Quick Guide to PTCS Air-Source Heat Pump Installation

Ducts – size right and seal

- ⇒ **Duct design – bigger is better, especially with flex**
- ⇒ **Airflow – need at least 350 CFM/ton and must prove it (TrueFlow)**
- ⇒ **Duct sealing – must be tight**
- ⇒ **Volume dampers highly recommended**

Heat Pump – maximize compressor heating and minimize auxiliary (strip) heating; confirm airflow & charge OK

- ⇒ **Use balance point of 30° F or lower (25° F recommended)**
- ⇒ **Install outdoor thermostat or equivalent control and set at 35° F**
- ⇒ **Do not specify discharge air sensor for single-stage compressor**
- ⇒ **Set discharge sensor to 85° F for multi-stage systems**
- ⇒ **Set low ambient cut out no higher than 0° F**
- ⇒ **Stage auxiliary heat elements greater than 5° kW**
- ⇒ **Follow mfr's guidelines on evacuating system, brazing, installing electrical conductors, components and metering device**
- ⇒ **Weigh in charge with scale and account for non-standard line sets**
- ⇒ **Check system operating pressures**

Documentation – fill out PTCS start up forms

Tools you will need

Standard refrigeration hand tools
Calibrated refrigerant manifold gauge set
Digital thermometer with known accuracy
Type K or J thermocouples with recent calibration (Fluke or equivalent)
Digital refrigerant scale with 0.50 oz accuracy and fresh battery (if applicable)
Refrigerant recovery cylinder
Vacuum pump with freshly changed oil
Soap solution or other leak detection equipment

TrueFlow air handler meter
Digital pressure gauge

(optional) duct pressurization fan kit (alternate airflow measurement device)

PTCS New Heat Pump Installation Procedure

Outline of Tests & Form Entries

1. Record site location, electric utility, technician name and company.
2. Record house age, house foundation type, type of system being replaced (if applicable), and duct location.
3. Record indoor and outdoor unit model numbers, thermostat and/or zone control info.
4. Verify compressor low ambient cut out (if present) not set above 0° F.
5. Verify electric auxiliary heat elements are staged in 5 kW increments.
6. Set up and verify auxiliary heat is controlled so it does not operate above 35° F.
7. If discharge air sensors installed (multi-stage compressor systems only), set to 85° F for staging control.
8. Record length of refrigerant line set; adjust charge as needed for non-standard line sets.
9. Measure system airflow with TrueFlow or Duct Blaster; confirm stage tested (for multi-stage systems) and mode (heating/cooling).
10. Run system for at least 15 minutes in compressor-only mode (heating assumed but cooling test can also be done) and record operating pressures. Compare pressures to manufacturer's recommended pressures.

Fax completed forms in to complete process.

NW Heat Pump Startup Form

Invoice #	

Controls Page *(to be completed by HVAC service tech)* (Data form 1 of 3)

Site Name & Address			
Installing Technician Name			
Installing Technician Company			
Installing Tech. cell phone number			
Electric utility company			
Date installed		Date of Test	
Area/zone served if not whole house			

Controls settings concern 3 primary areas:

- low-ambient compressor lockout (if present/enabled)
- resistance heat staging/sequencing
- control of resistance heat (operation in Stage 1 not allowed; operation in Stage 2 allowed below 35° F (or below 40° F is using Honeywell VisionPro (or OEM equivalent) t'stat)

For all systems (single and multi-stage compressors)

Is compressor low-ambient lockout control set no higher than 0° F ☐ yes ☐ N/A

Are resistance heat elements greater than 5 kW staged or sequenced ☐ yes

Auxiliary (Strip) Heat Control

Make/model of indoor thermostat _____

Make/model of zoning control (if applicable) N/A _____

Check if system has single compressor stage _____ or multiple stages_____

Does the system have a discharge air sensor controlling strip heat? _____yes _____no

On <u>single capacity</u> compressor systems, confirm discharge air sensor not installed or disabled: ☐

On <u>multiple capacity</u> compressor systems, confirm discharge air sensor control, if used to control auxiliary heat, is set no higher than 85° F: ☐

PTCS requires resistance heat lockout at temperatures above 35° F. How is auxiliary heat controlled on this system?

_____indoor thermostat + outdoor sensor
_____add-on outdoor thermostat (ODT)
_____indoor unit board or zoning control
_____other. Explain:

Confirm strip heat does not operate above 35°F (or lowest temp. allowed by thermostat): ☐

Use procedures in training notebook or recommended by manufacturer.

<u>If outdoor sensor used:</u>

Record outdoor temperature at time of test _____

Record output of outdoor sensor (if applicable) _____ Record expected value _____

Measured value shall be within 5% of expected value. If not, replace sensor.

NW Heat Pump Startup Form

Invoice #	

(to be completed by refrigeration startup personnel) *Airflow/Charge page* (Data Form 2 of 3)

Site Name & Address				Yr built	
Heated floor area of house (ft^2)		If retro, replacing... (circle)	HP* EFA room EFA/AC		
Foundation type (circle one)	crawl bsmnt	1/2 bsmnt slab	House type (circle)	Site built Apt Mfd	
% of ducts outside conditioned space	supply:	return:	Duct leakage<10%**	yes no	
Tech Company/Name					
Electric utility company			Electricity meter number		
Date installed		Date of Test			
Note unit #or area/zone served if multiple units at site					

*HP=ht pump, EFA=elec. frcd air, room=basebrd/wall htrs, AC=central AC **exterior leakage at 50 Pa /heated floor area

	Make/Model #	Tons*	# htg stages
Outdoor unit			
Indoor unit		*@ full capacity	

External Static Pressure test *Check in full capacity unless conditions do not permit.*

ECM blower? Y N *Attach additional sheets as needed if test must be re-run.*

Tested in heating____ or cooling ____ Stage/capacity tested? tons

1) Record expected flow based on settings (CFM/ton)	heating	cooling
2) Measure return plenum pressure		inches or Pa (circle one)
3) Measure supply plenum pressure		inches or Pa (circle one)
4) Add values together (ignore (-) sign on return pressure)		inches or Pa (circle one)

Note result of 0.8" (200 Pa) or more in step 4)can result in extreme fan energy use and early fan failure

True Flow test

TrueFlow cannot be used: If checked, use Duct Blaster matching worksheet; record result in last line below.

Tested in heating____ or cooling ____ Stage/capacity tested? tons

Note where plate installed: _____filter slot @ ID unit _____filter grille other (describe):_____

Use consistent pressure units (inches of water or Pa) throughout.

		A		
Measure normal supply operating pressure (NSOP)			Filter size (16x20 etc)	
Insert plate; which one?	14 20	***B***		**square root(*A/B*)…**
Measure supply pressure with plate in (TFSOP)			Correction factor (CF)	
Pressure at plate (green/red hose channel)		Raw flow (CFM)		**...or use lookup card**
Corrected Flow (CFM) [raw X CF]		CFM/ton		
		Is flow target met?	Yes No	

If True Flow installed on filter grille or other unducted entry, multiply raw flow by 1.04 (then apply CF)

Alternate Airflow Measurement (attach worksheet for alternate method)

Flow from DB matching method (CFM/ton)		Is flow target met?	Yes No

NOTES:

NW Heat Pump Startup Form
(to be completed by refrigeration startup personnel)

Invoice #	

Airflow/Charge page (Data Form 3 of 3)

Site Name & Address			
Tech Company/Name			
Electric utility company			
Date installed		Date of Test	
Note unit #or area/zone served if mulitple units at site			

Charge adjustment

For the most common sizes of tubing used on these systems, an adjustment of about 0.6 oz of refrigerant per foot of line length shall be made for systems using non-standard line set lengths.

Refrigerant	R-22 R410A		
Line set length (estimate feet)		std length for this unit (ft)	15 25 other_____
Ounces of refrigerant added (+)/removed (-)**			

*****Note any complications in adjusting charge:***

Performance Check ***[run system at least 15 minutes before taking readings]***

	First test (required)	Second test (if needed)	3rd test (if needed)
Air temp entering OD unit			
Stage tested (if variable capacity)			
Heating or cooling tested?	Heating Cooling	Heating Cooling	Heating Cooling
[optional] entering drybulb*			
[optional] entering wetbulb*			
Measured suction pressure (psig)			
Mfr suction pressure (psig)**			
Measured discharge pressure (psig)			
Mfr discharge pressure (psig)**			
Supply temperature (optional)			
Return temperature (optional)			
Temperature split (optional)			

*if needed for pressure check
**from manufacturer info

NOTES:

Measuring System Airflow with Duct Blaster

(alternate procedure if TrueFlow cannot be used)

1. Turn on air handler (by using fan-only switch or by turning on heat/AC). It is best to call for the flow that will be used during heating.
2. Drill access hole as needed and point hooked end of static tap into airflow**. Do not drill into the duct at any point where you are concerned with hitting something.** Note if fan is variable speed and note expected flow given size of unit and DIP or other settings on system control board.
3. Record normal system operating pressure (NSOP) as described in flow plate test.
4. Next, install split between supply and return so that all air flowing through Duct Blaster will go into supply side.
5. Install Duct Blaster on furnace. Ingenuity with cardboard and duct tape is often needed.
6. ***Turn on air handler to heating speed.***
7. Turn Duct Blaster on and slowly increase flow until the supply plenum pressure is the same as NSOP.
8. Check to make sure the pressure in the return system is 0 or very close to 0 (to confirm system split is good).
9. Record Duct Blaster flow pressure, ring#, and CFM.

