	2456
86	261	292	21.8%	294	443	16.2%	2407	3679
87	146	214	9.1%	175	276	7.3%	1161	1781
88	276	406	19.7%	323	642	23.1%	1627	2550
89	109	164	9.1%	119	182	9.3%	1185	1921
90	174	249	10.9%	277	432	13.6%	732	1194
91	128	194	10.7%	324	531	20.3%	1221	1890
92	103	165	6.4%	282	423	18.3%	1531	2405
93	287	415	14.4%	461	744	6.4%	3270	5519
94	126	189	10.5%	385	601	27.0%	2137	3330
95	32	52	5.3%	141	215	32.1%	1148	1872
96	72	117	3.6%	270	405	20.7%	1564	2432
97	104	163	5.2%	150	252	23.1%	1578	2538
98	272	370	17.0%	279	551	17.6%	2230	3357
99	133	200	6.7%	179	268	23.5%	1316	2001
100	162	258	11.6%	172	279	9.0%	881	1363

Table 5: Manual J Loads

Site ID	Manual J Sensible Cooling Load (Btuh)	Manual J Total Cooling Load (Btuh)	Manual J Rec. Tonnage	Installed Tonnage	Tonnage Difference Between Manual J and Installed (> 0 oversized, < 0 undersized)
1	36,695	39,135	3.6	4.0	0.4
2	43,087	44,147	4.8	5.0	0.2
3	27,862	28,230	3.1	4.0	0.9
4	34,561	36,239	3.8	4.0	0.2
5	34,337	35,457	3.8	4.0	0.2
6	39,428	41,163	4.4	4.0	-0.4
7	34,815	35,866	3.9	4.0	0.1
8	42,810	44,550	4.8	5.0	0.2
9	25,489	27,087	2.8	3.0	0.2
10	40,128	41,704	4.5	5.0	0.5
11	46,469	49,847	5.2	5.0	-0.2
12	24,501	25,072	2.7	3.0	0.3
13	41,857	42,982	4.7	5.0	0.4
14	26,649	27,910	3.0	3.0	0.0
15	28,953	29,886	3.2	3.0	-0.2
16	30,879	31,815	3.4	3.0	-0.4
17	40,700	42,475	4.5	5.0	0.5
18	18,487	18,954	2.1	2.5	0.5
19	19,851	20,871	2.4	2.0	-0.4
20	26,679	27,922	3.0	3.0	0.0
21	27,518	28,462	3.1	3.0	-0.1
22	30,881	32,242	3.4	3.5	0.1
23	29,743	31,297	2.6	3.0	0.4
24	42,133	43,672	3.6	5.0	1.4
25	29,800	32,142	3.2	3.5	0.3
26	35,929	37,390	3.1	4.0	0.9
27	35,107	36,556	3.1	4.0	1.0
28	31,326	32,298	3.7	3.0	-0.7
29	29,612	31,254	2.6	3.0	0.4
30	37,390	39,152	4.2	4.0	-0.2
31	25,829	27,394	2.3	3.0	0.7
32	29,698	30,146	3.3	3.0	-0.3
33	22,467	24,126	2.5	3.0	0.5
34	27,539	29,107	3.1	3.0	-0.1
35	40,689	41,842	4.8	4.0	-0.8

Site ID	Manual J Sensible Cooling Load (Btuh)	Manual J Total Cooling Load (Btuh)	Manual J Rec. Tonnage	Installed Tonnage	Tonnage Difference Between Manual J and Installed (> 0 oversized, < 0 undersized)
36	23,634	25,913	2.2	3.0	0.8
37	45,280	45,880	5.0	5.0	0.0
38	25,901	27,316	2.3	3.0	0.7
39	21,704	23,410	2.0	2.0	0.1
40	39,935	40,837	3.4	4.0	0.6
41	34,263	35,233	3.8	4.0	0.2
42	47,217	48,632	4.1	5.0	1.0
43	31,362	32,921	2.7	3.5	0.8
44	34,531	35,441	3.0	4.0	1.1
45	36,127	36,274	3.0	4.0	1.0
46	23,408	25,086	2.6	3.0	0.4
47	27,196	28,329	3.2	3.0	-0.2
48	26,550	27,349	3.0	3.0	0.0
49	23,381	25,011	2.1	3.0	0.9
50	34,866	36,317	3.0	4.0	1.0
51	-	22,464	2.3	2.5	0.2
52	-	57,661	6.0	4.0	-2.0
53	-	21,983	1.2	2.5	1.3
54	-	71,194	7.9	4.0	-3.9
55	-	79,636	8.8	5.0	-3.8
56	-	-	-	3.0	-
57	-	52,573	5.8	3.0	-2.8
58	-	47,423	5.3	5.0	-0.3
59	-	34,294	3.5	4.0	0.5
60	-	43,956	4.7	4.0	-0.7
61	-	34,376	3.6	5.0	1.4
62	-	51,431	5.4	3.0	-2.4
63	-	51,829	5.6	4.0	-1.6
64	-	39,048	4.1	4.0	-0.1
65	-	37,904	4.0	3.0	-1.0
66	-	40,668	4.3	3.0	-1.3
67	-	34,391	3.7	3.0	-0.7
68	-	30,482	3.1	3.0	-0.1
69	-	57,169	6.2	5.0	-1.2
70	-	45,526	4.7	3.5	-1.2
71	-	44,786	4.8	3.0	-1.8

Site ID	Manual J Sensible Cooling Load (Btuh)	Manual J Total Cooling Load (Btuh)	Manual J Rec. Tonnage	Installed Tonnage	Tonnage Difference Between Manual J and Installed (> 0 oversized, < 0 undersized)
72	-	36,339	4.0	2.5	-1.5
73	-	36,247	3.9	2.5	-1.4
74	-	42,476	4.5	3.0	-1.5
75	-	32,364	3.4	3.0	-0.4
76	-	48,535	4.9	3.5	-1.4
77	-	64,734	7.2	5.0	-2.2
78	-	37,616	3.8	3.0	-0.8
79	-	46,035	4.7	3.0	-1.7
80	-	21,913	2.2	2.0	-0.2
81	-	17,909	1.9	4.0	2.1
82	-	62,832	6.8	-	-
83	-	46,268	4.6	4.0	-0.6
84	-	63,811	6.9	3.0	-3.9
85	-	44,992	4.8	3.0	-1.8
86	-	44,609	4.8	3.0	-1.8
87	-	48,053	5.2	4.0	-1.2
88	-	43,979	4.9	3.5	-1.4
89	-	35,484	3.7	3.0	-0.7
90	-	36,009	3.7	4.0	0.3
91	-	28,922	3.1	3.0	-0.1
92	-	64,667	7.0	4.0	-3.0
93	-	63,683	7.1	5.0	-2.1
94	-	46,346	5.1	3.0	-2.1
95	-	43,410	4.8	1.5	-3.3
96	-	77,924	9.8	5.0	-4.8
97	-	83,516	9.2	5.0	-4.2
98	-	54,811	6.1	4.0	-2.1
99	-	54,736	5.9	5.0	-0.9
100	-	47,916	5.1	3.5	-1.6

Table 6: Manual S Loads (Participants Only)

Site ID	Manual S Sensible Cooling Load (Btuh)	Manual S Total Cooling Load (Btuh)	Manual S Rec. Tonnage	Installed Tonnage	Tonnage Difference Between Manual S and Installed (> 0 oversized, < 0 undersized)
1	37,753	42,347	3.5	4.0	0.5
2	39,627	47,233	3.9	5.0	1.1
3	27,910	32,830	2.7	4.0	1.3
4	39,541	44,651	3.7	4.0	0.3
5	38,156	45,825	3.8	4.0	0.2
6	37,676	43,868	3.7	4.0	0.3
7	37,953	40,265	3.4	4.0	0.6
8	45,561	54,941	4.6	5.0	0.4
9	28,235	32,190	2.7	3.0	0.3
10	44,636	48,225	4.0	5.0	1.0
11	47,538	51,126	4.3	5.0	0.7
12	27,280	29,690	2.5	3.0	0.5
13	44,969	54,875	4.6	5.0	0.4
14	29,392	34,507	2.9	3.0	0.1
15	28,562	32,410	2.7	3.0	0.3
16	29,982	35,153	2.9	3.0	0.1
17	45,837	55,492	4.6	5.0	0.4
18	19,612	24,750	2.1	2.5	0.4
19	19,250	22,583	1.9	2.0	0.1
20	28,182	32,573	2.7	3.0	0.3
21	29,217	34,893	2.9	3.0	0.1
22	30,620	35,840	3.0	3.5	0.5
23	30,450	34,860	2.9	3.0	0.1
24	46,761	57,125	4.8	5.0	0.2
25	30,692	36,693	3.1	3.5	0.4
26	37,527	45,150	3.8	4.0	0.2
27	39,400	45,600	3.8	4.0	0.2
28	30,330	34,460	2.9	3.0	0.1
29	26,080	34,000	2.8	3.0	0.2
30	38,800	48,200	4.0	4.0	0.0
31	26,041	30,947	2.6	3.0	0.4
32	28,800	34,100	2.8	3.0	0.2
33	25,700	30,500	2.5	3.0	0.5
34	31,200	34,800	2.9	3.0	0.1
35	37,840	42,160	3.5	4.0	0.5

Site ID	Manual S Sensible Cooling Load (Btuh)	Manual S Total Cooling Load (Btuh)	Manual S Rec. Tonnage	Installed Tonnage	Tonnage Difference Between Manual S and Installed (> 0 oversized, < 0 undersized)
36	27,273	30,408	2.5	3.0	0.5
37	49,600	55,600	4.6	5.0	0.4
38	26,013	31,266	2.6	3.0	0.4
39	21,889	25,301	2.1	2.0	-0.1
40	39,400	45,600	3.8	4.0	0.2
41	31,707	41,504	3.5	4.0	0.5
42	48,100	51,900	4.3	5.0	0.7
43	33,924	37,632	3.1	3.5	0.4
44	36,500	42,800	3.6	4.0	0.4
45	40,300	45,800	3.8	4.0	0.2
46	26,600	33,500	2.8	3.0	0.2
47	25,868	33,622	2.8	3.0	0.2
48	29,150	35,300	2.9	3.0	0.1
49	24,962	31,533	2.6	3.0	0.4
50	39,700	42,200	3.5	4.0	0.5

Table 7: Fan Power and Draw

Site ID	Fan Watts (cooling mode)	Airflow, CFM	Fan Draw, W/CFM
1	-	1213	-
2	838	1509	0.555
3	-	1361	-
4	1096	1392	0.787
5	748	1526	0.490
6	656	1332	0.492
7	431	1112	0.387
8	-	1383	-
9	254	1089	0.233
10	-	1137	-
11	-	1522	-
12	385	977	0.394
13	842	1433	0.588
14	522	1033	0.505
15	-	1183	-
16	246	943	0.261
17	266	1312	0.203
18	-	859	-
19	580	936	0.620
20	589	927	0.635
21	458	1109	0.413
22	-	-	-
23	335	1045	0.321
24	1132	1283	0.882
25	616	1296	0.475
26	616	1431	0.431
27	482	1448	0.333
28	478	1285	0.372
29	213	888	0.240
30	790	1516	0.521
31	430	436	0.986
32	351	656	0.535
33	380	959	0.396
34	848	1409	0.602
35	745	1565	0.476
36	-	857	-

Site ID	Fan Watts (cooling mode)	Airflow, CFM	Fan Draw, W/CFM
37	-	1347	-
38	502	1175	0.427
39	-	1009	-
40	776	1190	0.652
41	627	1162	0.540
42	901	1893	0.476
43	-	1531	-
44	1003	1515	0.662
45	559	956	0.585
46	369	1112	0.332
47	-	969	-
48	461	1072	0.430
49	420	1276	0.329
50	614	1487	0.413
51	454	830	0.547
52	1531	999	1.533
53	180	617	0.291
54	700	704	0.994
55	916	1400	0.654
56	607	954	0.636
57	609	1410	0.432
58	295	1781	0.166
59	937	1254	0.747
60	810	894	0.906
61	770	1076	0.716
62	-	1138	-
63	872	1478	0.590
64	953	998	0.955
65	-	723	-
66	646	786	0.822
67	1225	873	1.403
68	430	756	0.569
69	810	1237	0.655
70	-	1152	-
71	556	920	0.604
72	-	772	-
73	710	700	1.014

Site ID	Fan Watts (cooling mode)	Airflow, CFM	Fan Draw, W/CFM
74	721	1238	0.582
75	-	884	-
76	-	1027	-
77	627	1160	0.540
78	329	742	0.443
79	-	1418	-
80	644	-	-
81	578	-	-
82	-	-	-
83	550	795	0.692
84	325	634	0.512
85	410	750	0.547
86	-	817	-
87	561	1385	0.405
88	424	981	0.432
89	408	669	0.610
90	561	1138	0.493
91	540	1572	0.344
92	542	807	0.672
93	370	1512	0.245
94	290	928	0.313
95	242	855	0.283
96	1145	2026	0.565
97	-	1111	-
98	566	1433	0.395
99	-	1769	-
100	-	690	-

D. Laboratory Instrumentation Testing

D.1 Laboratory Tests – Field Measurement Instrument Accuracy Tests

The following field measurement instruments are being tested: 1) digital instruments to measure refrigerant tube surface temperatures, 2) digital instruments to measure air relative humidity (dry-bulb and wet-bulb), 3) digital refrigerant pressure gauges, 4) analog refrigerant pressure gauges, 5) digital instruments to measure airflow (CFM), 6) digital instruments to measure airflow static pressure, and 7) digital instruments to measure duct pressurization (and leakage). Tests are partially completed for refrigerant tube, airflow, and pressure measurement instruments at 95°F and 115°F condenser entering air temperature and 80°F drybulb and 67°F wetbulb return air temperatures.

Refrigerant Tube Measurement Instrument Tests

Refrigerant tube measurement instruments are tested at 55°F, 95°F, and 115°F condenser entering air temperatures. Approximately 100 instruments from 9 manufacturers are being tested. The refrigerant tube measurement instruments are described in **Table 8**. Best tests are performed with sensors mounted at 10:00 or 2:00 o'clock positions (cross-section view) on suction and liquid lines near the Intertek TC sensors located near the service valves. The worst case tests are performed with sensors mounted at the bottom 6:00 o'clock position and no insulation for bead or linear probes (**Figure 4**). Liquid refrigerant might be flowing at the bottom 6 o'clock position. Other worst cases include improperly calibrated sensors or sensors mounted more than 12 inches away from the service valve.

