WO32 HVAC Evaluation Interim Findings of Commercial Quality Maintenance HVAC Programs

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Presentation Overview

- CPUC Strategic Plan Goals
- WO32 Research Study Goals & Sample
- CQM Program Overview
- ASHRAE Standard 180
- Manufacturer Instructions provide "performance baseline" for ACCA 180
- Field Observations
- Laboratory and Field Measurements
- Conclusions

CPUC Strategic Plan for HVAC

- CLEESP Goal 3: “Heating, Ventilation and Air Conditioning (HVAC) will be transformed to ensure that its energy performance is optimal for California’s climate.”
- Vision: “The residential and small commercial heating, ventilation, and air conditioning (HVAC) industry will be transformed to ensure that technology, equipment, installation, and maintenance are of the highest quality to promote energy efficiency and peak load reduction in California’s climate.”

HVAC Maintenance Rules of Thumb

- Testing or adjusting refrigerant charge based on an “approved specification” improves efficiency
- Increasing airflow by increasing fan speed improves efficiency
- Opening outdoor air dampers improves efficiency
- Adding new sensors and digital FDD controllers to economizers improves efficiency
- Without proper instructions, installation, maintenance, evaluation, and laboratory testing these procedures can actually reduce efficiency

WO32 Research Study Goals

- Develop load impact savings estimates for residential and commercial HVAC QM and QI measures implemented by statewide and 3rd party programs
- Provide feedback for program improvement
- Field observations and laboratory measurements of QM and QI measures will be used to develop reliable energy and peak demand savings estimates for program design, implementation, and strategic planning

WO32 Sample Frame (127/199)

- Data logger sample of 44 units and 75 circuits
- SCE 53 units and 92 circuits – 73% of total
- PG&E statewide ex post observations of 5 units and 10 circuits with more scheduled
- SDG&E statewide data logger observations of 20 units and 35 circuits – 100% of total
- PG&E ACP ex post observations of 37 units and 50 circuits – 59% of total
- SDG&E 3rd party ex post inspections of 12 units and 12 circuits – 36% of total

Commercial HVAC Programs

- EM&V study of 5 HVAC maintenance programs
- 3 statewide programs require ACCA 180 and 3-year maintenance agreements and pay customer incentives up to $3836/unit, contractor inventory incentives of $75/unit plus $2230/unit for repairs
- 2 local programs do not require ACCA 180 or 3-yr agreements and pay contractor incentives up to $775/unit (8x less than statewide)
- Measures: coil cleaning, refrigerant charge, airflow, economizers, thermostats, and notched v-belts

Statewide CQM Programs

- Statewide contractors are required to have C-20 license, financials, insurance, 5-yrs experience, no BBB claims, 3 qualified technicians, references, etc
- One large property management customer without C-20 license is participating in program
- Statewide programs offer training on marketing and entering data into program database
- ACCA 180 includes 30 inspection/maintenance tasks for Rooftop Units (per table 5-20)
- CSA includes 40+ tasks (30% > ACCA 180)

ACCA 180 Implementation

1. Responsible party (owner or designate)
2. Maintenance program for each unit to achieve manufacturer performance baseline ("discretion of technician" is inconsistent with ACCA 180)
3. Inventory to establish unacceptable conditions, indicators, inspection frequencies, and tasks
4. Maintenance plan development (objectives, indicators, inspection & maintenance tasks, frequency, documentation)
5. Maintenance plan authorization and implementation
6. Revision of maintenance program

ACCA 180 Check List

#	ACCA 180 Check List (Table 5-20)	Freq	#	ACCA 180 Check List (Table 5-20) Cont'd	Freq
1	Check for particulate accumulation on filters.	30 days	16	Lubricate field serviceable bearings.	Annually
2	Check air filter and housing integrity.	30 days	17	Check for fouling on heat exchange surfaces.	Annually
3	Check UV Lamp.	90 days	18	Check drain-pan, line, coils for mold.	Annually
4	Check steam traps, pumps and controls.	180 days	19	Check evaporator coil fins.	Annually
5	Check control system for improper operation.	180 days	20	Inspect moisture from cooling coil drain pan.	Annually
6	Check P-trap.	180 days	21	Check for proper damper operation.	Annually
7	Check fan belt tension, wear, and alignment.	180 days	22	Inspect air-cooled condenser surfaces.	Annually
8	Check VFD for proper operation.	180 days	23	Check low ambient head pressure control.	Annually
9	Check proper cooling/heating coil operation.	180 days	24	Check for scale or debris on condenser.	Annually
10	Check control box dirt, debris, terminations.	Annually	25	Check combustion chamber, burner and flue.	Annually
11	Check motor contactor for pitting or damage.	Annually	26	Visually inspect moisture and mold.	Annually
12	Check fan blades.	Annually	27	Check condensate pump.	Annually
13	Check refrigerant pressures or temperatures.	Annually	28	Check refrigerant pressure/level controls.	Annually
14	Check drive-alignment, wear, and operation.	Annually	29	Visual inspect exposed ductwork and piping.	Annually
15	Check integrity of all panels on equipment.	Annually	30	Check internal supply ducts to first turn or 20.'	Annually