NSOP _____Pa

Ring # _____

Flow pressure _____Pa

Air Handler flow _____CFM

Note: if highest pressure reached is not NSOP, a correction is needed.

Record highest pressure reached (HPR)_____

Correction: take square root of (NSOP/HPR) _____

And multiply by Air Handler flow (from above) _____

This is the corrected flow: _____

Data Form Procedures

Entries to the data form will be described by page and from top to bottom.

Controls Page

Information on the first third of the page identifies the location of the unit, the installer, the electric utility jurisdiction, when the unit was installed and tested, physical characteristics of the house and ducts, and the area served by the unit if there is more than one unit at a site. The Invoice# is meant to give the unit an (almost) unique identifying number; it is assumed the installer will use the Invoice# from their service ticket.

In the two checkboxes below the identity block, the installer is asked to confirm the low-ambient compressor lockout is set to activate at a temperature no warmer than 0° F (PTCS specification). The installer is also asked to confirm the strip heat is staged or sequenced in 5 kW increments (if applicable).

The installer must specify the type of indoor thermostat installed and also the zoning control (if applicable). The installer must also specify if the system has one or multiple stages of compressor operation and also whether a discharge air sensor can be used to control staging.

Important note: use of discharge sensors to control backup heat is not allowed on single-stage compressor systems, as it tends to bring on backup heat unnecessarily. On multiple-capacity compressor systems which use a discharge air sensor for staging, the staging temperature can be set no higher than 85°F.

The auxiliary heat control mechanism (outdoor thermostat, outdoor temperature sensor, etc.) must be checked and proper operation verified. It is usually possible only to determine whether or not the system does cut out operation and not the exact temperature where this occurs. The most commonly used technique is to make a heating call which is at least 2° F above the displayed thermostat temperature and measure register temperatures to see if they go above expected heat pump delivery temperature (rarely above 95° F except on a very mild day (above 55° F)). On days where outdoor temperatures are below 35-40° F, it may be necessary to warm up the outdoor sensor (or decrease the cutout temperature (if possible) in order to do this test.)

On multi-stage systems, the installer must confirm that the second stage of heating is compressor-only (that is, that strip heat only comes on for the third stage).

If the system uses an outdoor sensor for auxiliary heat control, its output must be checked (last lines on the page). A lookup table which shows resistance (ohms) vs. outdoor temperature is usually provided by the equipment manufacturer.

Airflow Page

The PTCS specifications call out a recommended airflow across the indoor coil of 375-425 CFM/ton of outdoor unit capacity. The **minimum allowed** airflow is 350 CFM/ton.

Information on the first third of the page identifies the location of the unit, the electric utility jurisdiction, when the unit was installed and tested, the house size, house age, house type (single family, multifamily, manufactured home, foundation type (crawlspace, basement, slab, etc.), percentage of ducts outside the conditioned space (that is, in the crawlspace, attic, garage, or otherwise outside the heated envelope of the building), heating system replaced (if a retrofit) and the area/zone served by the unit if there is more than one unit at a site. The Invoice# is meant to give the unit an (almost) unique identifying number; it is assumed the installer will use the Invoice# from their service ticket.

The middle third of the page asks for air handler type, expected flow at the mode/stage tested, and static pressure readings. The tester should specify the pressure units used; generally, it is assumed readings will be taken in water column inches.

The intention is that the technician will test the system at full capacity in heating mode. In newer systems, attaining full capacity flow may be complicated and can require detailed review of system controls and sensors. Temporary settings and/or sensor jumpering may be required. Also, it may be possible to get to full capacity and flow by using the test mode of the indoor thermostat.

The static pressure test will identify systems that may not achieve their full potential because of increased fan energy usage. Holes shall be drilled in the supply and return plenum and be large enough to be patched with rubber plugs. Care shall be taken to avoid drilling into the indoor coil. **Important: make sure registers and dampers are open, look for constrictions; if considering duct system repairs, note size of plenums and trunks and overall number of supply and return registers**.

The TrueFlow calibrated plate is the preferred means of measuring system airflow. The procedure described with the TrueFlow plate is to be used and results recorded here. In summary, the process requires measurement of system supply static pressure with a static pressure tap; this is the Normal System Operating Pressure (NSOP). The system filter is then replaced with TrueFlow (spacers added as needed) and the supply static pressure remeasured (this pressure is called the True Flow System Operating Pressure (TFSOP)). The pressure drop across the plate (red and green hoses) is recorded and the raw flow in CFM recorded. If the NSOP and TFSOP differ, a correction is needed (the correction is found on the look up cards supplied with the TrueFlow).

If the TrueFlow cannot be used because of physical obstacles or other problems, use the Duct Blaster matching method (procedure found on worksheet at end of the Forms tab). If using this method, make sure to double-check the supply plenum pressure reached during the test and correct the apparent flow as needed (correction process described fully on Duct Blaster matching worksheet).

Charge/Performance Page

Refrigerant charge evaluation relies on measurement of operating pressures and comparison to pressures specified by the manufacturer. The specified pressures correspond to measured ambient (and, perhaps, indoor) temperatures. Occasionally, the outdoor unit arrives improperly charged and a check of operating pressures could indicate a problem.

Take special care to follow manufacturers' instructions when evacuating and brazing refrigerant lines. Detailed instructions can be found in Tabs 6, 9, and 10.

Refrigerant line set length and any adjustments shall be recorded. Most systems utilize liquid/suction line sizes that require adding (removing) about 0.6 oz of refrigerant for every foot of piping above (below) the standard set length (typically 15 or 25 feet depending on the system). Use a reliable scale with fresh battery (if applicable). Check the manufacturer's installation instructions to determine the proper adjustment amount.

When running the performance check, make sure system runs for at least 15 minutes in compressor-only mode before taking measurements. ***It is intended the system be in full capacity when tested, or, at least, in the capacity tested that corresponds to the airflow tested***.

If operating pressure(s) are not within limits suggested by the manufacturer, re-check lineset adjustment amount. Additional testing may be needed to confirm proper charge.

When checking outdoor temperature, use a digital thermometer and reliable, calibrated thermocouple to take measurements.

It is recommended (but not required) that the temperature split across the indoor coil be measured and recorded. This information is very useful as a cross-check on system performance and has direct bearing on occupant comfort.