Table 8. Refrigerant Tube Measurement Instrument Tests

	Description	Qty.	Labels	Best Tests	Worst Case Tests
1	Type K Clamp 1.25-2.5" dia.	8	A1-A8	10 or 2 o'clock	6 o'clock
2	Type K Clamp 0.375-1.375" dia.	8	B1-B8	10 or 2 o'clock	6 o'clock
3	Type K Clamp 0.375-2.25" dia.	8	C1-C8	10 or 2 o'clock	6 o'clock
4	10K Thermistor Clamp 0.25-1.4" dia	8	D1-D8	10 or 2 o'clock	6 o'clock
5	10K Thermistor velcro strap 3" dia.	7	E1-E7	10 or 2 o'clock	6 o'clock
6	Type K Clamp 0.25-1.375" dia.	8	F1-F8	10 or 2 o'clock	6 o'clock
7	10K Thermistor Clamp 0.375-2.125" dia.	5	G1-G5	10 or 2 o'clock	6 o'clock
9	Type K Clamp 0.25-2.125" dia.	1	I1	10 or 2 o'clock	6 o'clock
10	Type K Clamp 0.25-1.375" dia.	8	J1-J8	10 or 2 o'clock	6 o'clock
11	10K Thermistors 0.1875" x 1.125"	4	K1-K4	10 or 2 o'clock	6 o'clock and no insulation
12	10K Thermistors 0.25" dia. x 1.25"	8	L1-L8	10 or 2 o'clock	6 o'clock and no insulation
13	Type K bead AWG #24	8	N1-N8	10 or 2 o'clock	6 o'clock and no insulation

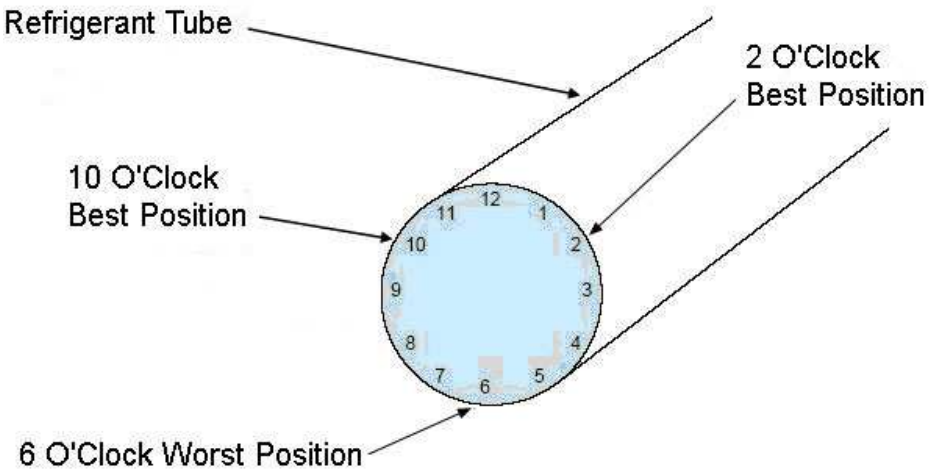


Figure 5. Best and Worst Positions to Attach Refrigerant Tube Sensors

Preliminary test results for refrigerant tube measurement instruments are shown in **Figures 6** through **13**. The figures show that it can take 5 to 10 minutes or longer for sensors to measure refrigerant temperatures. Tests were conducted with eight sensors on liquid and suction lines. The smallest differences are with specific Type-K clamp probes with accuracy ranging from 1.1 +/- 0.6°F on suction lines at 115°F. Some Type-K clamp probes have suction line accuracy ranging from 6.8 +/- 1.0°F when tested at 115°F outdoor conditions. Differences in accuracy are attributable to design and manufacturing. The largest differences were found with Type-K bead probes and thermistors. Bead probes had differences of 10.7 +/- 3.3°F, cylindrical thermistors had differences of 9.7 +/- 7.1°F, and clamp thermistors had differences of 5.4 +/- 2.1°F. The largest differences are with the suction line measurements where tube temperatures are 25 to

40°F less than ambient. The liquid line temperature is typically 8F to 12F above ambient so there are smaller variations from measured temperatures to actual tube temperatures. It took 15 to 20 minutes to install bead and cylindrical probes and 15 to 20 minutes to bring test chambers to conditions so these probes were on tubes three times longer than clamp probes. Some refrigerant tube tests need to be performed again for consistency in terms of time probes are attached to tubes.

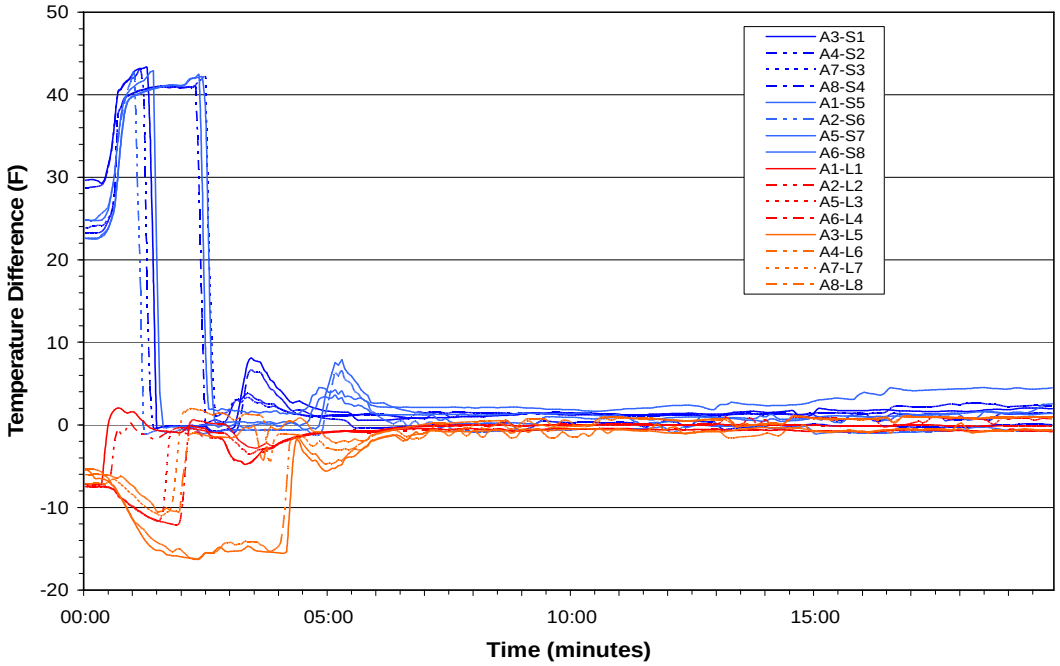


Figure 6. Type-K Pipe Clamp A1-A8 Temperature Difference at 95°F Ambient

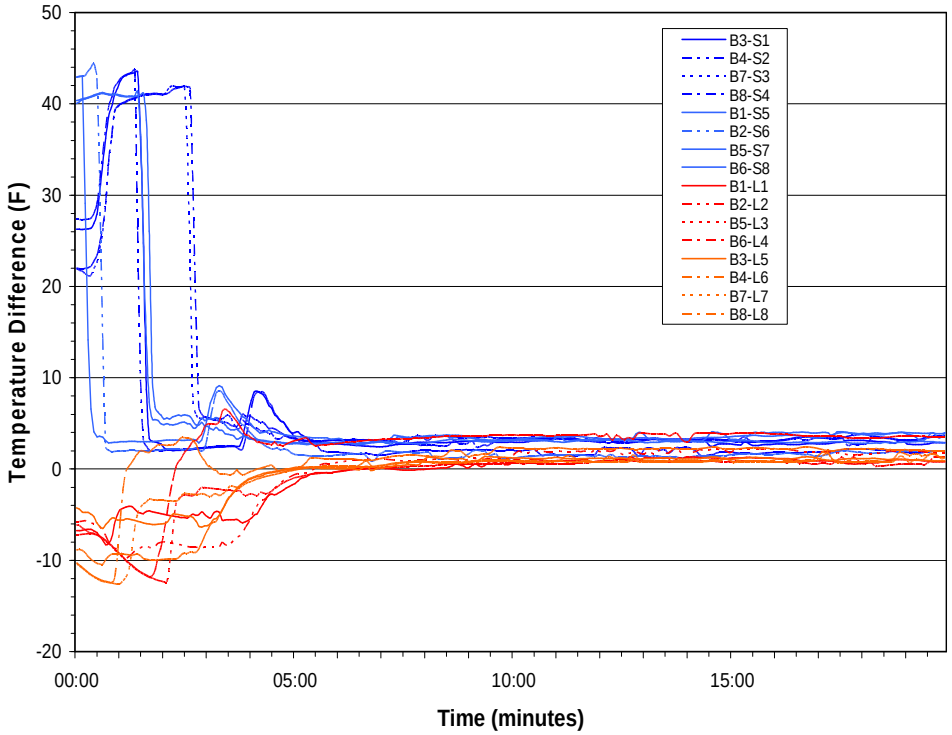


Figure 7. Type-K Pipe Clamp B1-B8 Temperature Difference at 95°F Ambient

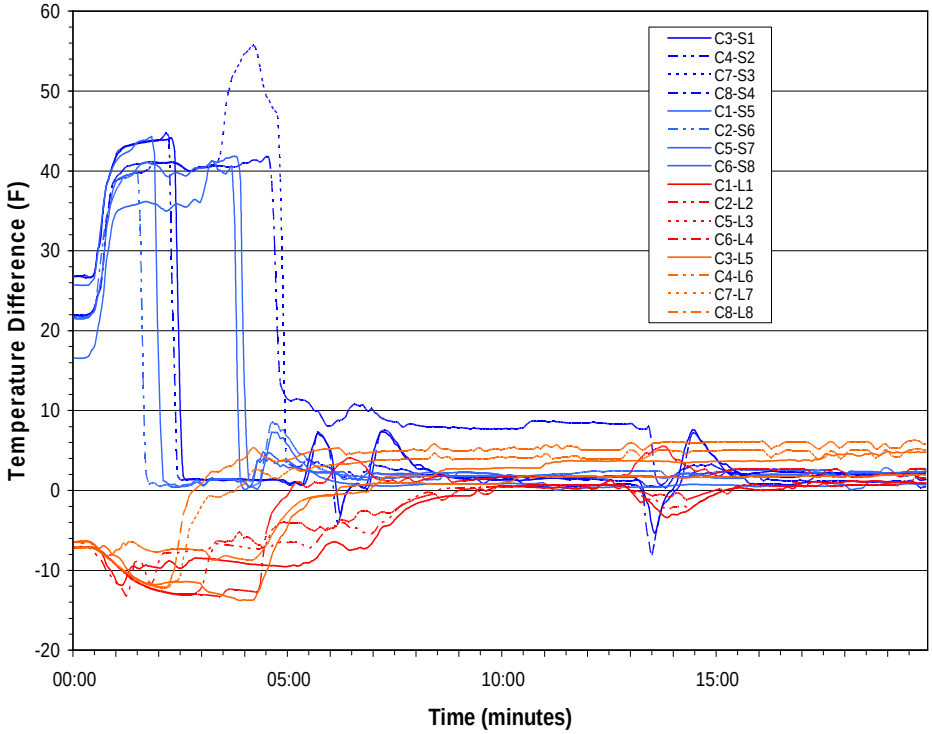


Figure 8. Type-K Pipe Clamp C1-C8 Temperature Difference at 95°F Ambient

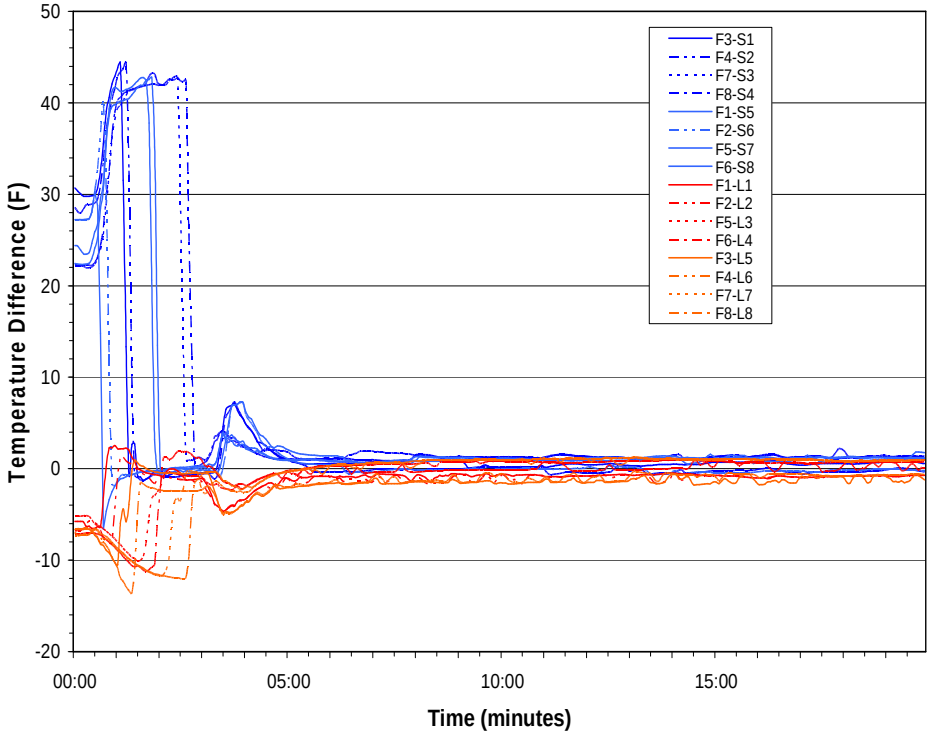


Figure 9. Type-K Pipe Clamp F1-F8 Temperature Difference at 95°F Ambient

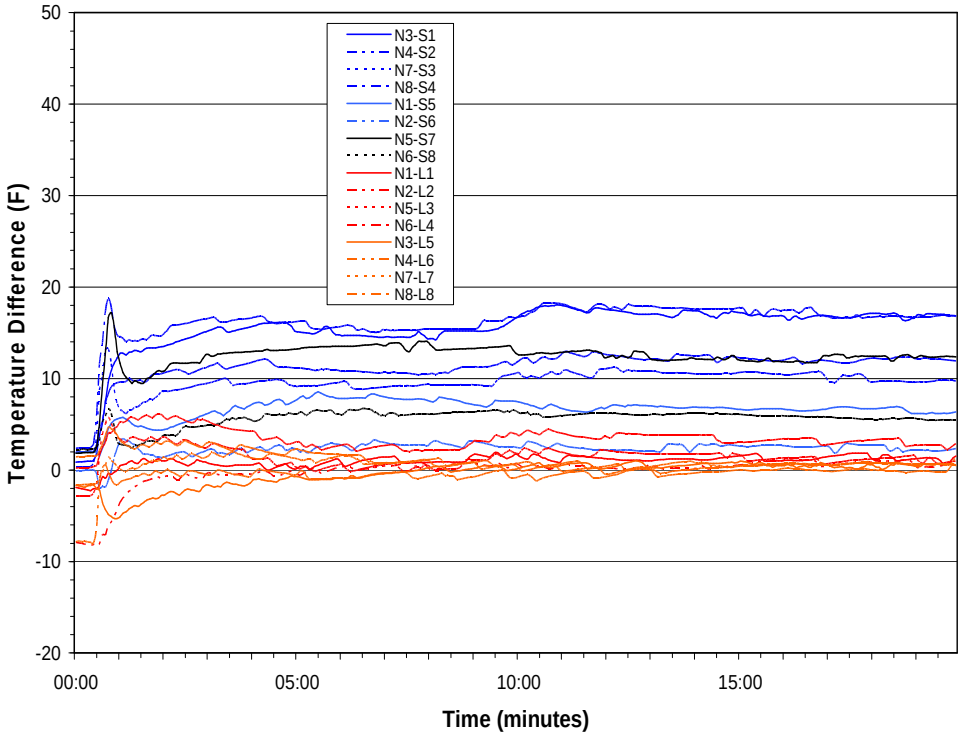


Figure 10. Type-K Insulated Bead Probes N1-N8 Temperature Difference at 95°F Ambient