Note: ACCA 180 includes 30 tasks, but only seven (7) tasks impact energy efficiency for most units.

ACCA 180 Check List

#	ACCA 180 Check List (Table 5-20)	Freq	#	ACCA 180 Check List (Table 5-20) Cont'd	Freq
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2	Check air filter and housing integrity.	30 days	17	Check for fouling on heat exchange surfaces.	Annually
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4	Check steam traps, pumps and controls.	180 days	19	Check evaporator coil fins.	Annually
5	Check control system for improper operation.	180 days	20	Inspect moisture from cooling coil drain pan.	Annually
6	Check P-trap.	180 days	21	Check for proper damper operation.	Annually
7	Check fan belt tension, wear, and alignment.	180 days	22	Inspect air-cooled condenser surfaces.	Annually
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11	Check motor contactor for pitting or damage.	Annually	26	Visually inspect moisture and mold.	Annually
12	Check fan blades.	Annually	27	Check condensate pump.	Annually
13	Check refrigerant pressures or temperatures.	Annually	28	Check refrigerant oil levels.	Annually
14	Check drive-alignment, wear, and operation.	Annually	29	Visual inspect exposed ductwork and piping.	Annually
15	Check integrity of all panels on equipment.	Annually	30	Check internal supply ducts to first turn or 20.'	Annually

Note: Blue and yellow highlighted tasks impact energy efficiency for most units. Blue are already performed by technicians and yellow are not.

ACCA 180 Check List

- Programs assume technicians know how to properly perform all ACCA 180 tasks to bring a unit up to discretionary performance “baseline”
- According to one program bringing a unit to “baseline” means the “contractor has completed all tasks, required repairs, and maintenance to make the unit operate efficiently”
- ACCA 180 doesn’t provide procedures for technicians to follow to properly diagnose and perform repairs for the unit to operate efficiently

What is "Performance Baseline?"

- Manufacturers provide unit-specific "Installation, Start-Up and Service Instructions" for airflow (fan speed/belt tension/alignment), coil cleaning, economizer setup/maintenance, refrigerant charge
- Non-TXV specifications: suction temperature as a function of condenser entering temperature and suction pressure
- TXV specifications: liquid pressure and temperature or discharge pressure and suction pressure as a function of condenser entering and indoor drybulb/wetbulb temperature

Mfgr Coil Cleaning Instructions

SERVICE

⚠ CAUTION

When servicing unit, shut off all electrical power to unit and install lockout tag to avoid shock hazard or injury from rotating parts.

Cleaning — Inspect the unit interior at the beginning of each heating and cooling season and as operating conditions require.

EVAPORATOR COIL

1. Turn unit power. Install lockout tag. Remove evaporator coil access panel.
2. If economizer or two-position damper is installed, remove economizer or two-position damper by disconnecting Molex plug and removing mounting screws. Refer to Accessory Economizer or Two-Position Damper Installation Instructions for more details.
3. Slide filters out of unit.
4. Clean coil using a commercial coil cleaner or dishwasher detergent in a pressurized spray canister. Wash both sides of coil and flush with clean water. For best results, backflush toward the return-air section to remove foreign material.
5. Flush condensate pan after completion.
6. Reinstall economizer or two-position damper and filters.
7. Reconnect wiring.
8. Replace access panels.

CONDENSER COIL

1. Turn off unit power. Install lockout tag.
2. Remove top panel screws on condenser end of unit.
3. Remove condenser coil corner post. See Fig. 53. To hold top panel open, place coil corner post between top panel and center post. See Fig. 54.
4. Remove screws securing coil to center post.
5. Remove fastener holding coil sections together at return end of condenser coil. Carefully separate the outer coil section 3 to 4 in. from the inner coil section. See Fig. 55.
6. Use a water hose or other suitable equipment to flush down between the 2 coil sections to remove dirt and debris. Clean the outer surfaces with a stiff brush in the normal manner.
7. Secure inner and outer coil rows together with a field-supplied fastener.
8. Reposition the outer coil section, and remove the coil corner post from between the top panel and center post.
9. Reinstall the coil corner post, and replace all screws.