Notes on Auxiliary Heat Controls and Thermostats

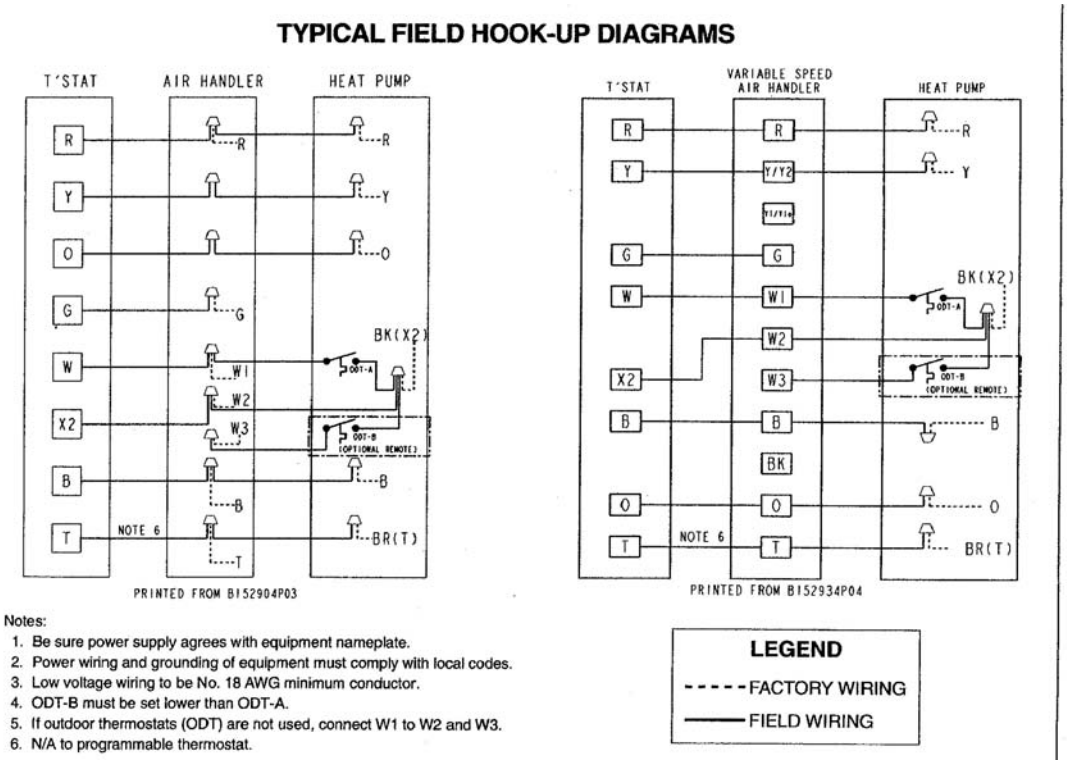
The PTCS specifications now place great emphasis on control of auxiliary ("strip") heat. In many parts of the NW, if the system is sized properly, the ducts are tight, and the airflow is good, the number of hours that backup heat SHOULD operate is expected to be relatively few. The last thing needed in this chain, though, is reliable lockout of auxiliary heat operation when outdoor temperature is relatively mild. "Relatively mild" in PTCS terms is 35° F.

Note we are not talking about use of strip heat on a normal, stage 1 heating call. This is definitely not allowed in the program, whether it is via hard-wiring or the result of a discharge air sensor (discussed below).

Control of auxiliary heat cannot be left up solely to the indoor thermostat through adaptive recovery or similar means. Adaptive recovery is effective if the homeowner does not use deep setback and does not adjust the thermostat frequently during occupied periods. Thermostat studies tend to show, however, that people do all sorts of things with the controls. With heat pumps, this tends to encourage strip heat usage even when it is not needed to keep the house at setpoint. Since PTCS is primarily about energy efficiency, more needs to be done to control strip heat.

Control will differ depending on the type of thermostat or overall control package. Many newer thermostats are equipped with an outdoor sensor (or it can be added as an option) and the temperature at which the elements can come on is programmed at the thermostat. In these cases, the installer needs to make sure the sensor works (usually by testing resistance vs. measured temperature; a common sensor is a thermistor), hook up the sensor, program in the cut out temp, and then confirm the strips don't operate (assuming the ambient testing temperature is above the cut-out temperature). If the ambient temperature is below the cut-out temperature, it will be necessary to warm up the sensor to make sure it has the intended effect.

Another option is use of an after-market close-on-fall switch, whether adjustable or fixed-temperature. The switch must be wired in series with the auxiliary heat circuit, so there needs to be a spare control wire between indoor and outdoor unit to allow this if it is installed in the usual way. The installer must keep this in mind during installation. **Before** this control is installed, its operation must be confirmed; the best way to do this is to place its sensing bulb in a solution of ice cubes and dilute salt water (temperature near 32° F), attach an



Notes:
1. Be sure power supply agrees with equipment nameplate.
2. Power wiring and grounding of equipment must comply with local codes.
3. Low voltage wiring to be No. 18 AWG minimum conductor.
4. ODT-B must be set lower than ODT-A.
5. If outdoor thermostats (ODT) are not used, connect W1 to W2 and W3.
6. N/A to programmable thermostat.

ohmmeter between the control terminals, and turn the adjustment dial until the circuit is closed (resistance on ohmmeter goes from infinite to 0 or near 0). If the circuitry does not make/break right around 32° F, the control will have to be exchanged for another control. The use of a more accurate, refrigeration-type 35° F fixed temperature control (such as the PSG ACC S-35) is strongly encouraged. Place the sensing bulb for the control in accordance with the manufacturer's instructions. Before installation is considered complete, confirm the emergency heat circuit energizes the strips. Also, as part of this installation, make sure the auxiliary and emergency heat circuits are controlled separately; if they are not, a different thermostat or other wiring work-around will be needed. (See cut sheets on following pages for more details.)

An alternate method of getting the same effect (and one not requiring an extra wire before indoor and outdoor units) is an additional thermostat installed inside the house (and set to 35° F) in series with the auxiliary heat circuit. This is somewhat unorthodox but avoids having to get into the outdoor and indoor unit control wiring

Some new systems rely on discharge air sensors to control the transition from compressor-only heating. Typically these sensors operate on a 4-5 minute delay before bringing on strip heat. The PTCS specifications do not allow use of these sensors in single-stage compression systems. On systems with multiple compression stages, discharge sensors are often required. In these cases, PTCS requires a maximum setting of 85° F for the sensor.

Thermostats have changed drastically in the last year. Honeywell and others have introduced touch-screen technology to the residential and commercial markets and it is proving very successful, primarily because of ease of programming and adjustment. The price point (around $100) is also attractive. In addition, communicating (three or four wire) thermostats are becoming more popular. Whichever thermostat is chosen, it is critical to assure proper operation of Stage 1 heating (compressor-only), Stage 2 heating (usually compressor plus auxiliary heat but second stage of compressor operation in some systems) and emergency heat. Some of the newer thermostats, most notably the Honeywell TH8321 series, have a dedicated test mode in the installer set-up that can be used. This feature speeds up the performance check.

If a zoning control is used, follow instructions to make sure dampers open properly (since they can be wired backward). If the system depends on a discharge air sensor for staging, it may be necessary to cool down the sensor to get both stages of compression in multi-stage systems.

Honeywell

TH8320U and TH8321U Touch Screen Programmable Thermostats

INSTALLATION INSTRUCTIONS

APPLICATION

The TH8320U and TH8321U Touch Screen Universal Programmable Thermostats provide electronic control of 24 Vac heating and cooling systems or 750 mV heating system. See Table 1 for a general description.

Table 1. TH832 Thermostats Description.

Model	Power Method	Changeover	System Selection	Fan Selection	Comments
TH8320U	Batteries or common wire	Automatic or manual selectable	Heat-Off-Cool-Auto (Em. Heat for heat pumps)	On-Auto-Circ	System and Fan selection vary based on system type
TH8321U					System and Fan selection vary based on System type. Humidity sensor to control dehumidification.

MERCURY NOTICE

If this control is replacing a control that contains mercury in a sealed tube, do not place your old control in the trash. Dispose of properly.

Contact your local waste management authority for instructions regarding recycling and the proper disposal of the old control.

INSTALLATION

When Installing this Product...

1. Read these instructions carefully. Failure to follow the instructions can damage the product or cause a hazardous condition.
2. Check the ratings given in the instructions to make sure the product is suitable for your application.
3. Installer must be a trained, experienced service technician.
4. After completing installation, use these instructions to check out the product operation.

Selecting Location

Install the thermostat about 5 ft. (1.5m) above the floor in an area with good air circulation at average temperature. See Fig. 1.

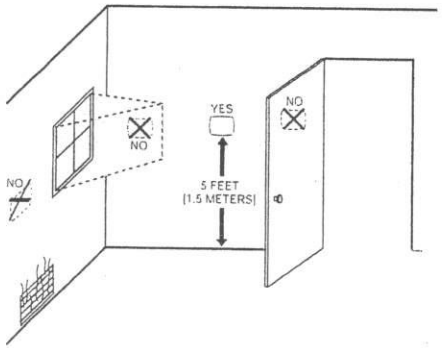


Fig. 1. Selecting thermostat location.

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OPERATION

System and Fan Settings

The System default setting is Heat and the Fan default setting is Auto.

SYSTEM SETTINGS

Heat: Thermostat controls heating system.
Off: Both heating and cooling are off.
Cool: Thermostat controls cooling system.
Auto: Thermostat automatically changes between heating and cooling systems, depending on indoor temperature. (See Installer Setup section.)
Em Heat: Emergency heat cycles to maintain temperature. Compressor is locked out. (Used only for heat pump systems with backup heat.)

FAN SETTINGS

The Fan setting can be programmed into the thermostat schedule for each period (Wake, Leave, Return, Sleep). See the Owners' Guide for additional information.

LED Indication (Requires 24 Vac Common Connection)

An LED indicator is located in the upper right corner of the thermostat. It is only visible when lighted:

- It indicates when the thermostat is in the Emergency Heat mode. When in Em. Ht. mode, the L terminal is continuously energized and the LED is on.
- When the L terminal is wired to an equipment monitor, the LED signals when a check or fail signal is sent to the thermostat from the system. See Fig. 21. (This can occur only when the thermostat is not in Em. Ht. mode.)