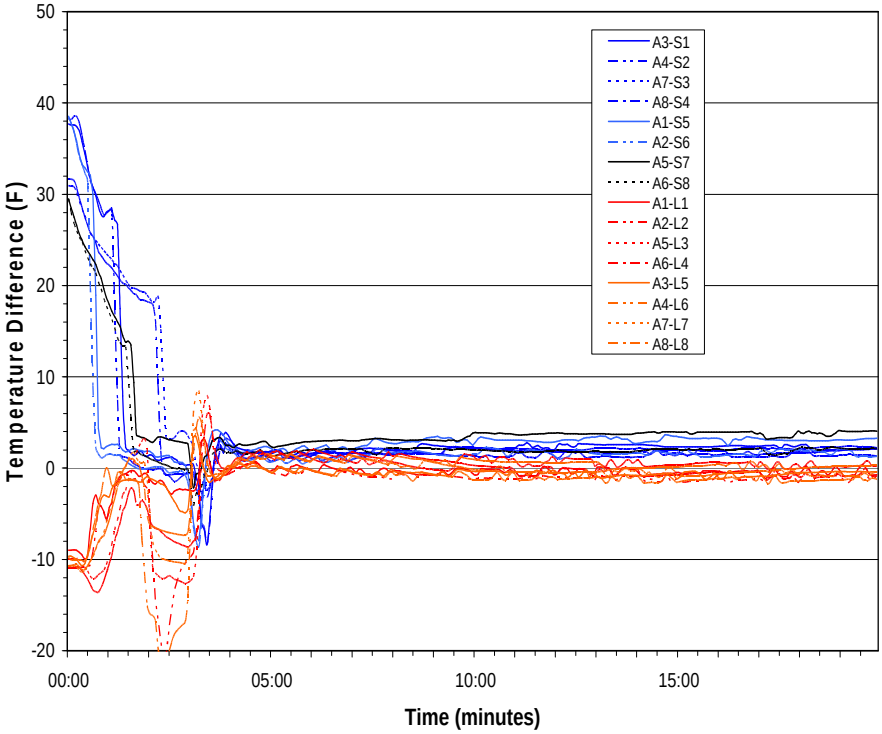


Figure 11. Type-K Clamp A1-A8 Temperature Difference at 115°F Ambient

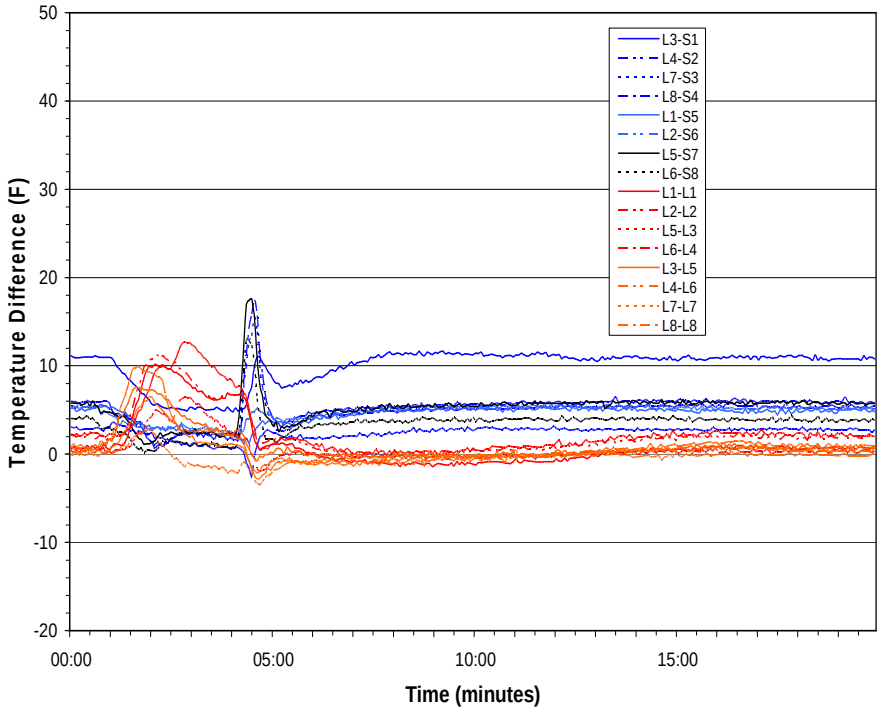
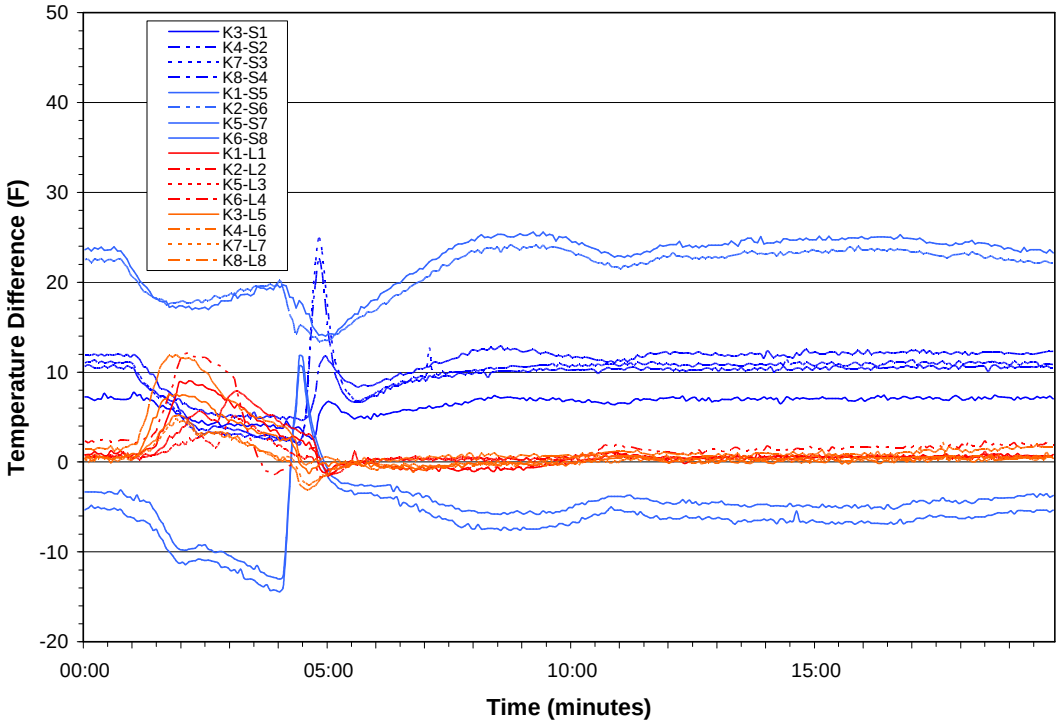


Figure 12. 10K Thermistor ¼" Diameter L1-L8 Temperature Difference at 115°F Ambient

Figure 2: 10K Thermistor 3/16" Diameter K1-K8 Temperature Difference at 115°F Ambient



Supply and Return Air Measurement Instrument Tests -Table 9 provides a summary of the supply and return air measurement instruments. There are approximately 93 instruments or sensors to test from 5 manufacturers. Tests will be performed with proper factory charge at the following conditions 80DB/67WB/95°F, 85DB/80WB/115°F, and 80DB/57WB/55°F.

Table 9. Supply and Return Air Measurement Instrument Tests

	Description	Qty.	Labels	Best Tests	Worst Tests
1	Digital Capacitance RH (WB) NTC (DB)	10	P1-P10	3	Bottom of duct, insulation, return
2	Digital Capacitance RH (WB) NTC (DB)	5	Q1-Q10	3	Bottom of duct, insulation, return
3	Digital Capacitance RH (WB) NTC (DB)	10	R1-R10	3	Bottom of duct, insulation, return
4	Digital Capacitance RH (WB) NTC (DB)	5	S1-S5	3	Bottom of duct, insulation, return
5	Digital Capacitance RH (WB) NTC (DB)	5	U1-U5	3	Bottom of duct, insulation, return
6	Digital Capacitance RH (WB) NTC (DB)	5	V1-V5	3	Bottom of duct, insulation, return
7	Digital Capacitance RH (WB) NTC (DB)	10	W1-W10	3	Bottom of duct, insulation, return
8	Digital Capacitance RH (WB) NTC (DB)	5	V1-V5	3	Bottom of duct, insulation, return
9	K-Type with wet wick	20	N1-N20	3	Dirty wick and muddy waters
10	K-Type with wet wick	10	O1-O10	3	Dirty wick and muddy waters
11	NTC with wet wick	3	Z1-Z3	3	Dirty wick and muddy waters

Pressure Measurement Instrument Tests - Table 10 provides a summary of the field pressure measurement instruments. There are approximately 63 instruments or sensors to test from 8 manufacturers. Tests are performed at five liquid and suction pressures (LP/SP) in pounds per square inch gauge (psig): 1) R22 low pressure (190LP/35SP), 2) R22 average pressure (270LP/70SP), 3) R22 high and R410 low pressure (320LP/105SP), 4) R410A average pressure (390LP/120SP), and 5) R410A high pressure (470LP/125SP). The worst case measurements are performed with refrigerant in hoses outfitted with EPA low-loss fittings left to soak in hot chamber (115°F) to strain sensors. Two digital pressure manifolds were found to be leaking refrigerant when taken out-of-the-box. These were removed from the sample. Preliminary laboratory tests of 15 digital and 7 analog field pressure measurement instruments have been completed. Best case average difference between laboratory and digital instruments is 0.57% +/- 0.24% based on measurements at ten different pressures with 15 instruments from 6 manufacturers. Best case average difference in accuracy between laboratory and analog instruments is 1.76% +/- 0.57% based on measurements at ten different pressures with 7 instruments from 2 manufacturers. Additional tests will be performed.

Table 10. Field Pressure Measurement Instrument Tests

	Description	Qty.	Labels	Best Tests	Worst Tests
1	Digital w/2 K-type clamps	5	AO1-AO5	Out of box	EPA hoses w/refrigerant hot chamber
2	Digital w/vacuum + 2 K-type clamps	2	AP1-AP2	Out of box	EPA hoses w/refrigerant hot chamber
3	Digital w/vacuum + 2 K-type clamps	2	AQ1-AQ2	Out of box	EPA hoses w/refrigerant hot chamber
4	Digital w/2 NTC clamps	3	AR1-AR3	Out of box	EPA hoses w/refrigerant hot chamber
5	Digital w/2 NTC clamps + datalogger	3	AS1-AS3	Out of box	EPA hoses w/refrigerant hot chamber
6	Digital w/2 NTC clamps	5	AT1-AT5	Out of box	EPA hoses w/refrigerant hot chamber
7	Digital	15	AU1-AU15	Out of box	EPA hoses w/refrigerant hot chamber
8	Digital w/1 K-type clamps	1	AV1	Out of box	EPA hoses w/refrigerant hot chamber
9	Digital w/2 K-type clamps	2	BKl-BK2	Out of box	EPA hoses w/refrigerant hot chamber
10	Digital w/2 K-type clamps	2	BL1-BL2	Out of box	EPA hoses w/refrigerant hot chamber
11	Analog	5	AW1-AW5	Out of box	EPA hoses w/refrigerant hot chamber
12	Analog	5	AX1-AX5	Out of box	EPA hoses w/refrigerant hot chamber
13	Analog	5	AY1-AY5	Out of box	EPA hoses w/refrigerant hot chamber
14	Analog	5	AZ1-AZ5	Out of box	EPA hoses w/refrigerant hot chamber
15	Analog	2	BA1-BA2	Out of box	EPA hoses w/refrigerant hot chamber

Airflow Measurement Instrument Tests - Table 11 provides a summary of the airflow measurement instruments. There are approximately 25 instruments or sensors to test from 8 manufacturers. Tests are performed with airflow ranging from 2,000, 2,500 to 3000 CFM (3 tests) at the following conditions 80DB/67WB/95F. The worst case measurements will be performed with airflow measurements taken at non-standard locations. Preliminary laboratory tests of the Pitot-tube array airflow grid from 1 manufacturer have been completed. The average difference between laboratory and field measurement instruments is 10.2% +/- 0.64% based on three measurements at 2,000, 2,500, and 3,000 CFM. Additional tests will be performed.

Table 11. Airflow Measurement Instrument Tests

	Description	Qty.	Labels	Best Tests	Worst Tests
1	Digital Vane Anemometer Data Logger	1	AA1	8	Non standard locations
2	Digital Vane Anemometer	1	AB1	8	Non standard locations
3	Pitot-Tube Array Airflow Grid	1	AC1	8	Non standard locations
4	Fan Powered Flow Hood	1	AD1	8	Non standard locations
5	Balometer hot-wire anemometer flow hood	1	AE1-AE3	8	Non standard locations
6	Mini-vane anemometer	2	AF1-AF2	8	Non standard locations
7	Vane anemometer	2	AG-1AG2	8	Non standard locations
8	Hot Wire Anemometer	1	AH1	8	Non standard locations
9	Integral Differential Pressure.	1	AI1	8	Non standard locations
10	Hot Wire Anemometer	2	AJ1-AJ2	8	Non standard locations
11	Mini-vane anemometer	2	AK1-AK2	8	Non standard locations
12	Hot-wire anemometer	2	AL1-AL2	8	Non standard locations
13	Micro-manometer	2	AM1-AM2	8	Non standard locations
14	Hot Wire Anemometer	1	AN1	8	Non standard locations
15	Digital Diff. Pressure Sensor	1	KEMA1	8	Non standard locations
16	Digital Thermal Airflow Sensor	1	KEMA2	8	Non standard locations

Vacuum Pump Measurement Instrument Tests- Table 12 provides a summary of the vacuum pump measurement instruments. There are 4 vacuum pumps and 3 micron gauges to test from 7 manufacturers. The worst case measurements will be performed with no vacuum/liquid drier, 30 minute vacuum with drier, 60 minute vacuum with drier. Tests are performed with airflow at approximately 3000 CFM at the following conditions 80DB/67WB/95F to evaluate the efficiency impact associated with each evacuation method.

Table 12. Vacuum Pump Measurement Instrument Tests

	Description	Qty.	Labels	Best Tests	Worst Tests
1	Vacuum Pump 10 CFM, 2-stage	1	VP1	1	30 minute and 60 minute vacuum
2	Vacuum Pump 8 CFM, 2-stage	1	VP2	1	30 minute and 60 minute vacuum
3	Vacuum Pump 8 CFM 2-stage	1	VP3	1	30 minute and 60 minute vacuum
4	Vacuum Pump 5 CFM	1	VP4	1	30 minute and 60 minute vacuum
5	Digital Micron Gauge	1	VP5	1	30 minute and 60 minute vacuum
6	Digital Micron Gauge	1	VP6	1	30 minute and 60 minute vacuum
7	Digital Micron Gauge	1	VP7	1	30 minute and 60 minute vacuum

Fan Belt Tension and Alignment Measurement Instrument Tests- Table 13 provides a summary of the fan belt tension and alignment measurement instruments. There are 14 belt tension and alignment instruments to test from 5 manufacturers. Fan belt tension and alignment measurement instruments tests will be performed with airflow at

approximately 3000 CFM. Belts will be tested with proper tension and alignment, as well as loose and tight tension and misalignment of 0.25 and 0.375 inches at the following conditions 80DB/67WB/95F. The worst case measurements will be performed with fan belt tension either loose or tight and the belt misaligned by either ¼ or 3/8 inches. Out-of-box fan belt tests indicated tension was looser than manufacturer recommendations. Out-of-box fan belt alignment tests indicated the belt was properly aligned.