CONDENSATE DRAIN — Check and clean each year at start of cooling season. In winter, protect against freeze-up.

FILTERS — Clean or replace at start of each heating and cooling season, or more often if operating conditions require it. Replacement filters must be same dimensions as original filters.

OUTDOOR-AIR INLET SCREENS — Clean screens with steam or hot water and a mild detergent. Do not use disposable filters in place of screens.

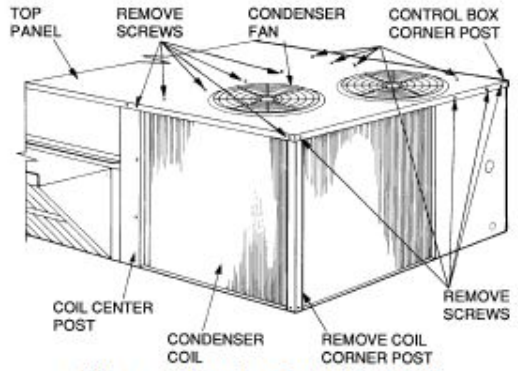


Fig. 53 — Cleaning Condenser Coil

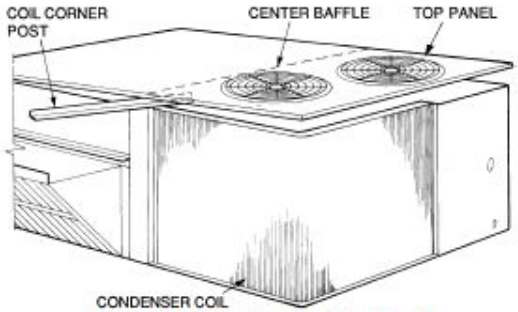


Fig. 54 — Propping Up Top Panel

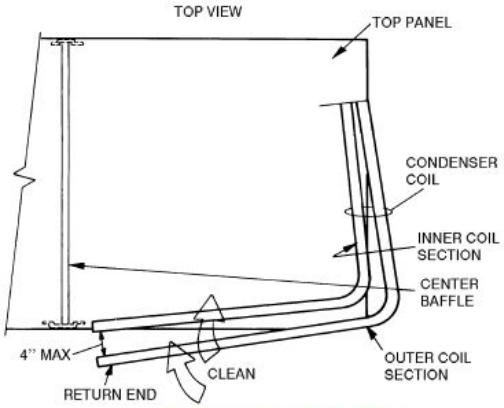


Fig. 55 — Separating Coil Sections

Mfgr Economizer Instructions

1. Disconnect power at terminals TR and TR1. Disconnect jumper across terminals P and P1. See Fig. 17.
2. Jumper terminals TR and 1.
3. Connect enthalpy sensor to terminals SO and +. The factory-installed 620-ohm resistor should be in place on terminals SR and +.
4. Turn enthalpy set point to "A."
5. Jumper terminal T to terminal T1.
6. Spray a small amount of refrigerant in the upper left vent of the enthalpy sensor to simulate low enthalpy conditions. See Fig. 28.
7. Connect 24-v power at terminals TR and TR1. The LED (light-emitting diode) will turn on and the economizer motor will drive the damper full open.
8. Disconnect the jumper at terminals T and T1. The economizer motor will drive the damper full closed.
9. Connect a jumper across terminals P and P1.
10. Turn minimum position potentiometer adjustment counterclockwise and the economizer motor drives the damper closed.
11. Turn minimum position potentiometer adjustment clockwise and the economizer motor drives the damper open.
12. Disconnect the power at terminals TR and TR1. The economizer motor spring-returns the damper to closed position.