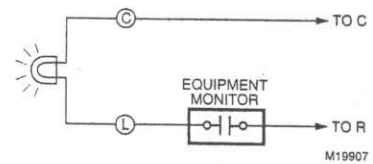

Fig. 21. L terminal switch to R (power) side of system transformer.

Preprogrammed Settings

Table 3 shows the default program settings. See Owners' Guide for complete instructions on changing the program.

Table 3. Default Program Settings.

Schedule Period	Time	Setpoints		Fan Setting
		Heat	Cool	
Wake	6:00AM	70°F (21°C)	78°F (25.5°C)	Auto
Leave	8:00AM	62°F (16.5°C)	85°F (29.5°C)	Auto
Return	6:00PM	70°F (21°C)	78°F (25.5°C)	Auto
Sleep	10:00PM	62°F (16.5°C)	82°F (28°C)	Auto

INSTALLER SETU

This Universal Thermostat works with many different system types. To operate correctly, the thermostat must be set up to operate the installed heating and/or cooling system.

Installer Setup Menus

Main Menu: Offers the most commonly used options. ***It is necessary to enter this menu to set the thermostat to the type of system it is operating. Many applications use only the Main Menu.***

Regional Menu: Offers choices often changed due to a particular area or region. For example, temperature display in Fahrenheit or Celsius is offered in this menu.

Advanced Settings Menu: Offers more settings to fully customize the thermostat. Many of these settings do not require changing from the factory settings.

Entering Installer Setup

1. Thermostat must be powered either with Alkaline AAA batteries or with 24 Vac Common wire.
2. From the home screen, press System key. (Press Done or Cancel key to return to home screen.)
3. Five blank touch keys show on the bottom of the screen between the Done and Cancel keys. Press and hold the two blank keys on either side of the center blank key for approximately five seconds until screen changes. See Fig. 22.

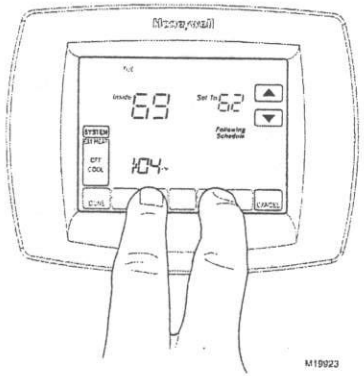

Fig. 22. Entering Installer Setup.

4. The Installer Setup Number is displayed in the lower left. It is a four-digit code beginning with zero. The factory setting or other choice selection is displayed in the lower right. See Fig. 23. This is a two-digit code shown in the Option column of Table 4.

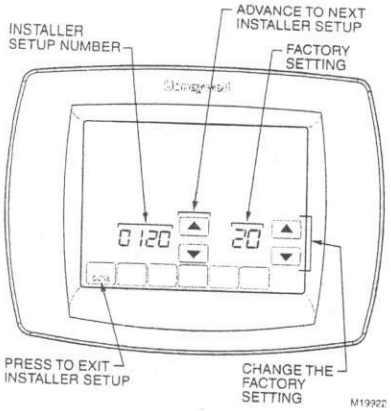

Fig. 23. Installer Setup Number and factory setting selection locations.

Changing Installer Setup Selections

1. Advance to the next Installer Setup Number by pressing the up and down arrow keys to the right of the four-digit Installer Setup Number. See Fig. 23.
2. Change the factory Setting Options by pressing the up and down arrow keys to the right of the two-digit code selection. See Fig. 23.

Exiting Installer Setup

1. Press the Done key to exit the Installer Setup screen.

IMPORTANT

The three Installer Setup Menus (Tables 4-6) show all the available options. These options customize themselves as you make selections to the Installer Setup. Therefore, not all Installer Setup Selections are shown or are available to change.

Table 4. Main Installer Setup Menu.

Select	Installer Setup Number	Factory Setting		Other Choices		Comments
		Option	Description	Options	Description	
Not used.	1 thru 0099	—	—	—	—	—
Date (Year Upper)	0120	20	Set first two digits of current calendar year (20 for year 2005, etc)	21	21 —first two digits of current calendar year (21xx)	2000 -2178 available
Date (Year Lower)	0130	04	Represents last two digits of current calendar year (2004).	00 -99	Select last two digits of current calendar year.	2001-2178 available
Date (Month)	0140	6	Digit(s) represents current calendar month.	1-12	Select number that represents current calendar month.	—
Date (Day)	0150	15	Digit(s) represents current calendar date.	1-31	Select number that represents current calendar date.	—
Schedule Options	0160	4	7-day programming	0	0 —nonprogrammable	—

Table 5. Regional Settings Menu. (Continued)

Select	Installer Setup Number	Factory Setting		Other Choices		Comments
		Option	Description	Options	Description	
Remote Temperature Sensor (Outdoor or Indoor)	0340	0	No remote temperature sensor	1-3	1—outdoor temperature sensor for display only. 2—outdoor temperature sensor for control. Used for select heat pump systems. (See Special Heat Pump Features section for more details.) 3—indoor temperature sensor	Defaults and Options depend on System Type selection. Indoor Temperature Senso uses an averaging network and does not include on-boarc sensor. When number 0210 is set to zero, this item is automaticall selected to number 2 and not shown.
Heat Pump Compressor Lockout or (Balance Point)	0350	0	No compressor lockout.	15, 20, 25, 30, 35, 40, 45	No lockout. 15°F(-9.5°C) 20°F(-6.5°C) 25°F(-4°C) 30°F(-1°C) 35°F(1.5°C) 40°F(4.5°C) 45°F (7°C)	Default depends or other selections. Shown if Outdoor Temperature for control is selected. (See Advanced Features section fo more information.)
Heat Pump Auxiliary Lockout	0360	0	No heat pump auxiliary lockout	40, 45, 50, 55, 60	No lockout. 40°F(4.5°C) 45°F(7°C) 50°F(10°C) 55°F(13°C) 60°F (15.5°C)	Shown if electric is chosen for backup heat source and outdoor temperatur sensor for control is selected. (See Advanced Features section fc more information.)
Indoor Dehumidification Control	0380	0	No indoor dehumidification control	1	1—dehumidification droop control. (See Advanced Features section for more information.)	Available on model with humidity sensor.

SYSTEM LOCKOUT

Installer System Test

The Installer System Test mode is used to test the HVAC system(s). See Table 7. While in System Test mode, minimum off -time for compressors is bypassed.

The Installer Test is part of the Installer Setup options. Entering the Installer Setup screen and pressing the down arrow key to bring up the test selection(s) accesses it quickly. See Fig. 22.

⚠ CAUTION

Equipment Damage Hazard.
Minimum compressor off-time is bypassed during Installer System Test.
Avoid cycling compressor quickly.

Table 7. System Test(s).

Select	Installer Setup Number	Factory Setting		Other Choices		Comments
		Options	Description	Options	Description	
Installer Test Cool	Test 1	0	Cool is off	1,2	0—cool off 1—cool stage 1 turns on 2—cool stages 1 and 2 on	System selection determines which tests are available and the number of stages shown.
Installer Test Fan	Test 2	0	Fan is off	1	0—fan off 1—fan turns on	
Installer Test Heat	Test 3	0	Heat is off	1-3	0—heat off 1—stage 1 heat on 2—stages 1 and 2 heat on 3—stages 1, 2 and 3 (Aux Ht) on	
Installer Test Em Ht	Test 4	0	Emergency heat is off	1	0—emergency heat off 1—emergency heat on	Available only if heat pump with auxiliary heat is selected.

ADVANCED FEATURES

Outdoor or Indoor Temperature Sensor

Allow outdoor or indoor temperature sensor to absorb the air for a minimum of five minutes before taking a reading. See the Sensor instructions for more information.

Special Heat Pump Features

Heat Pump with Fossil Fuel Auxiliary Heat (Dual Fuel) and Outdoor Temperature Sensor

In this operation, there is no external fossil fuel kit (dual fuel kit) installed; the thermostat controls this function.

1. Choose correct heat pump application in Installer Setup Number 0170.
2. Choose **Fossil Fuel Option** as the backup heat source in Installer Setup Number 0200.
3. Choose **No External Fossil Fuel Kit Option** is controlling back up heat in Installer Setup Number 0210.
4. **Outdoor Temperature Sensor for Control Option** is automatically chosen in Installer Setup Number 0340 (0340 is not shown).
5. Choose appropriate **Balance Point Temperature** in Installer Setup Number 0350.