Table 13. Fan Belt Tension and Alignment Measurement Instrument Tests

	Description	Qty.	Labels	Best Tests	Worst Tests
1	Digital Force Gauge	2	BD1-BD2	1	6 tests (loose, tight, misaligned)
2	Belt Tension Checker 1302546	3	BE1-BE3	1	6 tests (loose, tight, misaligned)
3	Belt Tensiometer 102761	3	BF1-BF3	1	6 tests (loose, tight, misaligned)
4	Belt Tension Finder, 108039-A	3	BG1-BG3	1	6 tests (loose, tight, misaligned)
5	Digital Laser Alignment Tool	1	BH1	1	6 tests (loose, tight, misaligned)
6	Digital Sonic Tension Tool	1	BI1	1	6 tests (loose, tight, misaligned)
7	Laser Pulley Belt Alignment Tool	1	BJ1	1	6 tests (loose, tight, misaligned)

Cold Weather Charging Hood and Digital Refrigerant Scale Measurement Instrument Tests - Table 14 provides a summary of the cold weather charging hood and wireless digital refrigerant scale. There are 4 instruments to test from 1 manufacturer. Two tests are performed at the following conditions 80DB/67WB/95°F. The worst case measurements will be performed with cold weather conditions down to 55°F and inaccurate measurements and check scale with known weights or 1, 5, 10, 15, 25, 50, and 100 pounds to +/- 0.25 ounces.

Table 14. Cold Weather Charging Hood and Wireless Scale Instrument Tests

	Description	Qty.	Labels	Best Tests	Worst Tests
1	Wireless Digital Refrigerant Scale	2	BB1-BB2	1	Inaccurate
2	Low Temperature Charging Hood	2	BC1-BC2	1	Doesn't fit condenser

E. Upstream Survey Instrument

Upstream Distributor Survey Questions	Response Codes
Company Name	text
Respondent Name1	text
Date/Time	text
Survey length	text
Upstream Distributor Survey Questions	**Response Codes**
C1. Let's start by getting a little information about your company my records show you are a HVAC Distr. Is that correct? (Yes -1; No -2)	Let's start by getting a little information about your company my records show you are a HVAC Distr. Is that correct? (Yes -1; No -2)
C2. Of the following, which best describes your firm's business?	1-An Independent HVAC equipment Dist; 2- A manufacturer-owned or franchise distributor; 3- Independent manufacturers' representative
C2. Notes.	
C3. Does your company also do HVAC installations?	notes
C4. Would you say you're company is more of an installer or more of a distributor?	1- Installer/ 2- Distributor/3- About evenly divided/ NA - Skipped question
C5. The CA Investor Owned Utilities (our IOU's), PG&E, SCE and SDG&E have an Upstream Distributor rebate program that buys down the cost of HVAC products and packaged RTU. Are you currently participating in this program?	Yes-1; No-2; DK -98
C6. What year did your company begin participating in this program?	What year did your company begin participation?
C6a. Program notes on participation:	Notes
C7. Were you personally involved in the decision to participate?	Were you personally involved in the decision to participate? Yes-1; No-2; DK -98
TERRITORY SERVED	Response Codes
T1. What is your HVAC distribution area within California? Can you list major metropolitan areas?	(a) SF Bay Area, (b) Northern Valley (Redding, Yuba City), (c) Sacramento Area, (d) Central Valley (Modesto, Fresno, Bakersfield), (e) Desert (Palm Springs, Imperial Valley), (f) LA-Coastal (LA, Orange County), (g) LA-Inland Empire (h) San Diego (I) Other: _____
Other Areas' in CA	Other Areas' in CA
T2. Does your company sell HVAC products like packaged RTU and split system units outside of California?	Yes 1 ; No 2 [Request name and number for the person who is] ; Don't know 98; [SKIP TO FE1]; Refused 99 [SKIP TO FE1];

T2a. Which states?	Which states?
[IF YES TO OTHER STATES] Are you knowledgeable about market and sale trends outside of California?	
I'd like to know how the market for high efficient packaged and split system units in <states mentioned> compares to California. Would you say the demand for high efficiency from these other states is relatively proportional? Or is the demand in these alternate states higher or lower?	Proportional? Or is the demand in these alternate states higher or lower?
T4a. Outside of California, how long has this trend persisted?	Yrs.:_____
T5. Would you consider the market demand for high efficiency in these other states as volatile or has the demand remained stable?	1- Stable/2- Volatile/3-Other/98 Don't Know
T6. Are you aware of any influences in <states> that would offset the cost of high efficiency units?	
FOCUS ON EFFICIENCY	Response Codes
FE1. Is energy-efficient HVAC a particular focus of your marketing effort or product offerings?	Yes 1 [Go to FE2] No 2 [SKIP TO FE4] 97 N/A Do not do any marketing 2 [SKIP TO FE3] Don't know 98; [SKIP TO T3]; Refused 99 [SKIP TO T3];
FE2. On a scale of 0 to 10 how important is the sale of energy-efficient HVAC equipment in your marketing efforts? Score:____	
FE2_txt	supportive comments for FE2.
FE3. [IF FE2 > 4] In what ways does your company focus on the sale of energy-efficient HVAC equipment?	
FE4. [Ask all edit introduction clause if FE1 =No] Intro clause: You mentioned your company doesn't focus on energy efficient marketing but can you tell me…] Does your company try and up-sell higher efficient units or product lines?	1-Yes/2-No/98-Don't know
FE4a. [IF FE4 = 1(yes) otherwise skip to FE5] Which ones?	
FE4b. Would you say up-selling occurs:	sometimes/always/rarely/or never
FE5. Do your customers know you're a program distributor?	1-Yes/2-No/-98-Don't Know

FE6. Is there anything else on the topic of energy efficiency you would like to share with us before we move on to the next topic?	
STOCKING - GENERAL	Response Codes
SG1 I'd like to ask you about stocking, just to confirm we're speaking in the same terms. To have an item "in-stock" what exactly does that mean to your company? I'm going to read a short-list please tell me which is most appropriate: "The item is… [READ LIST]	(1) Is in our warehouse at this location/ or another warehouse in CA (2) Is in a warehouse outside of CA or (3) Is available to order from the manufacturer? (98) Don't Know (50) Other:_____
SG2. I have a similar question, if an item is "in-stock" how soon could the customer typically receive it? And if an item is not "in-stock" what would you estimate is the amount of time it would take before the customer receives it? SG2a. In-stock	(a) Immediately (b) 1-2 days (c) 3-5 days (d) 6-10 days (e) Within 10 days to 2 weeks (f) Within 2-4 weeks (g) Within 31-60 days (h) > than 61 days; ; (Don't know 98)
SG2b. Not In-stock	(a) Immediately (b) 1-2 days (c) 3-5 days (d) 6-10 days (e) Within 10 days to 2 weeks (f) Within 2-4 weeks (g) Within 31-60 days (h) > than 61 days; ; (Don't know 98)
SG3.1. Including your own company, which distributors do you think account for the largest share of packaged and split system unit sales in CA?	[GET EXACT NAMES OF COMPANIES_____ Don't know 98 [SKIP TO SG3 1]; Refused 99 [SKIP TO FE1;
SG3.2 About how many different packaged and split system manufacturers does your company carry?	(e.g. Carrier, Bryant, Lennox, Rudd, Trane) #: ____
SG3.2 Open Ends	
SG4. Do you have exclusive rights to distribute this/these manufacturers' product(s) in specific geographical areas?	Yes 1 [Go to SG4a] No 2 [SKIP TO SG5.] DK 98/ REF- 99 [SKIP TO SG5.]
SG4a. To your knowledge do any other distributors have rights to distribute the same manufacturers in the same areas?	Yes 1 [Go to SG4b] No 2 [SKIP TO SG5.] DK 98/ REF- 99 [SKIP TO SG5.]
SG4b. Which distributors and in which areas?	a- Distributors: b- Areas: c- DK -98/ REF- 99 [SKIP TO SG5.]
SG5. To your knowledge, do any of these manufacturers have their own dealer network for which they directly ship systems? There is a network o	Yes 1 [Go to SG5a] No 2 [SKIP TO SG6.] DK 98/ REF- 99 [SKIP TO SG6.]

SG5a .1[IF SG5=Yes otherwise skip] Which manufacturers are those?	
SG5c. What percentage of this manufacturer(s) packaged and split system units would you estimate are shipped directly to this dealer network?	%
SG6. Approximately how many packaged and split AC units can your company keep in-stock, for shipments supplied to CA, at any given time?	#_____ DK -98/ REF- 99
SG7. Roughly speaking, what size units do you offer?	Smallest :_____(tonnage) Largest _____(tonnage)
As a reminder, for these next couple of questions we're interested in Unitary Air Cooled Split and packaged units, Ductless Split systems, Water Sourced Heat Pumps, and Evaporative AC units stocked for customers in California.	
Stocking – Quantity Overall	
ST1. Between January 2010 and December 2012, did the **overall quantity of AC units your company kept in stock** (1) increased (2) decreased (3) did not change? [IF NEEDED: We realize there may be seasonal variations; please compare relative to 2009]	
ST1a. [IF CHANGE OTHERWISE SKIP] How many more/fewer units are you stocking?	
ST1b. [IF CHANGE OTHERWISE SKIP] What factors influence the change in the quantity of the units stocked for this HVAC equipment?	
ST1c. [IF UNCHANGED] Why have the quantity of units stocked remained the same?	
Stocking – Quantity Qualified for a Rebate	
ST2. Between January 2010 and December 2012, did **the quantity of AC units stocked that qualified for a program rebate** [compared to those that do not qualify] (1) changed or (2) remained the same?	(1) changed or (2) remained the same?
ST2a. [IF CHANGED OTHERWISE SKIP] How did the stocking change?	Increase/decrease
ST2b. [IF UNCHANGED ask question and then skip to ST3] Why did the volume of AC that qualify for a program rebate remain the same?	text

ST2c. [IF INCREASED] What specific information or data source do you rely on to support this conclusion?	text
ST2db. [IF CHANGE] What efficiency levels are you stocking more/less of?	text
Influences on Stocking	
ST3. What specific factors influence your company's decision to stock a certain efficiency level for packaged and split system units? Please cite as many factors as you think are relevant.	
ST3a. <factor1>:____ ST3d. <factor4>:____	text
ST3b. <factor2>:____ ST3e.<factor5>:____	text
ST3c. <factor3>:____ ST3f.<factor6>:____	text
ST4 For each of the factors you cited [in ST3] could you rate on a 0 to 10 scale how influential each individual factor is in your stocking decision? Where 0 means not at all influential and 10 means extremely influential:	
ST4a. <factor1>score:____ ST4d. <factor4> score:____	text
ST4b. <factor2> score:____ ST4e.<factor5> score:____	text
ST4c. <factor3> score:____ ST4f.<factor6> score:____	text
STOCKING SUMMARY	
ST4.1. [DID THE RESPONDENT MENTION REBATE IN ST3? IF NO THEN READ OTHERWISE SKIP TO ST5] In the previous question you did not mention the rebate program as a factor that influenced in your stocking decisions, I'd like to confirm did the rebate have an influence you're stocking decisions?	text
Yes 1 Influenced; [Go to ST4.2, ask to rate influence] No; 2 [SKIP TO ST5.] 97N/A /98 DK [SKIP TO ST5]	
ST4.2 Could you rate on a 0 to 10 scale how influential the rebate was? Rebate:_____	0-10
ST4.3 [ST4.2 - CONSISTANCY CHECK If points >8; read] You did not previously mention the rebate as a factor that influenced stocking. By providing a score of [>8] I would interpret this to mean the program was very influential. Could you please explain why you gave this rating? And why you did not mentioned the rebate initially?	text
Influences on Sold Equipment	
I have a few similar questions regarding the sales of split and packaged systems.	

ST5. Between January 2010 and December 2012, did the **quantity of AC units sold that qualified for a program rebate** [compared to those that do not qualify]	(1) increase (2) decrease (3) unchanged?
ST5a. [IF CHANGED OTHERWISE SKIP] How did the sales change? (Open ended)	text
ST5b. [IF UNCHANGED] Why did the sale of AC that qualify for a program rebate remain the same? (Open ended)	text
ST6. What specific factors influenced the sale of that equipment that qualified for a program rebate[between January 2010 and December 2012]? Please cite as many factors as you think are relevant.	text
ST6a. <factor1>:____	text
ST6b. <factor2>:____	text
ST6c. <factor3>:____	text
ST6d. <factor4>:____	text
ST6d. <factor5>:____	text
PROGRAM CREDIT FOR IS APPLIED IF REBATE IS MENTIONED ST7. For each of the factors you cited [in ST6] on factors that influenced sales could you rate the level of influence the factor had on the sale of the equipment? Again, use the same scale where 0 mean is not at all influential and 10 is extremely influential.	0-10
ST7a. <factor1> score:____	text
ST7b. <factor2> score:____	text
ST7c. <factor3> score:____	text
ST7d. <factor4> score:____	text
SALES	
ST7.1. [DID THE RESPONDENT MENTION REBATE IN ST5? IF NO THEN READ OTHERWISE SKIP TO ST8]: In the previous question you did not mention the rebate as a factor that influenced your sales I'd like to confirm did the rebate have any influence you're sales ? Yes Influenced [Go to ST7.2, ask to rate influence] No 2 [SKIP TO ST11.] [IF NO] THEN PROGRAM GETS ZERO CREDIT FOR SALES 97N/A/ 98 DK [SKIP TO ST118] [IF NO] THEN PROGRAM GETS ZERO CREDIT FOR SALES	
ST7.2. Could you rate on a 0 to 10 scale how influential the rebate was on the sale of the equipment? Rebate:_____	0-10

ST7.3 [CONSISTANCY CHECK If points assigned is >8; read] You did not previously mention the rebate as a factor that influenced the sale of your equipment. By providing a score of [>8] I would interpret this to mean the program was very influential. Could you please explain why you gave this rating? And why you did not mentioned the rebate initially?	text
ST7.4 [CONSISTANCY CHECK If ST3.2 = yes and ST4 & ST7 = rebate and ST7: rebate < than ST4]] (If respondent said stocking influences sales in ST3.2 and attribute little influence of rebate on sales to the program	
CONSISTANCY CHECK READ: Previously you mentioned the program was an influence on stocking but later stated there was minimal (<5) to (or no) influence on sales. I would interpret this to mean the rebate was not very influential to your business. Could you please explain why you gave that rating?	
[DO NOT READ] Did the program have an influence (>5) on sales and some influence on stocking?]	
DO NOT READ: If they say yes but then later attribute little influence on sales to the program, treat that as an inconsistency to be explored. If there is no inconsistency, then that suggests there is no rationale for giving additional credit for influence on stocking.]	
(Non-Rebate) Program Influence on Stocking & Sales	
ST8. [IF ST3 OR ST5 (a-z) = rebate; then ask OTHERWISE SKIP TO ST11]	
In a previous question(s) on factors that influenced stocking/sales you mentioned the program rebate was an influence. Considering the rebate program specifically, besides the rebate dollars, **are there any other "program" factors** that resulted in an increase of higher efficiency units stocked or sold ?	Yes- 1, [continue to ST9 otherwise skip]/ No- 2 [skip to ST11]
ST9. What other program factors influenced your stocking or sales?	ST9a. <factor1>:____ ; ST9b. <factor2>:____
ST10. For each of the factors you cited [IN ST9] could you rate on a 0 to 10 scale, with 0 meaning not very influential and 10 meaning extremely influential, how influential that factor was on the [stocking/sale] of the equipment?	ST10a. <factor1>score: ____