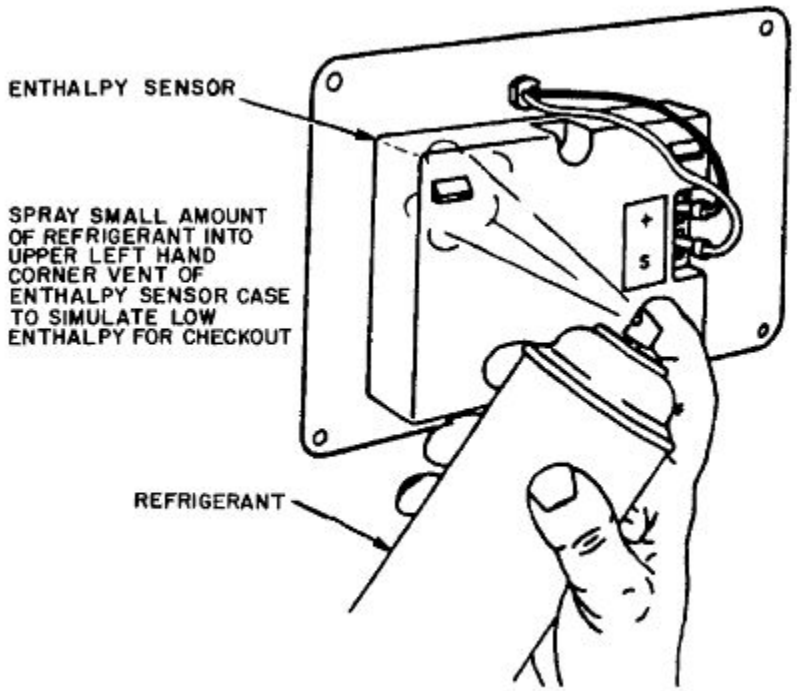


Fig. 28 – Use of Refrigerant Spray on Sensor to Simulate Low Enthalpy

Mfgr Fan-Pulley/Belt Instructions

Evaporator-Fan Adjustment — Fan motor pulleys are factory set for speed shown in Table 1. The 48DP020 units have fixed pulleys. Fan speed can be adjusted only by changing the pulley.

To change fan speeds on sizes 014 and 016:

1. Shut off unit power supply.
2. Loosen belt by loosening fan motor mounting plate nuts.
3. Loosen movable-pulley flange setscrew (see Fig. 26).
4. Screw movable flange toward fixed flange to increase speed and away from fixed flange to decrease speed. Increasing fan speed increases load on motor. Do not exceed maximum speed specified in Table 1.

   See Table 3 for air quantity limits.
5. Set movable flange at nearest keyway of pulley hub and tighten setscrew. (See Table 1 for speed change for each full turn of pulley flange.)

To align fan and motor pulleys:

1. Loosen fan pulley setscrews.
2. Slide fan pulley along fan shaft.
3. Make angular alignment by loosening motor from mounting plate.

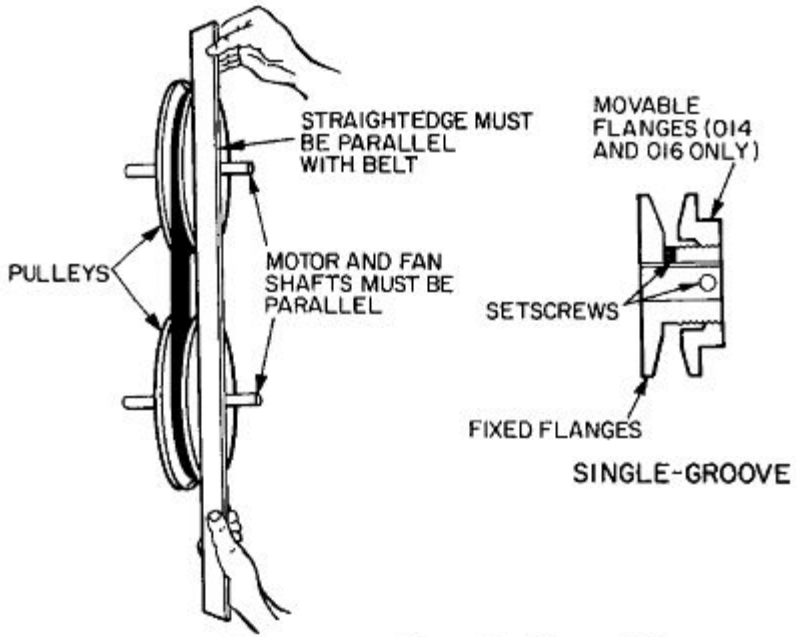
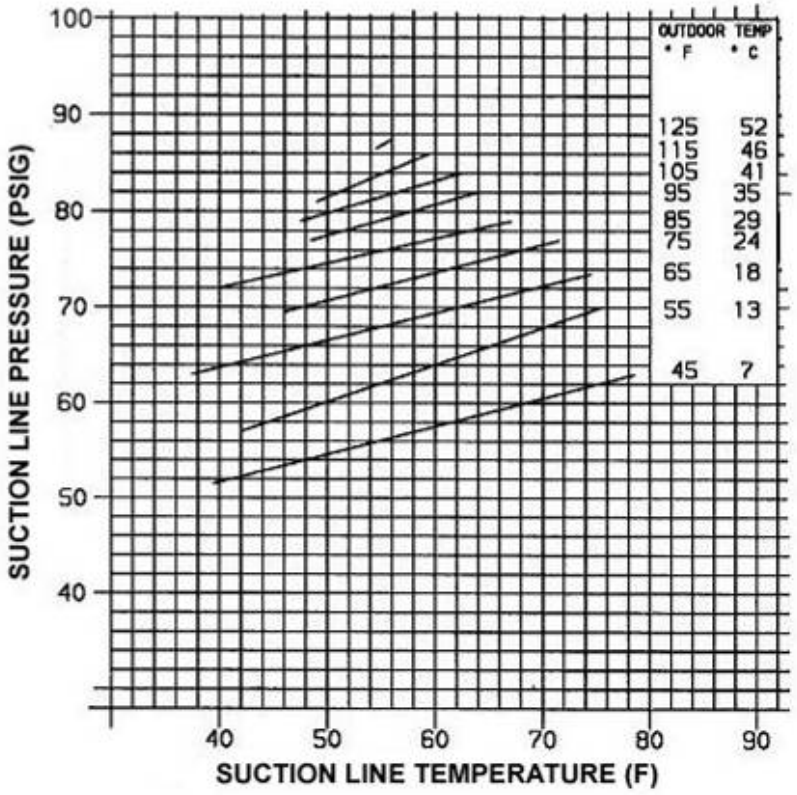