OPERATION IN HEAT MODE ABOVE BALANCE POINT (OUTDOOR TEMPERATURE)

When the outdoor temperature is above the selected Balance Point Temperature (ISU 0350), only the compressor operates and the fan (G terminal) energizes when the thermostat calls for heat.

OPERATION IN HEAT MODE BELOW BALANCE POINT (OUTDOOR TEMPERATURE)

When the outdoor temperature is below the selected Balance Point Temperature (ISU 0350), only the Fossil Fuel (auxiliary heat) operates and the fan (G terminal) does not energize when the thermostat calls for heat.

OPERATION IN EMERGENCY HEAT MODE

The balance point (outside) temperature is not used in the Emergency heat mode. When the thermostat is moved to the Emergency Heat position, the compressor is locked out. The first stage of heat is whatever is connected to the E terminal. The second stage of heat is what is connected to the Aux. terminal. Often there is only one source of non-compressor heat and the E terminal is jumped to the Aux. terminal.

Heat Pump with Electric Auxiliary (Backup) Heat and Outdoor Temperature Sensor

1. Choose correct heat pump application in Installer Setup Number 0170.
2. Choose Electric as **Auxiliary (Backup) Heat Source** in Installer Setup Number 0200.
3. Choose **Outdoor Temperature Sensor for Control Option** in Installer Setup Number 0340.
4. Choose **Compressor Lockout Temperature** in Installer Setup Number 0350.
5. Choose **Auxiliary Lockout Temperature** in Installer Setup Number 0360.

NOTE: There is a 5°F deadband between the Compressor and Auxiliary Heat Lockout Temperatures

Operation in Heat Mode

When the outdoor temperature is below the Compressor Lockout Temperature, only the Auxiliary Heat operates.

When the outdoor temperature is above the Auxiliary Lockout Temperature, only the Compressor operates. See Fig. 24.

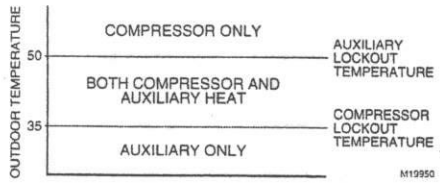

Fig. 24. Heat Pump Operation with Lockout Temperatures Set.

When the outdoor temperature is between the two temperatures, both the Compressor and Auxiliary Heat operate.

Operation in the Emergency Heat Mode

Once the thermostat is placed into the Emergency Heat mode, the compressor and auxiliary lockout features are turned off. In the Emergency heat mode, the compressor is locked out. The first stage of heat is whatever is connected to the E terminal. The second stage of heat is connected to the Aux. terminal. Usually the emergency and auxiliary heat sources are electric strip heat in these cases.

Dehumidification Droop Control

The dehumidification control attempts to control to the user's humidity setpoint by turning on the air conditioner. In extremely high humidity conditions, the thermostat keeps the air conditioner running for up to 3°F below the temperature setpoint. It does this while trying to achieve the desired humidity setpoint and balancing that with the temperature setpoint.

Carrier®
HEATING & COOLING

Thermidistat™ Control

Visit www.carrier.com

Installation, Start-Up, and Operating Instructions

NOTE: Read the entire instruction manual before starting the installation.

This symbol → indicates a change since the last issue.

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SAFETY CONSIDERATIONS

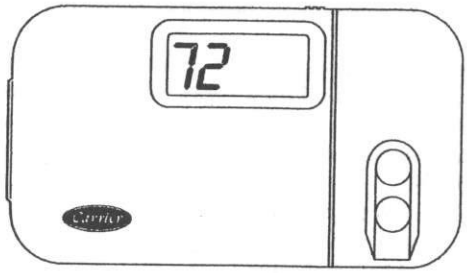
Read and follow manufacturer instructions carefully. Follow all local electrical codes during installation. All wiring must conform to local and national electrical codes. Improper wiring or installation may damage Thermidistat Control.

Recognize safety information. This is the safety-alert symbol ⚠. When you see this symbol on the equipment and in the instruction manual, be alert to the potential for personal injury.

Understand the signal words DANGER, WARNING, and CAUTION. These words are used with the safety-alert symbol. DANGER identifies the most serious hazards which **will** result in severe personal injury or death. WARNING signifies a hazard which **could** result in personal injury or death. CAUTION is used to identify unsafe practices which **would** result in minor personal injury or product and property damage.

INTRODUCTION

Carrier's 7-day programmable/non-programmable Thermidistat Control is a wall-mounted, low-voltage control which combines temperature and humidity control in a single attractive unit. An extension of Carrier's proven line of thermostats, it provides separate set points for heating and cooling, and now adds humidification and dehumidification. Different heating and cooling set points and times are programmable for 4 periods per day and 7 days per week. The Thermidistat Control can also be field-configured as a non-programmable thermostat. When operating in the non-programmable configuration it will still have both temperature and humidity control. Humidify and dehumidify outputs provide direct control of humidity. Batteries are not used. During power loss an internal memory stores programs and settings for unlimited time, and the clock continues to run for at least 8 hr.



A98426

HEIGHT (IN.)	WIDTH (IN.)	DEPTH (IN.)
4-3/8	7-3/8	1-3/8

Fig. 1—Thermidistat Control

INSTALLATION CONSIDERATIONS

POWER

Note that this control does not require batteries and is not "power stealing." It does require 24vac (R and C terminals) of the low-voltage transformer to be connected to it for proper operation. It will not operate without these 2 connections.

MODELS

There is a single programmable/non-programmable model for all applications. It can be configured for AC or HP, 1- or 2-speed compressor, and for dual fuel installations, allowing it to be used in place of all Carrier thermostats.

HUMIDIFY EQUIPMENT AND CONNECTIONS

The humidify output connects directly to 24vac operated humidifiers. No other connection or interlock is required. Any of several installer-selectable operating modes are available.

⚠ WARNING

→ **DO NOT** connect Furnace HUM terminal directly to Thermidistat HUM terminal. This will bypass furnace safety controls. See Low Voltage Wiring Daigrams and notes for proper connection.

DEHUMIDIFY EQUIPMENT AND CONNECTIONS

The dehumidify output connects to the dehumidify input on variable-speed furnaces and fan coils. Additional dehumidification is done by controlling the compressor. A variety of operating modes are available.

OUTDOOR TEMPERATURE SENSOR

Optimum performance is obtained when an outdoor temperature sensor is used with the Thermidistat Control. Plan installation so that 2 wires can be run from Thermidistat Control to an outdoor location, preferably on the north side of the house **or** refer to Installation Instructions included with the outdoor temperature sensor for simplified connection. Sensor can be mounted to outdoor unit and existing control wires may be used for its connection. Details are provided in sensor instructions.

Manufacturer reserves the right to discontinue, or change at any time, specifications or designs without notice and without incurring obligations.

INSTALLATION

Step 1—Thermidistat Control Location

Thermidistat Control should be mounted:

- Approximately 5 ft (1.5m) from floor.
- Close to or in a frequently used room, preferably on an inside partitioning wall.
- On a section of wall without pipes or duct work.

Thermidistat Control should NOT be mounted:

- Close to a window, on an outside wall, or next to a door leading to the outside.
- Exposed to direct light or heat from a lamp, sun, fireplace, or other temperature-radiating objects which could cause a false reading.
- Close to or in direct airflow from supply registers and return-air registers.
- In areas with poor air circulation, such as behind a door or in an alcove.

Step 2—Set DIP Switches

There is a 4 section DIP switch within the Thermidistat Control which must be properly set by the installer. It is easiest to set these 4 switches before the Thermidistat Control is mounted to the wall, so STOP and complete the following steps:

1. Open hinged Thermidistat Control cover.
2. Remove cover completely by snapping it apart at hinge.
3. Open Thermidistat Control by pressing back half of the right end of plastic case inward while, at the same time, pulling front and back halves apart at the right end. The 2 halves will swing apart.
4. Snap hinge apart to completely separate the 2 halves.
5. Switches are located in upper right corner of circuit board. To change switch position, use corner of a small screwdriver to slide switch to opposite position.
6. After switches have been set, do not reassemble the 2 halves. The rear plastic will first be mounted to the wall.

SWITCH 1—AC/HP SELECT

Use this switch to select between air conditioner and heat pump systems.

TO SET:
OFF—for air conditioner installations. This is factory default.
ON—for heat pump installations, using either a fan coil or furnace (dual fuel).

SWITCH 2—1 SPEED/2 SPEED

This switch tells the system whether the compressor is 1 or 2 speed.

TO SET:
OFF—for single-speed compressor. This is factory default.
ON—for 2-speed compressors, whether AC or HP.

SWITCH 3—SMART/CONVENTIONAL RECOVERY

Selects between conventional and smart recovery from setback. Conventional recovery changes to new set point at programmed time. Smart recovery, which is active in both heating and cooling, starts 90 minutes earlier and smoothly adjusts set point so room will arrive at programmed temperature at programmed time.