ST11a [Compare to tracking data] If the CPUC had terminated funding during these program years, **what equipment would you not kept in stock**? If any? Open ended? . I'd like to know this information by tier level. The tiers are indicated in the 2010-2012 Rebate Form.	
[Ask if customer has a copy from the email as previously provided or offer to email it to him/her now]. To clarify, there are four tiers however I'd like to know if funding was terminated how that might also affect equipment that was not rebated. For our purposes tier zero refers to units that did not qualify for a rebate while tiers 1-4 are qualified. Additionally, tier 4 includes any units that are of TIER 4 or higher efficiency.	
1st is TIER 0: ____%; 2nd is TIER 1___%; 3rd is TIER 2___%; 4th is TIER 3___% (if applicable) TIER 4 or higher:____%	
ST11b. [IF ST11. = NO CHANGES THEN SKIP] Why wouldn't you have stocked that equipment?	text
ST11c.[IF ST11. = NO CHANGES THEN SKIP] I'd like to get a general idea on how the stocking would have changed by tier level.	
1st is TIER 0: ____%; 2nd is TIER 1___%; 3rd is TIER 2___%; 4th is TIER 3___% (if applicable) TIER 4 or higher:____%	%
ST12. Similarly, can you estimate, if the CPUC had terminated funding during these program years, **how do you think sales would have changed**? If any? Open ended?	text
1st is TIER 0: _n/a___%; 2nd is TIER 1__n/a_%; 3rd is TIER 2__n/a_%; 4th is TIER 3__<50%_% (if applicable) TIER 4 or higher:__<50%__%	%
ST12a. [IF ST12 = NO CHANGES THEN SKIP] Why don't you think sales would have changed?	text
ST12b. [IF ST12 = CHANGED THEN SKIP TO NEXT SECTION] I'd like to get a general idea on how you think the sales would have changed by tier level.	%
1st is TIER 0: ____%; 2nd is TIER 1___%; 3rd is TIER 2___%; 4th is TIER 3___% (if applicable) TIER 4 or higher:____%	%
Volume	

Great, that addresses the questions about your stocking and sale influences. In order for the CPUC and California utilities to properly plan, budget, and manage an HVAC incentive program, they need a complete understanding of the types and amount of equipment currently being sold in their service territory. I have a few questions about the markets you serve in California. Please keep in mind that the information provided by individual distributors is kept completely confidential and will be aggregated with information from other distributors to develop a overall picture of the market. For these next couple of questions I'm going to ask about sale of equipment efficiency by tier level. V1. What would you estimate are your company's annual sales for all the products you sell?	$
V2. What would you estimate are your company's annual sales for just HVAC equipment like packaged and split system AC units? [IF NEEDED: We're specifically interested in HVAC Unitary Air Cooled or Evaporative Cooled Split and Packaged Air Conditioning Units.]	$
V3. About what percentage of your packaged and split systems sales occur in CA?	%
SG8. What packaged and split system efficiency levels do you offer?	Least efficient: _____SEER/ EER & Most efficient: _____SEER/EER
SG8XV. Turning our attention to the 2010-2012 program qualifying equipment list I'd like to know if you sold the following equipment types in 2011 and or 2012?	
Air Cooled Three-Phase Packaged & Split Equipment	Yes/No
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	Yes/No
Single Phase Air Cooled	Yes/No
Ductless Mini-Split	Yes/No
Ductless Multi-Split	Yes/No
[If SG8XV = yes; sold this equipment type] Thinking about these equipment types only about what percent of sales account for this equipment type? We want the total to add up to 100%. If the responded sells all 5; questions will be limited 90% of sales	SG8X. I'd like to know the approximate volume of AC units you sold by the following equipment types. For this question we're interested in all efficiency levels not just those that qualified for the program rebate

Air Cooled Three-Phase Packaged & Split Equipment	%
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	%
Single Phase Air Cooled	%
Ductless Mini-Split	%
Ductless Multi-Split	%
[Ask For each equipment type] In CA, about how many would you estimate you sold in total in 2011?	[If the respondent says don't know ask them - which of the following bins best describes the approximate volume? 1-100; 101-500; 501-1000; 1001-5000; 5001-10,000; 10,001-20,000; 20,001-50,000 50,001-100K; 101K-500K >500K]
Air Cooled Three-Phase Packaged & Split Equipment	QTY
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	QTY
Single Phase Air Cooled	QTY
Ductless Mini-Split	QTY
Ductless Multi-Split	QTY
[Ask For each equipment type] In CA, about how many would you estimate you sold in total in 2012?	[If the respondent says don't know ask them - which of the following bins best describes the approximate volume? 1-100; 101-500; 501-1000; 1001-5000; 5001-10,000; 10,001-20,000; 20,001-50,000 50,001-100K; 101K-500K >500K]
Air Cooled Three-Phase Packaged & Split Equipment	QTY
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	QTY
Single Phase Air Cooled	QTY
Ductless Mini-Split	QTY
Ductless Multi-Split	QTY
I would like to get a general idea of the equipment types you sold by efficiency level. I'm going to group these equipment types in 6 separate categories or tiers. The tiers are indicated in the 2010-2012 Rebate Form. For our purposes the first tier is tier zero it refers to units that did not qualify for a rebate while tiers 1-4 are rebate qualified. Additionally, tier 4 includes any units that are of tier 4 or higher efficiency. **In 2011 what percent of your sales occurred in tier 0,1,2,3,4 or >4 for equipment type ....[read each type]**	Year 2011
Air Cooled Three-Phase Packaged & Split Equipment	Year 2011
Tier 0	%
Tier 1	%
Tier 2	%

Tier 3	%
Tier 4	%
Greater than Tier 4	%
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	Year 2011
Tier 0	
Tier 1	
Tier 2	
Tier 3	
Tier 4	%
Greater than Tier 4	%
Single Phase Air Cooled	Year 2011
Tier 0	%
Tier 1	%
Tier 2	%
Tier 3	%
Tier 4	%
Greater than Tier 4	%
Ductless Mini-Split	Year 2011
Tier 0	%
Tier 1	%
Tier 2	%
Tier 3	%
Tier 4	%
Greater than Tier 4	%
Ductless Multi-Split	Year 2011
Tier 0	%
Tier 1	%
Tier 2	%
Tier 3	%
Tier 4	%
Greater than Tier 4	%
In 2012 what percent of your sales occurred in tier 0,1,2,3,4 or >4 for equipment type ....[read each type]	Year 2012
Air Cooled Three-Phase Packaged & Split Equipment	Year 2012
Tier 0	%
Tier 1	%
Tier 2	%
Tier 3	%

Tier 4	%
Greater than Tier 4	%
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	Year 2012
Tier 0	%
Tier 1	%
Tier 2	%
Tier 3	%
Tier 4	%
Greater than Tier 4	%
Single Phase Air Cooled	Year 2012
Tier 0	%
Tier 1	%
Tier 2	%
Tier 3	%
Tier 4	%
Greater than Tier 4	%
Ductless Mini-Split	Year 2012
Tier 0	%
Tier 1	%
Tier 2	%
Tier 3	%
Tier 4	%
Greater than Tier 4	%
Ductless Multi-Split	Year 2012
Tier 0	%
Tier 1	%
Tier 2	%
Tier 3	%
Tier 4	%
Greater than Tier 4	%
During that same time period of 2011 and 2012, what percent of those equipment types were sold to residential and what percent were sold to the non-residential markets? Starting with equipment type [read list]?	
Air Cooled Three-Phase Packaged & Split Equipment	Residential/Non-Residential
% Res	% Res
% non-Res	% non-Res
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	

% Res	% Res
% non-Res	% non-Res
Single Phase Air Cooled	
% Res	% Res
% non-Res	% non-Res
Ductless Mini-Split	
% Res	% Res
% non-Res	% non-Res
Ductless Multi-Split	
% Res	% Res
% non-Res	% non-Res
For units that meet the minimum program efficiency requirements did you always submit an incentives for them?	Yes/No
[If <100%] About what percent of program qualified units for equipment type [read list] are not rebated?	
Air Cooled Three-Phase Packaged & Split Equipment	%
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	%
Single Phase Air Cooled	%
Ductless Mini-Split	%
Ductless Multi-Split	%
Why aren't you submitting an incentive for these units?	text
TRACKING DATA	
We're almost finished; I have just a few questions about your internal tracking data.	
TD1.Does your company have sales tracking data that tracks **where the non-program** qualified HVAC units you sold get installed?	Yes/No/DK
TD1a. [IF NO] If the CPUC began requiring this information on non-qualified units would you have the ability to start tracking it?	
TD1b.[IF YES] If the CPUC requested sales tracking data on all units, what would it take obtain this information and how long would take to gather it?	
TD1c.[IF YES] Are you able to easily view the history of your sales data (within the year, over the course of several years, for example say 4 years ago, etc.?)	
TD1d. [IF YES] How are the rebated units tracked?	
SALES TRACKING SYSTEM	

Lastly, the CPUC and California utilities are considering working with HVAC distributors in California to obtain quarterly data on the sales of HVAC packaged and split system units. The utilities will, in turn, provide participating distributors with aggregated quarterly industry benchmark information so that you can measure your individual sales performance against that of the industry as a whole in California. Information provided by individual distributors, of course, would remain completely confidential and will be aggregated with information from other distributors to provide an overall picture of the market. This information will help you understand the effectiveness of your HVAC programs and could help increase your sales of higher efficiency equipment.	
STS1. Would you be the person at your company who makes the decision about participating in this process?	text
1 Yes; 2 No ---------> Can you please tell me who we should speak to about this? [OBTAIN CONTACT INFO]	text
STS1a.[IF YES TO ST1]. Do you think such information on how your quarterly sales performance measures up against that of the industry as a whole in California will be useful to your marketing and sales efforts?	text
STS1b. [IF NO TO STS1] Why do you say it would not be useful to you?	text
STS1c. [IF NO TO STS1] Is there any other information that would make it more useful to you?	text
STS2. Would you be willing to participate in such a system where you would be able to understand how your quarterly sales performance measures up against that of the industry as a whole in California?	Yes/No/DK

F. Summary of Individual NTG Results with Verbatim Comments and Recommended Score Adjustments

Presented is a summary of individual unweighted NTG stocking and sales scores for each participating distributor. The verbatim comments are used as supportive evidence to validate program influence has occurred and in some instance justify that no influence existed and their NTG scores are adjusted accordingly.

Distributor A (Stocking 0% Sales 0%) – The distributor made no changes to their stocking and did not experience an increase in sales. They relied on market demand and did not pass the rebate incentive on to their customers. They have since changed their sales strategy and believe the changes will make them more successful at selling higher efficiency equipment:

> *"Prior to us taking the money off at the front end we relied on selling jobs that were already specified as high efficiency. Our marketing approach to offer the rebate once we earn our money from the utility never really took off. If the customer asked for it we would sell it but we were not upselling any equipment then."*
>
> **Recommendation** – No changes to score.

Distributor B (Stocking 0% Sales 0%) – Respondent stated initially the rebate had no influence on sales nor stocking. Upon further questioning on what might happen in absence of the rebates customer stated they would sell less VRV equipment and the rebate does impact the products they develop. Verbatim comments:

> *"I think [the rebate] helps us drive some behavior in the products that we develop. If this program went away tomorrow it would have a slow transition before it had any impact we wouldn't see an immediate change. I don't think it has an impact on stocking with the exception of the multi-ductless; we might see an impact there. We would sell less multi-head ductless units. The VRV is heavily influenced by the rebate. It's a meaningful incentive that helps drive behavior in contracts and they figure it in to the cost."*

In earlier statements on rebate influence to stocking and sales respondent stated:

> *"We can't guarantee the rebates will be available when bidding the job nor can we guarantee we will get the necessary information (installation address) to submit the rebate. Occasionally a rebate could be used on an immediate replacement job but we really don't use them on most jobs."*

"We don't stock those products if we're not selling them. When I say it's a demand decision if all of a sudden there is a demand for a rebated product then yes we'll stock it. I suspect the distributor Upstream rebate has zero barring on what my competitor distributors decide to stock and that it just pads their bottom line. They can't give me enough money to stock a product I'm not going to sell unless they want to just pay for it. If I have something that has to sit for six months before I sell it it's not going to be in my stocking. When I look at incentives, I'm not a huge fan of Upstream programs; I think everyone takes it as just a bonus to their margin. I don't think they use it to drive a sale of a product. I think these rebates don't work because the simple fact is the rebate is not finding its way to the person who is spending the money on the product."

Recommendation – Respondent had a less than favorable opinion of Upstream rebates and it seems to cloud his initial declaration of program benefits but upon further probing respondent cited a few program influences to a certain product type (VRV ductless). When we surmise all statements, we would conclude the program is not an influence to the primary product they bring to market and the program is not being utilized. Respondent was asked if he/she wanted to change their score when inconsistencies were pointed out and he/she stated indicated a preference to keep as-is (no program credit). – No changes to score.

Distributor C (Stocking 0% Sales 0%) – The distributor did not stock equipment. Their sales cycle (from design to delivery) is lengthy and they're uncertain if rebates would be available by the time the product(s) shipped. For these reasons they're never factored into the sale and the rebates have no influence.

"No, we consider [the rebate] kind of as gravy. If it happens it's great, if it doesn't we still have to sell the product. And since [utility] has been good about saying there is limited funds we never count on it when we're quoting a project because we don't know when it will ship; our sales cycle is lengthy it could be several years before we ship any equipment. We don't know whether the rebates will be there or have money."

Recommendation – No changes to score.

Distributor D (Stocking 0% Sales 22%) – The distributor didn't have an effective sales strategy to upsell the higher efficiency equipment. They offered a couple promotions to sell SEER 14 to 16 but were unsuccessful, less than 5 percent of their customers took advantage of the reduced pricing. Additionally, a program barrier for them was obtaining the installation information which is considered proprietary information and not otherwise necessary without the rebate filing.

"Most people are not into high efficiency unless there is a rebate. There was a lack of focus internally; we are at the mercy of the customer and what the customer wants. If a

customer says they want a 13 SEER that's what I'm going to give them and that's what the majority of them want."

Recommendation – Score reduced to zero.

Distributor E (Stocking 0% Sales 29%) – The distributor did not stock equipment. Respondent stated they pushed sales of variable refrigerant flow equipment vs. air handler product line because they get the commission and the rebate for the VRF. Sales staff is commission based and the rebate provided them the extra incentive to recommend that technology. In absence of the rebate the respondent believes they would a sell a technology that is just as efficient.

"If I can sell a VRF instead I would rather sell that then the air handling system because I'll get the rebate on top of the commission for the sale… we would sell different non-rebate qualified equipment[in absence of the program] that is just as efficient."

Recommendation – The goal of the program is to sell higher efficiency equipment not to switch from one technology to another just because there is a rebate assigned to an alternate equipment type. Score reduced to zero based on assertion that sales would be just as efficient in absence of the program.

Distributor F (Stocking 0% Sales 55%) – Distributor had limited opportunity to utilize the rebate because the rebate is not offered in all the areas they serve. Additionally, they primarily serve a replacement market and indicated that building structural factors (such as the need to replace a unit that has the same footprint/size/weight) hindered their ability to sell high efficiency as it is often does not meet the same characteristics as the existing equipment . For these two reasons, the program has had not impacted their stocking and has had a minimal influence on sales.