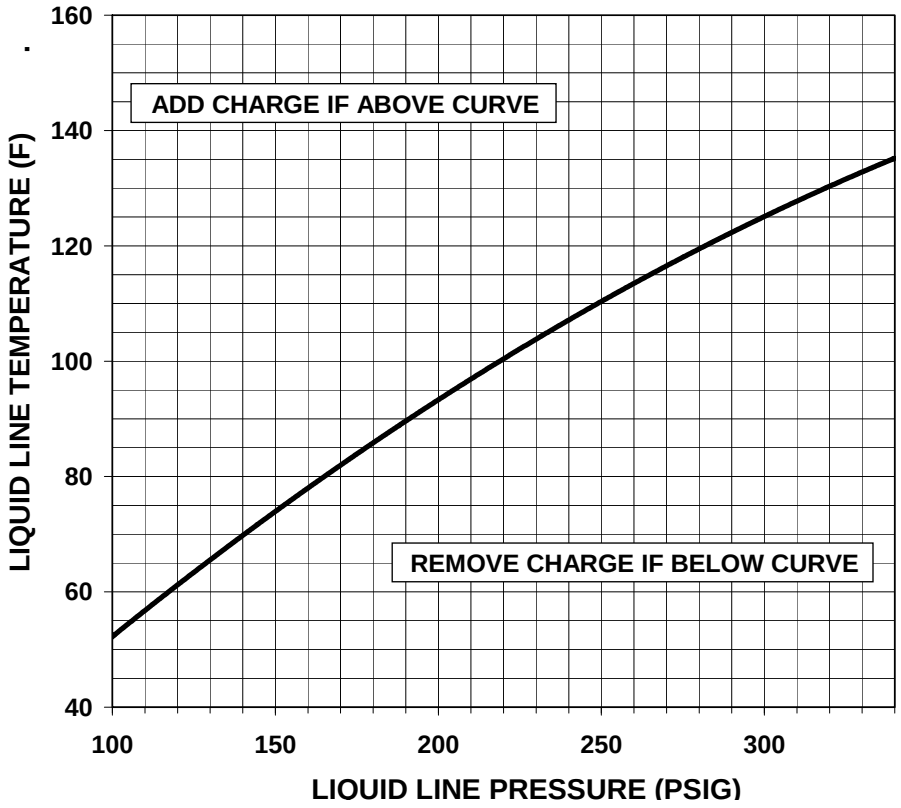
Fig. 26 — Evaporator-Fan Pulley Adjustment (014-016 Sizes)