TO SET:
OFF—for smart recovery. This is factory default.
ON—for conventional recovery.

SWITCH 4—INSTALLER TEST OFF/ON

Selects a special installer test mode which assists with system startup and checkout. See Step 5, System Startup and Check-out.

TO SET:
OFF—for normal operation. This is factory default.
ON—for installer test mode.

Step 3—Install Thermidistat Control

⚠ WARNING

Before installing Thermidistat Control, turn off all power to equipment. There may be more than 1 power disconnect. Electrical shock can cause personal injury or death.

1. Turn off all power to equipment.
2. If an existing thermostat is being replaced:
   a. Remove existing thermostat from wall.
   b. Disconnect wires from existing thermostat, 1 at a time.
   c. As each wire is disconnected, record wire color and terminal marking.
   d. New or additional wire may be needed to accommodate added humidity outputs.
   e. Discard or recycle old thermostat.

NOTE: Mercury is a hazardous waste and MUST be disposed of properly.

3. Select Thermidistat Control rear plastic. (If it is not separated from the remainder of the Thermidistat Control, refer to Step 2 above.)
4. Route wires through large hole in rear plastic. Level rear plastic against wall (for aesthetic value only—Thermidistat Control need not be leveled for proper operation) and mark wall through 2 mounting holes.
5. Drill two 3/16-in. mounting holes in wall where marked.
6. Secure rear plastic to wall with 2 screws and anchors provided. Additional mounting holes are available for more secure mounting if needed. Make sure all wires extend through hole in mounting base.
7. Adjust length and routing of each wire to reach proper connector block and terminal on rear plastic with 1/4-in. extra length. Strip only 1/4 in. of insulation from each wire to prevent adjacent wires from shorting together when connected.
8. Match and connect equipment wires to proper terminals of each connector block. (See Low Voltage Wiring Diagram Reference Chart and Figs. 1 through 28 in separate Wiring Diagram literature). Remember R and C **must** be connected for proper operation.

⚠ CAUTION

Improper wiring or installation may damage Thermidistat Control. Check to make sure wiring is correct before proceeding with installation or turning on power.

9. Push any excess wire into wall and against rear plastic. Seal hole in wall to prevent air leaks. Leaks can affect operation.
10. Reattach Thermidistat Control body to rear plastic by first reattaching hinge.
11. Close Thermidistat Control assembly, making sure pins on back of circuit board align with sockets in connector.
12. Turn on power to equipment.

On power up, all display segments will light for 5 sec. For the next 5 sec, a 2-digit code appears on large display which identifies Thermidistat Control configuration:

1. AC—for 1-speed air conditioner
2. HP—for 1-speed heat pump

3. A2—for 2-speed air conditioner
4. H2—for 2-speed heat pump
5. dF—for 1-speed dual fuel
6. d2—for 2-speed dual fuel
7. HS—for 1-speed heat pump with Intelligent Heat Staging (3-stage auxiliary heat with 40FK, FK4C, or FV4A Series fan coils.)

When this identifier disappears, normal operation begins. The MODE control should be set to OFF and FAN control to AUTO, so equipment does not start until further configuration and check-out is completed.

Step 4—Set Thermidistat Control Configuration

Configuration options, like DIP switch settings, are intended to be selected at installation and normally are not modified by the homeowner. These options are not discussed in the homeowner's manual and therefore must be made as part of the installation. A special procedure allows entry into the configuration mode. While in configuration mode, up to 17 selections can be made. A description of each selection and how to use the configuration mode follows.

CONFIGURATION OPTIONS — SUMMARY:

Option 1—Anticipator adjustment

Option 2—Clean filter timer adjustment

Option 3—English/Metric selection

Option 4—Fan (G) ON with W selection

Option 5—Variable-speed blower present selection

Option 6—Cooling lockout below 55° selection

Option 7—Variable-speed super dehumidification selection (only available when variable-speed blower is used)

Option 8—Auxiliary heat lockout temperature setting (only available when heat pump is used)

Option 9—Intelligent Heat Staging selection (only available when single-speed heat pump is used)

Option 10—Dual Fuel selection (only available when heat pump is used)

Option 11—Balance point setting (only available when Dual Fuel is selected)

Option 12—Defrost heat selection (only available when heat pump is used)

Option 13—Room temperature offset adjustment

Option 14—Heat/cool dead band adjustment

Option 15—Enable Auto mode

Option 16—Enables Super Comfort Heat Mode

Option 17—Non-Programmable selection

TO ENTER CONFIGURATION MODE:

Press and hold FAN button for approximately 10 sec until COOL set point display indicates a flashing 1. The Thermidistat Control is now in configuration mode. It will automatically exit this mode if no button is pressed for 3 minutes. Pressing END button will exit configuration mode immediately.

WHILE IN CONFIGURATION MODE:

The upper small (COOL set point) display indicates selected option number and large display indicates selection made within that option. One of these will be flashing. The up and down buttons are used both to move between available options and to make selection for each option. When option number (small display) is flashing, up and down buttons adjust it, moving between available option numbers. After desired option number has been selected, press SET TIME/TEMP button once. The large display will now flash, indicating that up and down buttons now control available choices within that option. Each press of TIME/TEMP button switches between available option (small display) and available selections within each option (large display).

CONFIGURATION OPTIONS — SELECTION:

Option 1—Anticipator Adjustment

This adjustment controls sensitivity and cycle rate of Thermidistat Control. Higher numbers decrease sensitivity and slow cycle rate. Lower numbers increase sensitivity and cycle rate. However, a limiting feature will not allow more than 4 cycles per hr, regardless of setting. Anticipator values can range from 1 to 9. Factory default is 3. This default selection provides optimum performance in nearly all installations. Try it first. Do not change setting unless there is evidence of need to do so.

Unlike conventional anticipators, this setting is not determined by current draw. There is no need to measure, know, or compensate for current draw. There is also no droop with this Thermidistat Control. Regardless of setting and number of stages, both heating and cooling will control to their respective set points.

TO ADJUST:

1. Enter configuration mode if not already there. See Step 4 "To Enter Configuration Mode." The upper small (COOL set point) display will be flashing 1. If not, use up and down buttons to move it to 1.
2. Press SET TIME/TEMP button once to flash current selection of 1, 2, 3, 4, 5, 6, 7, 8, or 9 on large display. Factory default is 3.
3. Use up and down buttons to move between available choices.
4. Press SET TIME/TEMP button again to flash upper small display for selection of another option, or press END to exit configuration mode.

Option 2—Clean Filter Timer

Select hours of blower operation (heating, cooling, or fan) before CLEAN FILTER icon is displayed. With OFF selected, icon will never come on, disabling this feature. Time selection can range from 400 to 3600 hr by selecting numbers 1 through 9. (Time is 400 X number selected.) Factory default is 2 (800 hr). Recommended selections are: disposable filter—400 to 800 hr, media filter—1200 to 1600 hr, or electronic air cleaner—1600 to 2400 hr of blower operation.

TO SELECT OR ADJUST:

1. Enter configuration mode if not already there. See Step 4 "To Enter Configuration Mode." Use up and down buttons to make small (now flashing) display indicate 2.
2. Press SET TIME/TEMP button once to flash current selection of OF, 1, 2, 3, 4, 5, 6, 7, 8, or 9 on large display. Factory default is 2.
3. Use up and down buttons to move between available choices.
4. Press SET TIME/TEMP button again to flash upper small display for selection of another option, or press END to exit configuration mode.

Option 3—English/Metric

Select between Fahrenheit and Celsius operation. Factory default is Fahrenheit.

TO SELECT OR ADJUST:

1. Enter configuration mode if not already there. See Step 4 "To Enter Configuration Mode." Use up and down buttons to make small (now flashing) display indicate 3.
2. Press SET TIME/TEMP button once to flash current selection of F or C. Factory default is F.

3. Use up and down buttons to move between F and C on large display.
4. Press SET TIME/TEMP button again to flash upper small display for selection of another option, or press END to exit configuration mode.

Option 4—Fan (G) On With W

This selection determines whether fan (G) output is to be ON or OFF when any W (furnace or strip heat) output is ON. Most furnaces and fan coils manage their own blowers and do not require separate G signal. For these applications, select OFF. Some auxiliary heaters require separate G signal to turn on blower. In this case, select ON. Factory default is OF (off).

TO SELECT:

1. Enter configuration mode if not already there. See Step 4 "To Enter Configuration Mode." Use up and down buttons to make small (now flashing) display indicate 4.
2. Press SET TIME/TEMP button once to flash large display.
3. Use up or down buttons to alternate between OF and ON on large display. Factory default is OF.
4. Press SET TIME/TEMP button again to flash upper small display for selection of another option, or press END to exit configuration mode.