"The stuff we are stocking is meeting minimum efficiency or maybe one tier. The higher efficiency units are not making sense from a dimensional, weight and aesthetic standpoint for the immediate replacement market."

When they can use the rebate:

"When the buyer is doing plan-and-spec or new construction….what the rebates do is it allow us [to] reduce the cost of the unit and help customers get the higher efficiency at a lower cost. We use the majority of the rebates for reducing the cost for the customer. If we have the rebate and we can offer higher efficiency units, then we do that. But if the rebates not there and the market is not demanding it, then I wouldn't see any manufacturer stocking those higher efficient units."

When asked what equipment they would have not kept in stock if the CPUC had terminated funding, the respondent said influence existed.

> *"Yes, when we are trying to upsell to higher efficiency equipment we use the rebate."* And, *"We wouldn't be able to sell higher efficiency equipment at a faster rate of return. We would continue with the same stocking as what we had in year 2005 less of the mid-tier and high efficiency stuff."*
>
> **Recommendation** – No changes to score.

Distributor G (Stocking 0% Sales 57%) – The distributor does not stock equipment. Design decisions are enhanced by the rebate program but even without these enhancements respondent believes all their equipment would qualify for a rebate. Respondent believes their sales volume would have decreased by 30 percent absent the rebate.

> *"We try to ship everything that qualifies for a rebate. The entire philosophy of our manufacturer is to be the most efficient and carry the most specialty products. No matter what we sell it's going to get a rebate. We don't really have an option to sell things that won't get a rebate because of the manufacturer's whole philosophy."* And, *"We could limit some of our features, which would reduce the efficiency level, but in most cases the rebates pay for these features. If we didn't get the rebate we probably wouldn't put it in because it would make the units more expensive."*
>
> **Recommendation** – No change to score. Distributor's products are premium efficiency and incentives drive efficiency even higher and positively influence sales volume.

Distributor H (Stocking 23% Sales 44%) – Respondent said the different equipment types they are stocking were a result of the rebates and how sales have changed due to the rebate.

> *"We are stocking more of everything but making an effort to stock additional products in the higher efficiency ranges. For us, there are two package units on that sell quickly. We have increased our stocking sizes and efficiency for these two, to match the program. It's fairly equal, tiers 1 and 2, in terms of an effort to stock." If the program was to go away, we certainly would not have kept the same quantity of that [unit type] and not the same levels of the high three-phase; we would not be expanding our offering. It would take at least 2 weeks to get as opposed to having it in-stock."*

Recommendation – Stocking increased from 23% to 30% program design to influence stocking is working as intended. Overall score increases from 67 to 74 percent.

Distributor I (Stocking 0% Sales 68%) – Distributor did not stock equipment during part of the program cycle. When asked about program influence on sales, respondent did not cite the rebate as influential. In a follow up question to confirm the rebate had no influence, the

respondent rated the program as very influential rating the rebate a 10 on a 0-10 scale. We treat this as an inconsistent statement. When asked how the rebate was influential respondent was unable to cite convincing examples:

> *"The rebate is something that we have when we are quoting a price, a column we account for, we track it. We look at how we can utilize in the best manor, to increase our profit line. We're not turning the rebate over to the customer. It's something we consider on every project that we work on from day one."*
>
> **Recommendation** – Respondent was resistant to disclose information even after countless attempts to re-interview. Score is reduced to zero based on inconsistencies and no indication that the rebate resulted in an increase in sales.

Distributor J (Stocking 0% Sales 70%) – Distributor does not stock equipment but described how the rebate has influenced sales by lowering the cost of the equipment.

> *"Rebates come into play on every job that is going on out there, if it's a retrofit jobs it's a good chance it's being driven by a contractor and the contractor is going to look to maximize the return, systems, suppliers etc. And in our case we are going to use the incentive dollars to put the best available package we can in front of the customer. So in a lot of cases it [rebate] might be all or most of the margin that we have got on the job in order to make the equipment as competitive as we possibly can."*
>
> **Recommendation** – No changes to score.

Distributor K (Stocking 20% Sales 55%) – Distributor demonstrates how the program can be a successful mechanism to transform the distribution market when administered judiciously. Distributor provided consistent statements but initially did not receive full program credit because they did not initially cite the rebate as a primary factor and rated it an 8 on a 0-10 score for stocking.

> *"All tier 3-4 sales, 80-100% of were driven by rebates. We aggressively priced higher efficiency equipment in a 'best, better, good' sales strategy, with a goal towards ROI difference between the units being small (thanks to the defraying of costs by rebates). Additionally, approximately 40% of tier 2 sales were value-driven choices based on the final sell price negotiated. Those sales likely would have been lost had we not been able to offer the higher efficiency unit at such a competitive price point. I feel like the rebate, has been influential because it affects the price and the efficiency. You can either look it as affecting the price or the efficiency. I'm hesitant to just name the rebate off as an influencing factor simply on its own because I feel like we are not presenting it into the market, from the customer's perspective the rebate is not a data point decision. It's clearly influencing our sales, we are able to offer a HE product at a comparable price."*

Verbatim comments on stocking:

"The rebate program being in effect has allowed us to defray caring costs such that there is little to no difference in caring costs between a (high efficiency) HE and a standard performance unit. It's influential in allowing us to make the switch to 60% HE. It also allows us the opportunity to put HE in front of the customer at an attractive enough price point. That drives market demand .There is little to no difference in the initial costs from low to high. Its rare people will go with the less efficient unit."

Recommendation – Increase score to provide full program credit, rebate is working as intended. Overall score increases from 75 to 100 percent.

Distributor L (Stocking 25% Sales 51%) – Distributor provides specific examples of how they are able to transform market demand through passing the rebate on to their buyers.

"Incentives (downstream to the user and for us as a manufacturer the Upstream incentives) are very powerful because we can then make a decision how aggressively we want to try to sell a product knowing that we have some money off setting the cost where we may be selling something at lower price then what we normally would in the market place, so certainly both up and downstream incentives are important."

"The higher tier levels would have dropped the most going down from tier 2 to tier 1 or from tier 4 to tier 3 and so on. On some of the bigger jobs knowing if we win them we can offset our margin loss as a result of the rebate. The rebates are passed on to the customer as far as the market pricing that they get. I won't say that's exclusively true but I would say that is often the case. When we are going into a competitive bid we look at the incentives we are going to get back as a distributor and we'll essentially pass that on, we'll lower the price in place knowing we'll get the money back from the rebate. It trickles down to the end user."

Recommendation – No changes to score.

Distributor M (Stocking 23% Sales 57%) – Distributor was slow to make changes to their stocking and sales, but they are able to transform market demand through passing the rebate on to their buyers.

"We got better figured how to upsell and utilize the rebates to for items that qualified. We picked a spot where the higher efficiency equipment and the rebate balanced each other out to some extent. Or was in our favor so in some situations we could offer a more efficient unit at the same price as a lesser efficient unit. That's what we would target for in a lot of stock situations… We pass on either some or the entire rebate. Prior to the program we were selling fairly little of the high efficiencies."

Recommendation – No changes to score.

Distributor N (Stocking 30% Sales 57%) – Distributor provided specific examples of how they have changed their stocking practices and increased HE sales.

> *"The rebate has caused us to have more high efficiency then less. The highest tiers are the most expensive and slowest selling pieces and we had a whole bunch because we were buying blindly, but we have been doing a much better inventory analysis and metrics."*
>
> *"We use [the rebate] to try to get people to do HE rather than standard efficiency and try and minimize the cost differential."*
>
> **Recommendation** – No changes to score.

Distributor O (Stocking 28% Sales 61%) – Through educating their purchasers and lowering the cost of HE equipment this distributor has been able to increase the stock and sale of program qualified equipment.

> *"Because we were out there promoting it and explaining it to the engineering community for the difference in price they pay they use less refrigerant and less electricity. The market has to be developed, in other words there is no market demand for high efficiency equipment, we have to bring that message to the engineers who then bring it to their developers and say for these reasons we think if you let us specify HE you gain these benefits. With the rebate we were able to narrow the gap from the lower to the higher equipment. If there were no tiers, 2, 3, or 4 you would definitely sales occur in tier 1 and below. To promote a low efficiency piece of equipment takes no time, no effort, and our stock of that equipment can be a lot less expensive than our high efficiency equipment. We can live in a commodity world of low efficiency equipment we can do that, and we have done that in the past but if we want to elevate ourselves to a HE and stock more expensive HE equipment the only way we can do that is to have the rebate offset and subsidize it."*
>
> **Recommendation** – Increase score to provide full program credit, rebate is working as intended.

Distributor P (Stocking 25% Sales 64%) – Distributor provided specific examples of how they have changed their stocking practices and increased HE sales. The rebate is the primary driver to HE demand.

> *"There are only a few things that a distributor does to sell equipment. You have customer service and sales, price, and delivery. And that's what customers are going to base their purchase decision on… The biggest factor in the price of the equipment is the rebate. My sales guy can be the greatest but if it's a 10 year payback no one is going to buy it… It's not only about the dollars, the program is very efficient, and it's the ease of*

use and quick response time to pay. In-directly I would say it's increasing our stocking we have increased our stock availability of HE because the market is demanding it, we have a higher sales volume because it's more expensive equipment, we have increased our sales which has allowed us to hire more people."

Recommendation – Increase score to provide full program credit, rebate is working as intended.

Distributor Q (Stocking 25% Sales 70%) – Financial rewards for sales staff as opposed to reducing equipment cost for customers resulted in few sales above tier one for this distributor.

"For us, the incentive is offered to my sales staff to incentivize them to sell HE equipment and help lower the first cost for the customer and get that higher tier equipment within an acceptable range. The tier one is what we sell the most because the price jump from tier zero to a tier one is an increase but not an overwhelming increase so it makes sense for the customers to purchase tier one. We have 80 percent in tier zero currently, and 20 percent in tier one. Without the rebate we probably wouldn't sell anything in tier one. Without incentives I think my guys wouldn't have been able to sell the HE and my guys only stock what they can sell."

Recommendation – How rebates are utilized is at each distributor's own discretion, however the assertion that sales would change to 100 percent tier zero is likely overstated. In more than one instance the distributor stated incentives go to sales staff suggesting this is what the rebate is primarily used for. When asked what factors influence stocking distributor cited market demand, rebate and turns rate with market demand weighted a higher score then the other two factors. It appears the distributor relies on naturally occurring market demand coupled with convincing sales staff. If the rebates are paid to sales staff then it is unrealistic to believe it is significantly influencing stocking practices. Stocking score reduced from 25 percent to 10 percent new overall score is 85 percent.

Distributor R (Stocking 25% Sales 67.5%) – Company is not stocking all high efficiency equipment but has made some changes and provided examples on how sales have changed.

"Rebates that help us pay for the stock. I have a 15 SEER but it doesn't sell as fast as the 13 SEER but when I have rebate money for the 15 I can bring in more 15 SEER and try and promote that 15 SEER. It's very important! Without the rebate the need to stock high efficiency wouldn't be there so it's very important for that type of product. Right now it's tuff to sell high efficiency with the rebate money so if you take the rebate money out of it most purchasers would have gone with the cheaper equipment."

Recommendation –No changes to score.

Distributor S (Stocking 30% Sales 70%) – Distributor provided specific examples of how they have changed their stocking practices and increased HE sales.

> *"I can look at the rebate amounts from years prior and those steadily increased."*
>
> *"It was a marketing decision to differentiate against the five other manufacturers that offer a low tier, baseline piece of equipment, which is usually just the replacement market. However we found we could sell to that market a HE piece of equipment if we kept it in-stock. There are 3 tiers, 13, 15, and 17. SEER 17 SEER those units were not stocked, the 13 and 15 were stocked, we were decreasing the amount of 13 SEER and selling more 15."*
>
> *"Rebate pass through, the element of the rebate pass through, in order to remain competitive the Upstream programs have become apparent and public knowledge. When we don't have the inventory costs we 'pass it through' to the owner."*
>
> **Recommendation** –No changes to score.

G. 2010-12 Upstream Rebates

Southern California Edison Commercial HVAC Distributor Incentive Program

2010-2012 Qualifying Minimum Equipment Efficiencies & Incentive Levels for Commercial Air Conditioners and Heat Pumps

Three Phase Package and Split Equipment

Equipment Type	Tier	Size Category	Sub-Category	Full Load Cooling Efficiency		Seasonal/Part Load Cooling Efficiency	Incentive ($/ton)
Air-Cooled	1	<65 kBtuh (< 5.4 tons)	Split System w/TXV	12.0 EER	or	14.0 SEER	$70
			Single Package	11.6 EER	or	14.0 SEER	
	2	<65 kBtuh (< 5.4 tons)	Split System w/TXV	12.5 EER	or	15.0 SEER	$120
			Single Package	12.0 EER	or	15.0 SEER	
	3	<65 kBtuh (< 5.4 tons)	Split System w/TXV	13.0 EER	or	16.0 SEER	$250
			Single Package	12.4 EER	or	16.0 SEER	
	4	<65 kBtuh (< 5.4 tons)	Split System w/TXV	13.5 EER	or	17.0 SEER	$400
			Single Package	13.0 EER	or	17.0 SEER	
	1	≥ 65 kBtuh and < 135 kBtuh (≥ 5.4 tons and < 11.3 tons)	Split System and Single Package	11.5 EER	or	11.7 IEER	$90
	2			12.0 EER	or	12.2 IEER	$125
	1	≥ 135 kBtuh and < 240 kBtuh (≥ 11.3 tons and < 20 tons)	Split System and Single Package	11.5 EER	or	11.7 IEER	$90
	2			12.0 EER	or	12.2 IEER	$115
	1	≥ 240 kBtuh and < 760 kBtuh (≥ 20 tons and < 63.3 tons)	Split System and Single Package	10.5 EER	or	10.6 IEER	$60
	2			10.8 EER	or	10.9 IEER	$110
	1	≥ 760 kBtuh (≥ 63.3 tons)	Split System and Single Package	10.0 EER	or	10.1 IEER	$100
	2			10.2 EER	or	10.3 IEER	$130
Water Source HP; Water/Evap. Cooled AC (Three Phase and Single Phase)	1	< 65 kBtuh (< 5.4 tons)	Split System and Single Package	14.0 EER			$150
	2			15.0 EER			$200
	3			16.0 EER			$250
	1	≥ 65 kBtuh and < 135 kBtuh (≥ 5.4 tons and < 11.3 tons)	Split System and Single Package	14.0 EER			$175
	1	≥ 135 kBtuh and < 240 kBtuh (≥ 11.3 tons and < 20 tons)	Split System and Single Package	14.0 EER			$175
	1	≥ 240 kBtuh (≥ 20 tons)	Split System and Single Package	13.0 EER			$175

Single Phase Equipment

Equipment Type	Tier	Size Category	Sub-Category	Full Load Cooling Efficiency		Seasonal Cooling Efficiency	Incentive ($/ton)
Air-Cooled	1	<65 kBtuh (< 5.4 tons)	Split System	12.0 EER	and	14.0 SEER	$60
			Single Package	11.0 EER	and	14.0 SEER	