Manufacturer Charging Charts

Non-TXV Suction Line Temperature



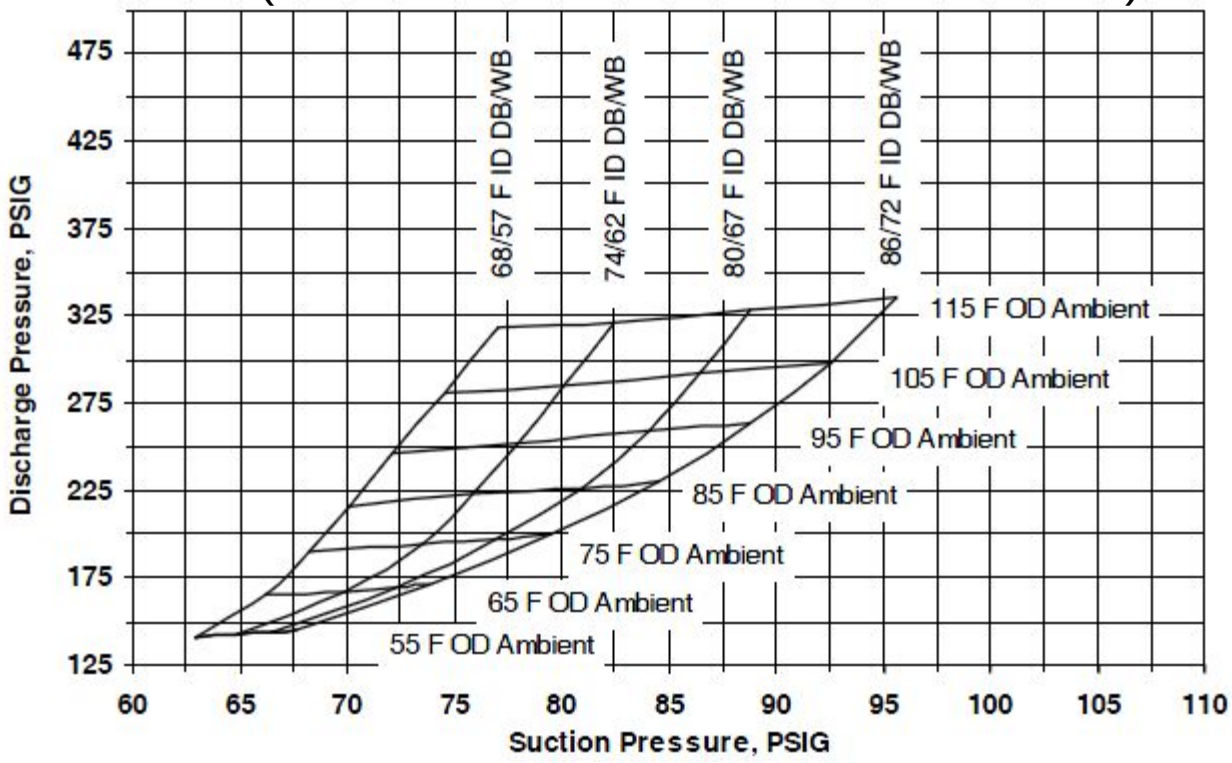
TXV Liquid Line Temperature



TO USE COOLING CHARGING CHARTS – Non-TXV - Measure outdoor temperature, suction pressure and temperature. TXV - Measure liquid pressure and temperature. Refer to charts for targets. Add refrigerant if high and recover charge if low. Tolerance is +/-5F.