Option 5—Variable-Speed (ICM) Blower

If furnace or fan coil contains a variable-speed (ICM) blower, set this option to ON. For normal (PSC) blowers, set to OF. This selection enables system to use special features available only in units with an ICM blower. Factory default is OF (off).

TO SELECT:

1. Enter configuration mode if not already there. See Step 4 "To Enter Configuration Mode." Use up and down buttons to make small (now flashing) display indicate 5.
2. Press SET TIME/TEMP button once to flash large display.
3. Use up or down buttons to alternate between OF and ON on large display. Factory default is OF.
4. Press SET TIME/TEMP button again to flash upper small display for selection of another option, or press END to exit configuration mode.

Option 6—Cooling Lockout Below 55°F

This option disables cooling when outdoor temperature is below 55°F. It requires an outdoor temperature sensor. Set to OF to allow cooling below 55°F. Set to ON to prevent cooling below 55°F. Factory default is OF (off).

TO SELECT:

1. Enter configuration mode if not already there. See Step 4 "To Enter Configuration Mode." Use up and down buttons to make small (now flashing) display indicate 6.
2. Press SET TIME/TEMP button once to flash large display.
3. Use up or down buttons to alternate between OF and ON on large display. Factory default is OF.
4. Press SET TIME/TEMP button again to flash upper small display for selection of another option, or press END to exit configuration mode.

Option 7—Variable-Speed Superdehumidify

This option requires prior selection of variable-speed (ICM) blower (Option 5). When selected, this option operates blower at further reduced airflow from that of normal dehumidification when there is a dehumidification demand without a cooling demand, achieving maximum humidity removal with minimum cooling. It is done by supplying blower with a Y signal and no G signal on a call for cooling. Not all products with ICM blowers have this feature. Check Installation Instructions for ICM air handler used. Select OF for normal operation (Y and G supplied on a cooling call). Select ON for super dehumidification (Y with no G on a dehumidify only call). Factory default is OF (off).

TO SELECT:

1. Enter configuration mode if not already there. See Step 4 "To Enter Configuration Mode." Use up and down buttons to make small (now flashing) display indicate 7.
2. Press SET TIME/TEMP button once to flash large display.
3. Use up or down buttons to alternate between OF and ON on large display. Factory default is OF.
4. Press SET TIME/TEMP button again to flash upper small display for selection of another option, or press END to exit configuration mode.

Option 8—Auxiliary Heat Lockout Setting

This option requires prior selection of heat pump (DIP switch 1--ON). It allows selection of an outdoor temperature of 5° through 55°F. (or equivalent values in C), or OF (off). Auxiliary heat (furnace in Dual Fuel applications) is prevented from operating for outdoor temperatures above selected temperature. If OF (off) is selected, auxiliary heat (furnace if Dual Fuel) operation is allowed at all outdoor temperatures. If selected, emergency heat (EHEAT) overrides this feature. Factory default is OF (off). This setting can only be equal to or above the setting choice made for Option 11. Moving this setting lower may 'push' Option 11 setting downward.

TO SELECT:

1. Enter configuration mode if not already there. See Step 4 "To Enter Configuration Mode." Use up and down buttons to make small (now flashing) display indicate 8.
2. Press SET TIME/TEMP button once to flash large display.
3. Use up or down buttons to move between OF, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, or 55 on large display. Factory default is OF.
4. Press SET TIME/TEMP button again to flash upper small display for selection of another option, or press END to exit configuration mode.

Option 9—Intelligent Heat Staging

This option requires prior selection of single-speed heat pump (DIP switch 1—ON, DIP switch 2—OF). It provides 3 stages of electric heat from W1 and W2 by sequencing W1 only, then W2 only, then both W1 and W2. See FK or FV Series Fan Coil Installation Instructions for further information. For 3-stage heat, select ON. For normal 1- or 2-stage heat, select OF. Factory default is OF (off).

TO SELECT:

1. Enter configuration mode if not already there. See Step 4 "To Enter Configuration Mode." Use up and down buttons to make small (now flashing) display indicate 9.
2. Press SET TIME/TEMP button once to flash large display.
3. Use up or down buttons to alternate between OF and ON on large display. Factory default is OF.
4. Press SET TIME/TEMP button again to flash upper small display for selection of another option, or press END to exit configuration mode.

Anticipator system.

Measure voltage in anticipator circuit as follows:

Outdoor Temp.	Test Point Lv. Term. Board	Expected Reading For Normal Operation
70° F. or above	R to T	22 volts
70° F. or above	B to T	2 volts
30° F.	R to T	19 volts
30° F.	B to T	5 volts
0° F.	R to T	15 volts
0° F.	B to T	9 volts

NOTE: If anticipator circuit is open thermostat will be 6 degrees to 8 degrees out of calibration.

Thermostat Calibration Test

Allow indoor temperature to remain at thermostat off point temperature at least one hour prior to test.

Place thermometer at thermostat location. Allow time for thermometer to stabilize.

Record temperature reading.

If thermostat is out of calibration replace thermostat.

Adjustments

Cover thermometer — screw adjustment on back of cover.

Heat/cool anticipators — voltage type non-adjustable. Mercury calibration — adjustments not recommended.

SP126 — OUTDOOR THERMOSTAT — AY28X125

The AY28X125 full range outdoor thermostat is adjustable from 40° F. to -10° F.

The AY28X125 is a single pole, single throw temperature operated device that closes on a temperature drop.

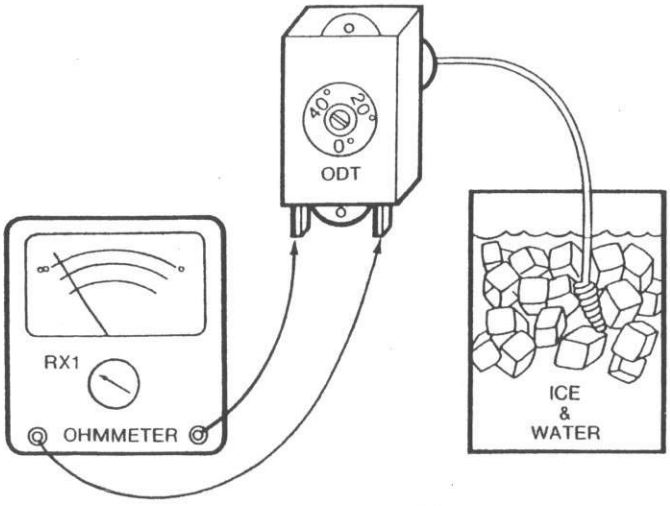
The temperature dial should be set at the temperature desired to energize the electric heater stage to be controlled.

Checking outdoor thermostat operation.

Connect an ohmmeter to the outdoor thermostat terminals.

Set the ODT temperature dial at 40° F. Place the ODT sensing element in a solution of 1 pint water, ice and a teaspoon of table salt.

Ohmmeter should read zero ohms when the sensing element is sufficiently chilled.



CHECK OUTDOOR THERMOSTAT CALIBRATION

Figure 126-1

Warm the sensing element, contacts should be open outdoor thermostat calibration.

Connect an ohmmeter to the outdoor thermostat terminals. (Fig. 126-1)

Immerse the outdoor thermostat sensing element in ice water.

Measure the ice water temperature. Stir the ice water until 32° F. is indicated by the thermometer.

Slowly rotate the outdoor thermostat temperature dial until the ohmmeter indicates closing of the outdoor thermostat contacts.

Outdoor thermostat dial should indicate 32° F. + or - 5° F.

If more than 5° F. error in dial reading exists at 32° F. ice water, replace the outdoor thermostat.

If the outdoor thermostat is within 5° F. dial indication at 32° F. ice water, set the dial to the desired electric heater energizing temperature.

SP130 — CHECKING RELAYS, CONTACTORS, SOLENOID COILS

Magnetic relays, coils, and solenoids may have coils rated at any AC or DC voltage. The device will have its coil voltage rating stamped or printed on the device.

Be sure that the voltage applied to the coil is within 10% of the voltage rating.

Power Off Checks on Magnetic Coil and Contacts.

Disconnect the magnetic coil from the power source.

Check the coil for continuity with an ohmmeter. (Fig. 130-1)

If the coil is open or shorted, replace the coil or relay.

Visually inspect the coil for discoloration or loose terminals.

Inspect the contacts for excessive burning or foreign materials.

Inspect the return spring for rust or disfiguration.

Manually close the relay or contactor and measure the contacts for resistance with an ohmmeter. Resistance across the contacts should be zero ohms.