Single Phase Ductless Mini and Multi-Split Equipment

Equipment Type	Tier	Size Category	Sub-Category	Seasonal Cooling Efficiency	Incentive ($/ton)
Ductless Mini-split	1	<65 kBtuh (<5.4 tons)	Air Conditioner	16 SEER	$20
	2			19 SEER	$125
	1	<65 kBtuh (<5.4 tons)	Heat Pump	16 SEER	$160
	2			19 SEER	$400
	3			22 SEER	$600
Ductless Multi-split	1	<65 kBtuh (<5.4 tons)	Air Conditioner	16 SEER	$125
	1	<65 kBtuh (<5.4 tons)	Heat Pump	16 SEER	$150
	2			19 SEER	$215

The SCE Commercial HVAC Incentive Program is implemented by Energy Solutions. For more information please contact (562) 200-7020

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Last Updated: 8/22/2012

Southern California Edison Commercial HVAC Distributor Incentive Program
2010-2012 Qualifying Minimum Equipment Efficiencies & Incentive Levels for
Air-Cooled Chillers, Water-Cooled Chillers and Variable Refrigerant Flow (VRF) Equipment

Three Phase Air-Cooled Chiller Equipment

Equipment Type	Tier	Size Category	Sub-Category	Full Load Cooling Efficiency		Part Load Cooling Efficiency	Incentive ($/ton)
Air-Cooled	1	All	with Condenser*	2.95 COP	or	4.19 IPLV (COP)	$25
				10.07 EER	or	14.29 IPLV (EER)	
				1.19 kW/Ton	or	0.87 IPLV (kW/Ton)	
	2	All	with Condenser*	3.19 COP	or	4.39 IPLV (COP)	$44
				10.90 EER	or	15.0 IPLV (EER)	
				1.10 kW/Ton	or	0.80 IPLV (kW/Ton)	
	3*	All	with Condenser*	3.38 COP	or	4.69 IPLV	$90
				11.5 EER	or	16.0 IPLV	
				1.04 kW/ton	or	0.75 IPLV	

Three Phase Water-Cooled Chiller Equipment

Equipment Type		Size Category	Sub-Category	Minimum Qualifying Efficiency: Percent (%) Improvement above T-24			Incentive ($/ton per 1% improvement over Title 24 IPLV/NPLV)
				Full Load		IPLV/NPLV	
Water-Cooled Chillers		<150 tons	Screw, Scroll	Title 24 Minimum	and	20.0%	$7.75
		≥150 tons < 300 tons	Screw, Scroll	Title 24 Minimum	and	20.0%	$5.00
		≥ 300 tons	Screw, Scroll	Title 24 Minimum	and	10.0%	$3.50
		≥150 tons < 300 tons	Centrifugal	Title 24 Minimum	and	15.0%	$3.50
		≥ 300 tons	Centrifugal	Title 24 Minimum	and	20.0%	$3.00

Three Phase Variable Refrigerant Flow (VRF) Equipment

Equipment Type	Tier	Size Category	Sub-Category	Full Load Cooling Efficiency	Incentive ($/ton)
VRF Heat Pump	1	<960 kBtuh (<80 tons)	Heat Pump	Interim Department of Energy Waiver	$990
	1	≥960 kBtuh (≥80 tons)		Interim Department of Energy Waiver	$630
VRF Heat Recovery	1	<960 kBtuh (<80 tons)	Heat Recovery	Interim Department of Energy Waiver	$1,530
	1	≥960 kBtuh (≥80 tons)		Interim Department of Energy Waiver	$1,170

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Last Updated: 8/22/2012

H. Residential QI Site Instrument

Site ID:	
Owner Name	
Occupant Name	
Address 1:	
Address 2:	
City:	
Zip:	
Owner Phone:	
Tenant Phone:	
Mo/Yr of Home Performance Work Completion:	
Number of Bedrooms:	
Number of Bathrooms:	
Number of Year Round Occupants:	
Change in occupants over the past 12 months?	
Any significant changes to household energy consumption over the past 12 months?	
SITE NOTES	
Inspector Initials:	
Site Visit Date:	
Inspection Time:	
Electric Utility Name	
Gas Utility Name	
Dwelling Type:	
Year Built:	
Stories:	
THERMOSTAT INFO	
Cooling system 1	
T-STAT TYPE	**Programmable/Mechanical/Other**
Occupied Cooling Temp	
Cooling Setback Temp	
Weekend Hours at Cooling Temp	**(___:___ to ___:___)**

Weekend Hours at Setback Temp	**(___:___ to ___:___)**
Weekday Hours at Cooling Temp	**(___:___ to ___:___)**
Weekday Hours at Setback Temp	**(___:___ to ___:___)**
Cooling T-stat Notes:	
Heating System 1	
T-STAT TYPE	**Programmable/Mechanical/Other**
Occupied Heating Temp	
Heating Setback Temp	
Weekend Hours at Occupied Heating Temp	**(___:___ to ___:___)**
Weekend Hours at Heating Setback Temp	**(___:___ to ___:___)**
Weekday Hours at Occupied Heating Temp	**(___:___ to ___:___)**
Weekday Hours at Setback Heating Temp	**(___:___ to ___:___)**
Heating T-Stat Notes:	
Cooling system 2	
T-STAT TYPE	
Occupied Cooling Temp	**Programmable/Mechanical/Other**
Cooling Setback Temp	
Weekend Hours at Cooling Temp	**(___:___ to ___:___)**
Weekend Hours at Setback Temp	**(___:___ to ___:___)**
Weekday Hours at Cooling Temp	**(___:___ to ___:___)**
Weekday Hours at Setback Temp	**(___:___ to ___:___)**
Cooling T-stat Notes:	
Heating System 2	
T-STAT TYPE	
Occupied Heating Temp	**Programmable/Mechanical/Other**
Heating Setback Temp	
Weekend Hours at Occupied Heating Temp	**(___:___ to ___:___)**
Weekend Hours at Heating Setback Temp	**(___:___ to ___:___)**
Weekday Hours at Occupied Heating Temp	**(___:___ to ___:___)**
Weekday Hours at Setback Heating Temp	**(___:___ to ___:___)**
Heating T-Stat Notes:	

System 1 Nameplate Info (TAKE PHOTO)	
Location of Furnace/Fan Coil	**Attic Garage Cond. Space Other (describe)**
TYPE OF UNIT	**Package Split Hydronic System Package Heat Pump Split Heat Pump w/Elec supp Other (describe)**
Fan Type	**Single-speed two-speed variable-speed**
Fan Speeds (For fixed speed units, this is the cooling and heating jumper settings; for two-speed units, this is 1st and 2nd stage fan speed settings for both heating and cooling.)	
Fan Delay Settings	**Heating:_____ Cooling:_____**
HEATING FUEL TYPE	Gas Propane Electric Wood Other
AC MANF	
COND. MODEL #	
COOLING CAPACITY	
FACTORY REF. CHARGE	
SUBCOOLING/SUPERHEAT TARGET	
TXV/Non-TXV	
REFRIGERANT TYPE	R410a R22 Other (Specify:)
AC MANF DATE	
AC SEER	
HEATING MANF DATE	
HEATING SYSTEM MANUFACTURER	
HEATING MODEL NUMBER	
HEATING SERIAL NUMBER	
HEATING EFFICIENCY	
HEATING EFFICIENCY TYPE	AFUE HSPF
HEATING INPUT	
HEATING OUTPUT	
HEATING INPUT/OUTPUT UNITS	kW kBtu
EVAP COIL MANUF.	
COIL MODEL #	
COIL SERIAL #	
PREDOMINANT SUPPLY DUCT LOCATION	Attic Crawl Space No Ducts Cond. Space Other (describe)
Supply R-value:	
SUPPLY DUCT TYPE	FLX Duct Sheet Metal Wall Cavity Asbestos Insulated Other

RETURN DUCT LOCATION	Attic Crawl Space No Ducts Cond. Space Other (describe)
RETURN R-value:	
RETURN DUCT TYPE	FLX Duct; Sheet Metal; Wall Cavity; Asbestos Insulated; Other
What percentage of total ducting is the return ducting?	0 % 10% 25% 50% 75% 90% 100%
NOTES (explain irregular heating types here):	
System 2 Nameplate Info (TAKE PHOTO)	
Location of Furnace/Fan Coil	**Attic Garage Cond. Space Other (describe)**
TYPE OF UNIT	**Package Split Hydronic System Package Heat Pump Split Heat Pump w/Elec supp Other (describe)**
Fan Type	**Single-speed two-speed variable-speed**
Fan Speeds (For fixed speed units, this is the cooling and heating jumper settings; for two-speed units, this is 1st and 2nd stage fan speed settings for both heating and cooling.)	
Fan Delay Settings	**Heating:_____ Cooling:_____**
HEATING FUEL TYPE	Gas Propane Electric Wood Other
AC MANF	
COND. MODEL #	
COOLING CAPACITY	
FACTORY REF. CHARGE	
SUBCOOLING/SUPERHEAT TARGET	
TXV/Non-TXV	
REFRIGERANT TYPE	R410a R22 Other (Specify:)
AC MANF DATE	
AC SEER	
HEATING MANF DATE	
HEATING SYSTEM MANUFACTURER	
HEATING MODEL NUMBER	
HEATING SERIAL NUMBER	
HEATING EFFICIENCY	
HEATING EFFICIENCY TYPE	AFUE HSPF
HEATING INPUT	
HEATING OUTPUT	
HEATING INPUT/OUTPUT UNITS	kW kBtu

EVAP COIL MANUF.	
COIL MODEL #	
COIL SERIAL #	
PREDOMINANT SUPPLY DUCT LOCATION	Attic Crawl Space No Ducts Cond. Space Other (describe)
Supply R-value:	
SUPPLY DUCT TYPE	FLX Duct Sheet Metal Wall Cavity Asbestos Insulated Other
RETURN DUCT LOCATION	Attic Crawl Space No Ducts Cond. Space Other (describe)
RETURN R-value:	
RETURN DUCT TYPE	FLX Duct; Sheet Metal; Wall Cavity; Asbestos Insulated; Other
What percentage of total ducting is the return ducting?	0 % 10% 25% 50% 75% 90% 100%
NOTES (explain irregular heating types here):	
Blower Door Test	
Blower Door Ring for CFM@25	Open 1 2
BD House Pressure near -25Pa	-25Pa Other_____
BD CFM near - 25Pa	_____CFM
Blower Door Ring for CFM@50	Open 1 2
BD House Pressure near -50Pa	-50Pa Other_____
BD CFM near -50Pa	_____CFM
* Flow Exponent Correct? Perform the following to check if Flow Exponent is Correct : 1.41 <= ($CFM_{50} \div CFM_{25}$) <= 1.68 (if not, perform test 2, then test 3 if necessary)	YES NO
Test 2*	
Blower Door Ring for CFM@25	Open 1 2
BD House Pressure near -25Pa	-25Pa Other_____
BD CFM near - 25Pa	_____CFM
Blower Door Ring for CFM@50	Open 1 2
BD House Pressure near -50Pa	-50Pa Other_____
BD CFM near -50Pa	_____CFM
* Flow Exponent Correct? Perform the following to check if Flow Exponent is Correct : 1.41 <= ($CFM_{50} \div CFM_{25}$) <= 1.68 (if not, perform test 3)	YES NO

Test 3*	
Blower Door Ring for CFM@25	Open 1 2
BD House Pressure near -25Pa	-25Pa Other_____
BD CFM near - 25Pa	_____CFM
Blower Door Ring for CFM@50	Open 1 2
BD House Pressure near -50Pa	-50Pa Other_____
BD CFM near -50Pa	_____CFM
* Flow Exponent Correct? Perform the following to check if Flow Exponent is Correct : 1.41<=(CFM @ 50/CFM @ 25<=1.68(if not perform test 2, then test 3 if necessary)	YES NO
Blower Door Test notes (explain unusual test conditions)	
DUCT LEAKAGE TO OUTSIDE TEST	
System #	
Test 1	
House Pressure 25 Pa	25Pa Other_____
Duct Pressure near 0Pa	
Duct Blaster Ring @25Pa	Open 1 2 3
Duct Blaster CFM@ 25 Pa House Pressure	_____CFM
Leakage % of Nominal Flow (400cfm/ton)	
House Pressure 50 Pa or as close to as possilbe	50Pa Other_____
Duct Pressure near 0Pa	
Duct Blaster Ring @50Pa	Open 1 2 3
Duct Blaster CFM@ 50 Pa House Pressure	_____CFM

* Flow Exponent Correct? (if not perform test 2, then test 3 if necessary)	YES NO
Presence and type of auxilary ventilation?	None Supply Only Balanced Supply/Exhaust HRV ERV
Please note any areas with excessive leakage:	
Please note any evidence of recent air sealing:	
Test 2*	
House Pressure 25 Pa	25Pa Other_____
Duct Pressure near 0Pa	
Duct Blaster Ring @25Pa	Open 1 2 3
Duct Blaster CFM@ 25 Pa House Pressure	_____CFM
Leakage % of Nominal Flow (400cfm/ton)	
House Pressure 50 Pa or as close to as possilbe	50Pa Other_____
Duct Pressure near 0Pa	
Duct Blaster Ring @50Pa	Open 1 2 3
Duct Blaster CFM@ 50 Pa House Pressure	_____CFM
* Flow Exponent Correct? (if not perform test 3)	YES NO
Test 3*	
House Pressure 25 Pa	25Pa Other_____
Duct Pressure near 0Pa	
Duct Blaster Ring @25Pa	Open 1 2 3
Duct Blaster CFM@ 25 Pa House Pressure	_____CFM
Leakage % of Nominal Flow (400cfm/ton)	
House Pressure 50 Pa or as close to as possilbe	50Pa Other_____
Duct Pressure near 0Pa	
Duct Blaster Ring @50Pa	Open 1 2 3
Duct Blaster CFM@ 50 Pa House Pressure	_____CFM
* Flow Exponent Correct?	YES NO
TOTAL DUCT LEAKAGE TEST	
System #	
Test 1	

Duct Pressure 25Pa (*P25)*	
Duct Blaster Ring @25Pa	Open 1 2 3
Duct Blaster CFM near 25Pa (*Q25)*	_____CFM
Leakage % of Nominal Flow 400cfm/ton	
Duct Pressure near 50 Pa (P50)	50Pa Other_____
Duct Blaster Ring @50Pa	Open 1 2 3
Duct Blaster CFM near 50 Pa *(Q50)*	_____CFM
* Flow Exponent Correct? (if not perform test 2, then test 3 if necessary)	YES NO
Please note any areas with excessive leakage:	
Please note any evidence of recent air sealing:	
Test 2*	
Duct Pressure 25Pa (*P25)*	
Duct Blaster Ring @25Pa	Open 1 2 3
Duct Blaster CFM near 25Pa (*Q25)*	_____CFM
Leakage % of Nominal Flow 400cfm/ton	
Duct Pressure near 50 Pa (P50)	50Pa Other_____
Duct Blaster Ring @50Pa	Open 1 2 3
Duct Blaster CFM near 50 Pa *(Q50)*	_____CFM
* Flow Exponent Correct? (if not perform test 3)	YES NO
Test 3*	
Duct Pressure 25Pa (*P25)*	
Duct Blaster Ring @25Pa	Open 1 2 3
Duct Blaster CFM near 25Pa (*Q25)*	_____CFM
Leakage % of Nominal Flow 400cfm/ton	
Duct Pressure near 50 Pa (P50)	50Pa Other_____
Duct Blaster Ring @50Pa	Open 1 2 3
Duct Blaster CFM near 50 Pa *(Q50)*	_____CFM
* Flow Exponent Correct?	YES NO