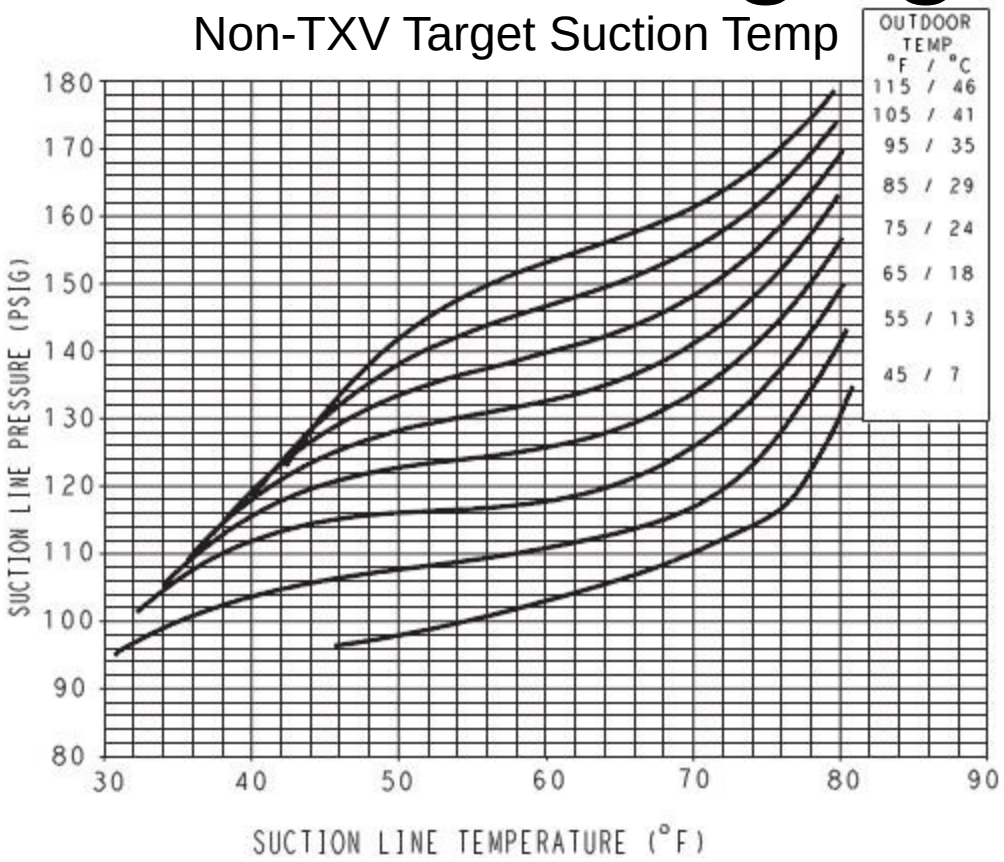
Manufacturer Charging Charts

TXV Cooling Cycle Pressure Curves
(Based on Indoor Airflow of 400 CFM/ton)



Check Operating Pressures: 1. Start unit and allow pressures to stabilize. 2. Measure indoor DB/WB temperature entering indoor coil. 3. Measure outdoor air dry bulb temperature. 4. Take discharge and suction pressure readings. 5. Plot outdoor dry bulb and indoor DB/WB temperature onto chart. 6. At point of intersection, read down for suction pressure and left for discharge pressure.

Manufacturer Charging Charts



Check Charge: 1. Start unit, energize all circuits, and allow pressures to stabilize for at least 15 minutes. 2. Measure outdoor air dry bulb temperature ad suction pressure. 3. Lookup outdoor temperature and suction pressure on chart. 4. At point of intersection, read down for suction temperature (tolerance is +/-5F).

Mfgr Restriction Instructions

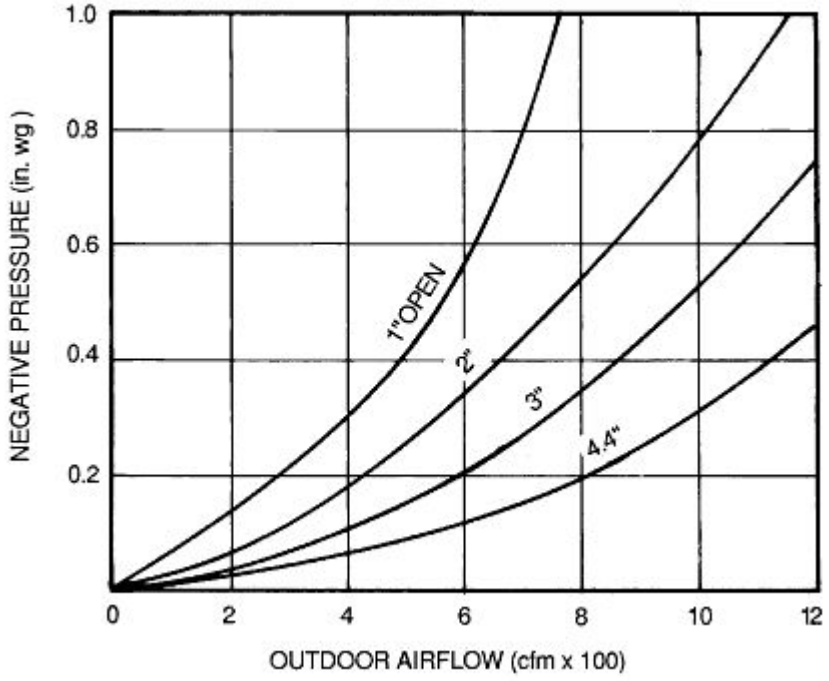
- Check restrictions in multiple non-TXV devices by disconnecting supply fan, start compressor, and verifying uniform frost pattern on evaporator
- Check for liquid line filter drier restriction by verifying temperature drop is less than 2°F
- If restrictions are present, recover refrigerant, make repairs, leak test with Nitrogen for 10 minutes (repair leaks and repeat), evacuate to 500 microns held at or below 1000 microns for 20 minutes before weighing in factory charge