BUILDING CHARACTERISTICS CALCULATION DATA

General	
TAKE PHOTOS of all 4 sides	
Front Orientation of Home	
Total conditioned floor area	
Total ceiling area	
Average ceiling height	
WALL ASSEMBLIES	
Primary Wall Type	
Framing	WF2x4 WF2x6 Other
O.C.	
Cavity R-Value	
External R-Value	
Front Wall Area	
Back Wall Area	
Right Wall Area	
Left Wall Area	
Secondary Wall Type	
Framing	WF2x4 WF2x6 Other
O.C.	
Cavity R-Value	
External R-Value	
Front Wall Area	
Back Wall Area	
Right Wall Area	
Left Wall Area	
Tertiary Wall Type	
Framing	WF2x4 WF2x6 Other
O.C.	
Cavity R-Value	
External R-Value	
Front Wall Area	
Back Wall Area	
Right Wall Area	
Left Wall Area	
Notes:	
OVERHANGS AND SIDEFINS	

Predominant Overhang	THIS MUST BE FILLED OUT!!!
Distance above top window	
Horizontal Projection	
Custom Overhang #1	
Distance above top window	
Horizontal Projection	
LFT/RT extension past window	
Custom Overhang #2	
Distance above top window	
Horizontal Projection	
LFT/RT extension past window	
Custom Sidefin #1	
LF depth	
LF distance from window	
Right fin depth	
RF distance from window	
Custom Sidefin #2	
LF depth	
LF distance from window	
Right fin depth	
RF distance from window	
WINDOW TYPES	
Primary Window Type	
Frame Type:	Metal Non-Metal
# Panes	Single Double
Tinted/Low E:	
Primary Window Type Front Wall Area	
Primary Window Type Back Wall Area	
Primary Window Type Right Wall Area	
Primary Window Type Left Wall Area	
Secondary Window Type	
Frame Type:	Metal Non-Metal
# Panes	Single Double
Tinted/Low E:	
Secondary Window Type Front Wall Area	
Secondary Window Type Back Wall Area	
Secondary Window Type Right Wall Area	
Secondary Window Type Left Wall Area	

Tertiary Window Type	
Frame Type:	Metal Non-Metal
# Panes	Single Double
Tinted/Low E:	
Tertiary Window Type Front Wall Area	
Tertiary Window Type Back Wall Area	
Tertiary Window Type Right Wall Area	
Tertiary Window Type Left Wall Area	
DOOR TYPES -	
Door Type #1	Wood Solid Core Wood Hollow Core Insulated Metal Insulated Other
Area	
Wall	Front Back Left Right
Window Y/N	
Window Area:	
Window Type:	
Door Type #2	Wood Solid Core Wood Hollow Core Insulated Metal Insulated Other
Area	
Wall	Front Back Left Right
Window Y/N	
Window Area:	
Window Type:	
Door Type #3	Wood Solid Core Wood Hollow Core Insulated Metal Insulated Other
Area	
Wall	Front Back Left Right
Window Y/N	
Window Area:	
Window Type:	
Door Type #4	Wood Solid Core Wood Hollow Core Insulated Metal Insulated Other
Area	
Wall	Front Back Left Right
Window Y/N	
Window Area:	
Window Type:	
FLOOR TYPES -	

Type 1	
Area	Slab Vented Crawl Sealed Crawl OverUncBsmt Over UncGarage Over Cond Space
16" or 24" O.C.	
INSULATION TYPE	
R-value	
Insulation Inches	
Type 2	
Area	Slab Vented Crawl Sealed Crawl OverUncBsmt Over UncGarage Over Cond Space
16" or 24" O.C.	
INSULATION TYPE	
R-value	
Insulation Inches	
Type 3:	
Area	Slab Vented Crawl Sealed Crawl OverUncBsmt Over UncGarage Over Cond Space
16" or 24" O.C.	
INSULATION TYPE	
R-value	
Insulation Inches	
ROOF TYPES	
Primary	
Area	
Flat or Cathedral	
Frame Thickness	
16" or 24" O.C.	
Insulation Type	
Cavity Depth	
Continuous Depth	inches
Radiant Barrier	inches
Secondary	

Area	
Flat or Cathedral	
Frame Thickness	
16" or 24" O.C.	
Insulation Type	
Cavity Depth	
Continuous Depth	inches
Radiant Barrier	inches
Tertiary	
Area	
Flat or Cathedral	
Frame Thickness	
16" or 24" O.C.	
Insulation Type	
Cavity Depth	inches
Continuous Depth	inches
Radiant Barrier	inches

TrueFlow Test

As-Found Cooling Stage[1] (circle one) Low Low-Med Med Med-Hi Hi

		Grid 1 size: 14 20				Grid 2 size: 14 20			
		Filter Size:				Filter Size:			
NSOP	Test #	TFSOP	Flow	Plate Pressure	Time	TFSOP	Flow	Plate Pressure	Time
	1								
	2								
	3								

As Found Heating Stage[1] (circle one) Low Low-Med Med Med-Hi Hi

NSOP	Test #	TFSOP	Flow	Plate Pressure	Time	TFSOP	Flow	Plate Pressure	Time
	1								
	2								
	3								

Static Pressure Test Cooling Mode

Static Pressure Across Unit (Supply Plenum to Return Plenum)				Static Pressure Across Fan (if taps available)		
Test #	**ESP (Pa)**	**Time**		**Test #**	**ESP (Pa)**	**Time**
1				**1**		
2				**2**		

Heating Mode

Static Pressure Across Unit (Supply Plenum to Return Plenum)			Static Pressure Across Fan (if taps available)	
Test #	**ESP (Pa)**		**Test #**	**ESP (Pa)**
1			**1**	
2			**2**	

Spot Power Measurements

Compressor (Amprobe)

Unit in Cooling Mode (wet coils)		Value	Time
	Volts1 Ph-Gnd V1		
	Volts2 Ph-Gnd V2		
	Amps1 A1		
	Amps2 A2		
	Power 1 W1		
	Power 2 W2		
	Power Factor1 PF1		
	Power Factor2 PF2		

Furnace/AHU (WattsUp or Amprobe)

Unit in Cooling Mode (wet coils)		Value	Time
Fan Stage 1	Power Across Unit[1]		

	Power Factor Across Unit		
	Power Across Fan[2]		
	Power Factor Across Fan		
Fan Stage 2	Power Across Unit[1]		
	Power Factor Across Unit		
	Power Across Fan[2]		
	Power Factor Across Fan		
[1]*If AHU power is hard-wired, use Amprobe. If AHU is plugged into an outlet, use WattsUp.*			
[2]*If possible, also measure power across fan only*			

Refrigerant Charge Measurements						
Estimated refrigerant line-set length:						
	Instantaneous Gauges				**Metering Equipment**	
Stage 1	**Test 1**	**Time**	**Test 2**	**Time**	**Test 1**	**Test 2**
Suction Temperature						
Suction Pressure						
Liquid Line Temperature						
Liquid Line Pressure (as available)						
Discharge Line Temperature						
Discharge Line Pressure (if liquid line unavailable)						
Stage 2	**Test 1**		**Test 2**		**Test 1**	**Test 2**
Suction Temperature						
Suction Pressure						
Liquid Line Temperature						
Liquid Line Pressure (as available)						
Discharge Line Temperature						

Discharge Line Pressure (if liquid line unavailable)						

***Instantaneous and metered readings should be taken nearly simultaneously. Always take the instantaneous reading first then wait for the metered values to refresh before recording readings.**

Logger Information	Hobo Micro Station Serial #	Temp/RH Sensor Serial #
Weather Station		
Temp Splits Supply		
Temp Splits Return		
Attic Ambient (if used)		
Other (explain)		

I. Commercial QM Site Instrument

ONSITE VERIFICATION FORM - QM Commercial Metering							
Site ID:						**Primary Contact:**	
Address 1:						**Phone 1:**	
Address 2:						**Phone 2:**	
City:			**Zip:**			**Email:**	
Account Number:			**Install Date:**			**Secondary Contact:**	
Application ID:						**Phone 3:**	
			Quantity to meter:		**Total quantity rebated:**		
SITE NOTES:							
Building Type:			**Industry Type:**				
Corrected Bld Type:			**Corrected Ind. Type:**				
Lead Site Engineer:		**Inital Visit Date:**	/ /	**Initial Visit Time:**			
Scheduling Notes:							

Building Hours of Operation							
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday

Open							
Close							

Holidays Observed			**Weather Station Info**		**Take a photo of the Weatherstation installation.**
Holiday	**# of Days**		**Logger/Sensor**	**Serial**	
New Year's Day			Microstation		
MLK Day			Temp/RH Sensor		
President's Day			**Describe logger location on site:**		
Easter					
Memorial Day					
July 4th					
Labor Day					
Columbus Day					
Veteran's Day					
Thanksgiving Day					
Christmas					

HVAC INFO							
UNIT #		**ZONE**					
Take a photo of the nameplate in all cases. Record the model number, serial number, and other "primary" information in all cases. Fill in the secondary information only if the nameplate information is not readable from the site photo. Take two additional photos of the unit from diagonally opposed corners in all cases.							
Primary Data							
HVAC UNIT							
REFRIGERANT	TXV NON-TXV		R-22	R-410a			
DUCT LOCATION	Roof	Plenum	In Zone	Other			
Duct Configuration	Downflow		Horizontal				
MANUFACTURER							
MODEL #			SERIAL #				
Secondary Data							
ELECTRIC INFO	**QTY**	**RLA**	**FLA**	**HP**	**CFM**	**NOTES (If more than one circuit,**	

COMPRESSOR 1						**specify which compressors belong to which circuit):**	
COMPRESSOR 2							
COMPRESSOR 3							
CONDENSER FAN 1							
CONDENSER FAN 2							
SUPPLY FAN 1							
SUPPLY FAN 2							
RETURN FAN 1							
RETURN FAN 2							
EXHAUST FAN 1							
EXHAUST FAN 2							
SUPPLY VOLTAGE		YR MANF					
COOLING CAPACITY		FACTORY CHARGE			Rated Efficiency		SEER/EER (circle one)
ECONOMIZER DATA							
ECONOMIZER TYPE	SINGLE POINT TEMP	SINGLE POINT ENTHALPY	DIFFERENTIAL TEMP	DIFFERENTIAL ENTHALPY	FIXED	OA FRACTION	
Appears Functional			Y N	Describe:			

CONTROLS ON UNIT							
UNIT #		**ZONE**					
Circle thermostat type:		**Mechanical Digital (non-programmable) Programmable EMS**					
Cooling							
CONTROL TYPE	(from above)	SETPOINT TEMP 1		TEMP 2		TEMP 3	
COOLING SETTINGS	SUN	MON	TUE	WED	THU	FRI	SAT
TIME SET TO TEMP1							
TIME SET TO TEMP2							
TIME SET TO TEMP3							
TIME OFF							
Cycling or continuous indoor fan operation?							

*If known, indicate whether the indoor fan runs continuously or cycles only as necessary to meet loads. If the fan switches to cycling control during setback hours, indicate the setback hours here.

Unit Number		
Zone		
Power Logging		* Take a photo of EVERY logger installation, with all sensors visible. Take additional photos to show all sensors as necessary.
Microstation Serial		
Wattnode Serial		
Unit Voltage (480 or 240)		
CT Size		
Refrigerant Logging	**C1 - Serial**	**C2 - Serial**	**C3 - Serial**
Energy Logger Pro Serial			
Flex Smart Adapter Serial (Pressure)			
Suction Line Temp Smart Sensor Serial			
Liquid Line Temp Smart Sensor Serial			
Discharge Line Temp Smart Sensor Serial			
Mixed Air Logging		*All directions (left, right, top, bottom) are referenced looking in the direction of airflow.
Logger/Sensor	**Serial**	
Microstation		
Top Left Quadrant Temp/RH Sensor		
Top Right Quadrant Temp/RH Sensor		
Bottom Left Quadrant Temp/RH Sensor		
Bottom Right Quadrant Temp/RH Sensor		
Supply Air Logging		
Logger/Sensor	**Serial**	**Identify sensor location in duct/plenum (e.g. top, left, right, bottom)**
Microstation		
Temp/RH Sensor 1		
Temp/RH Sensor 2		
Return Air Logging		
Logger/Sensor	**Serial**	**For return sensors location in duct/plenum (e.g. top, left, right, bottom)**
Energy Logger Pro Serial		
Return Temp/RH Sensor 1		
Return Temp/RH Sensor 2		
Economizer Temp/RH Sensor		

String Pot		
String Pot Flex Smart Adaptor		
Installation Notes:		

Unit Number		
Zone		

Refrigerant Metering Installation Quality Control Checks

	Instantaneous Guages		**Metering Equipment**	
Circuit 1	**Test 1**	**Test 2**	**Test 1**	**Test 2**
Suction Temperature				
Suction Pressure				
Liquid Line Temperature				
Liquid Line Pressure (as available)				
Discharge Line Temperature				
Discharge Line Pressure (if liquid line unavailable)				
Circuit 2	**Test 1**	**Test 2**	**Test 1**	**Test 2**
Suction Temperature				
Suction Pressure				
Liquid Line Temperature				
Liquid Line Pressure (as available)				
Discharge Line Temperature				
Discharge Line Pressure (if liquid line unavailable)				
Circuit 3	**Test 1**	**Test 2**	**Test 1**	**Test 2**
Suction Temperature				
Suction Pressure				
Liquid Line Temperature				
Liquid Line Pressure (as available)				
Discharge Line Temperature				
Discharge Line Pressure (if liquid line unavailable)				

***Instantaneous and metered readings should be taken nearly simultaneously. Always take the instantaneous reading first then wait for the metered values to refresh before recording readings.**

Spot Power Measurements

Unit in Cooling Mode (wet coils)

Reading	**Stage 1**	**Stage 2**	**Stage 3**
Volts1 Ph-Gnd V1			
Volts2 Ph-Gnd V2			
Volts3 Ph-Gnd V3			

Amps1	A1			
Amps2	A2			
Amps3	A3			
Power Factor1	PF1			
Power Factor2	PF2			
Power Factor3	PF3			
Power 1	W1			
Power 2	W2			
Power 3	W3			
Total Power				

Logger Power Reading QC		
Stage Tested (1 or 2)	**Counts**	**Power**

**Take photos of all sensors placements for all tests (True Flow Grids, anemometer holes, tachometer hole, ESP probe holes, etc.)

Unit Number	
Zone	

Cooling Stage		*Return traverses are only permissible on units without outdoor air economizers and no relief.

Traverse Location (circle one): Supply Return

*1,1 is the top left corner of the duct looking in the direction of flow

	1			2			3			4			5		
	FPM	**Temp**	**RH**	**FPM**	**Temp**	**RH**	**FPM**	**Temp**	**RH**	**FPM**	**Temp**	**RH**	**FPM**	**Temp**	**RH**
1															
2															
3															
4															
5															
6															

Duct Height (in)	
Duct Width (in)	

Tachometer Flow Measurement - Across Unit

Cooling Stage		
Test #	**ESP (in WG)**	**Fan RPM**
1		

Tachometer Flow Measurement - Across Fan

Cooling Stage		
Test #	**ESP (in WG)**	**Fan RPM**
1		

2						2			

True Flow Test									
Cooling Stage									
		Grid 1		Grid 2		Grid 3		Grid 4	
NSOP	Test #	TFSOP	Flow	TFSOP	Flow	TFSOP	Flow	TFSOP	Flow
	1								
	2								

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