Mfgr Heating Instructions

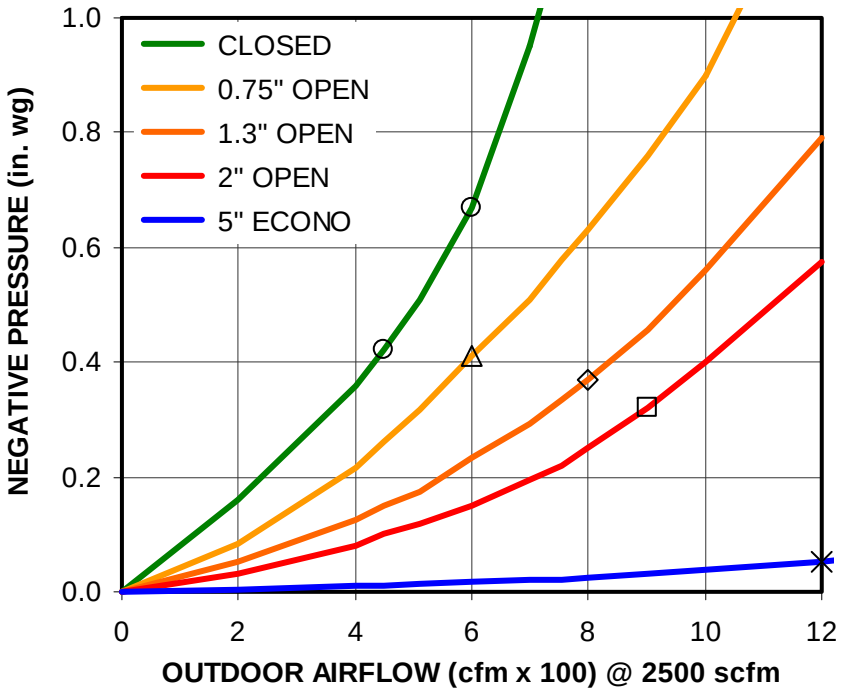
- Issue: Inefficient or inadequate space heating or continuous operation of furnace
- Probable cause: Dirty air filters, restricted airflow, or too much outdoor air
- Remedy: Clean or replace air filters, remove airflow restrictions, or adjust economizer minimum outdoor air damper position
- Analysis of laboratory data: Efficient OA damper position can improve heating efficiency and satisfy ASHRAE 62.1 for most buildings

Manufacturer OA Damper Charts

Manufacturer Data of Outdoor Air Damper Position for 7.5-ton RTU (OA CFM versus Inlet Pressure)



Laboratory Tests of Outdoor Air Damper Position for 7.5-ton RTU (OA CFM versus Inlet Pressure)



- Dampers open ¾” to 2” reduce efficiency by 5 to 62% compared to closed dampers which provide 15%+ OA

Manufacturer Airflow Charts

Manufacturer Airflow (cfm) vs. ESP (in H2O) and RPM

Horizontal Configuration

	External Static Pressure (Inches of Water)																			
	0.10		0.20		0.30		0.40		0.50		0.60		0.70		0.80		0.90		1.00	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
	2 HP Std Motor & Field Supplied Low Static Drive												2 HP Standard Motor & Drive							
2400					603	0.52	653	0.63	707	0.75	754	0.88	792	0.99	825	1.09	857	1.19	886	1.30
2700			595	0.56	644	0.66	686	0.77	732	0.89	780	1.03	824	1.17	863	1.30	895	1.42	925	1.54
3000	605	0.65	644	0.73	684	0.82	726	0.94	765	1.06	806	1.20	849	1.35	891	1.51	929	1.66	962	1.80
3300	658	0.84	694	0.93	728	1.02	767	1.15	805	1.28	840	1.40	876	1.55	916	1.71	955	1.89	991	2.06
3600	711	1.07	746	1.18	776	1.27	809	1.38	846	1.52	880	1.66	912	1.80	943	1.95	980	2.13	1016	2.30
							2 HP Standard Motor & Drive													

- At 935 RPM (3 turns) lab-measured airflow is 2682 cfm (358 cfm/ton) with 1.0” ESP and 6.85 EER
- At 756 RPM (6 turns) lab-measured airflow is 2523 cfm (336 cfm/ton) with 0.5” ESP and 7.66 EER (11.8% higher) with 6% total kW savings and 33% fan kW savings

Field Observations

- Field observation protocols follow the statewide or local program data collection protocols
- The study includes 4 types of field observations:
  1) Pre-observations of 44 participating units (75 circuits) with data loggers installed
  2) Ride-along observations of maintenance performed by participants on 44 units and 72 circuits
  3) Post-maintenance observations after program services were performed of 83 units and 127 circuits
  4) Observations of 22 non-participant units