Power On Checks for Coils and Contacts

With power on and the load connected to the relay or contactor, measure the voltage supply to the magnetic coil. Voltage to the coil should be within 10% of the coil rating. Voltages lower than 10% of coil rating may cause failure of the device to operate or cause the device to chatter.

Measure the voltage across the closed contacts of the relay or contactor. Voltage across closed contacts with the load connected should be zero volts. Any voltage measured across closed contacts indicates excessive contact resistance. The contacts or device should be replaced.

Excessive humming noise produced by a magnetic relay or contactor may be caused by mechanical misalignment, binding, rust, excessive spring tension or low voltage to the coil.

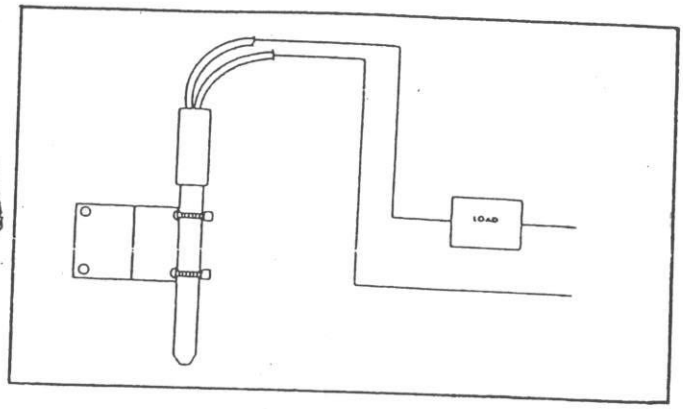
Never adjust the relay or contactor return spring tension. Contact closing time is determined by return spring tension. Any adjustment will cause premature failure of the contacts.

If contacts indicate excessive burning, check the circuit current draw against the contact rating of the device.

INSTRUCTIONS

OT-10 and FCX CLOSE ON RISE (COOLING TYPE)
OT-11 and FHX CLOSE ON FALL (HEATING TYPE)

PSG ACCUSTAT



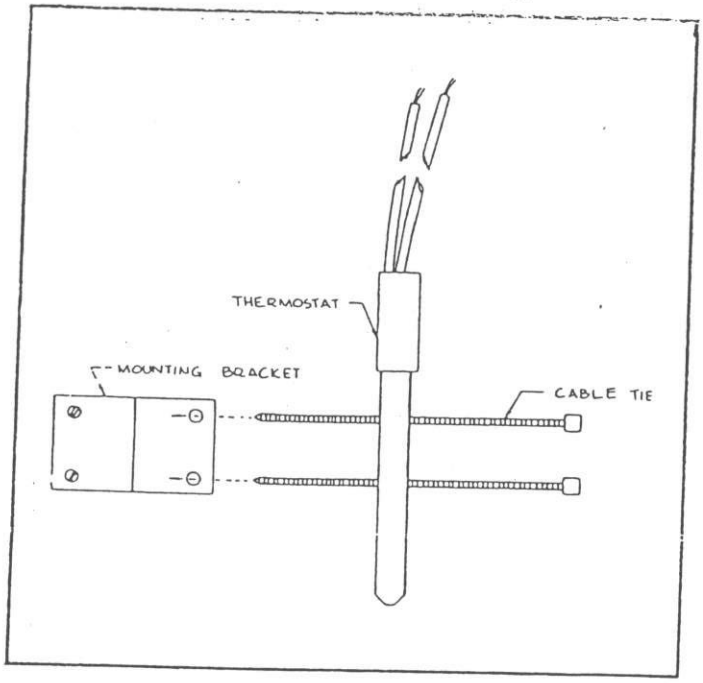
For specific load and voltage ratings, refer to unit.

THEORY OF OPERATION

OT controls incorporate a pre-set sensor which activates internal SPST solid state circuits. ACCUSTAT sensors are hermetically sealed and calibrated to the indicated temperature settings.

As room temperature increases, the rising column of mercury inside the sensor comes in contact with platinum electrodes. When contact is made, solid state circuitry is activated. The solid state switch turns the heating system off or the cooling system on, depending on thermostat type.

As room temperature drops, the column of mercury falls and the solid state switch turns the heating system on or the cooling system off, again depending on stat type.



GENERAL INSTRUCTIONS

1. CAUTION: Make sure that power is OFF before attempting installation.
2. All wiring must comply with application codes and ordinances.
3. On systems using low voltage gas valves, never apply a jumper across valve coil terminals. A burn out of the thermostat's solid state components may result.
4. A thorough checkout of system should be made after installation.

TESTING

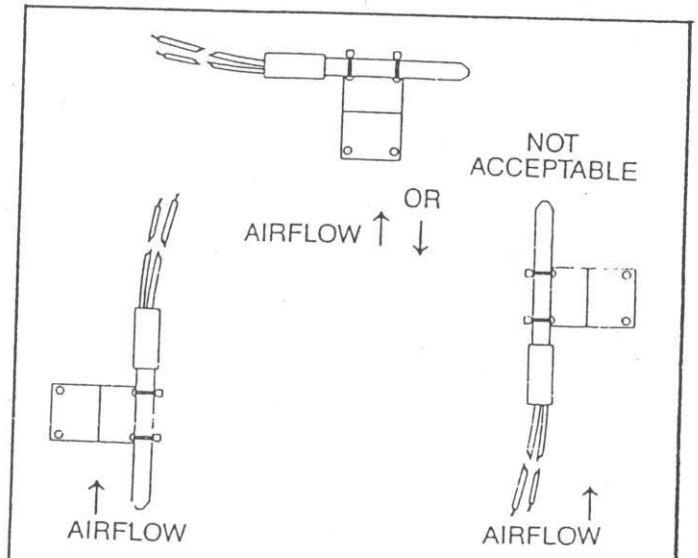
In order to test with a voltmeter, the STAT must have voltage applied to its terminals. Connect all wires as illustrated in the wiring diagrams.

CAUTION

To prevent damage to the STAT when measuring voltage across STAT terminals, use only a voltmeter or multimeter. NEVER use an electromechanical voltage indicator such as a Wigginton type tester.

OPERATIONAL CHECK OUT

When the STAT is "Call", the voltage read at the STAT terminals should be 3 volts or less. When the STAT is in "No Call", the voltage read at the STAT terminals should be the supply voltage.



Install units as shown with airflow orientation.

PSG Limited, L.L.C.
SETTING NEW STANDARDS IN TEMPERATURE CONTROLS
1225 Tunnel Road • P.O. Box 157 • Perkasie, PA 18944
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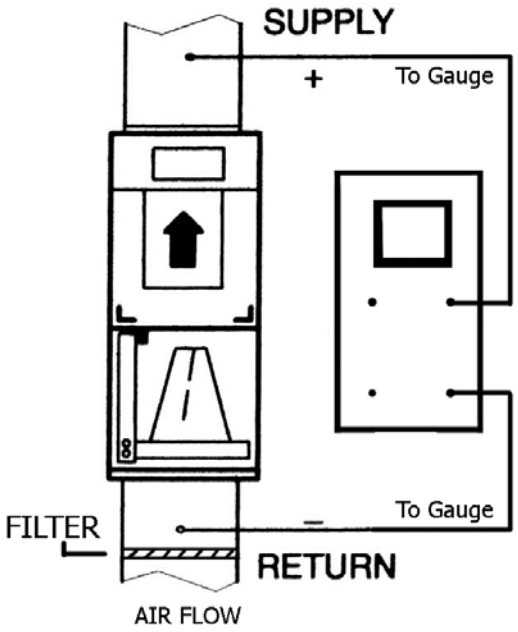
9510-0082

Notes on Setting and Measuring Airflow

The PTCS specifications recommend system airflow of between 375-425 CFM per ton of nominal system capacity. The minimum airflow needed to maintain system capacity and efficiency is 350 CFM/ton. This flow should be attainable in any new system if ducts are properly designed and the fan control is correct. For retrofit systems, it can be more challenging to attain this flow, especially with a PSC (permanent split capacitor) air handler motor. Electrically commutated motors (ECMs) will generally deliver the needed flow even if ducts present more challenges; however, if ducts are undersized, the resistance to flow will increase and this can cause problems for ECMs (higher energy usage and premature failure). For this reason, the procedure requires measurement of external static pressure at the outset of flow testing.



For heat pumps, this is a straightforward process. Measure static pressure in the return plenum (*downstream* of the system filter) and in the supply plenum WRT the area outside of the plenum and add the values together (neglect minus sign on return pressure). Use a static pressure tap with tip pointed into the flow of air. Values over 0.8” of water (200 Pa) should be considered excessive and the technician should see if adjustments (changing filters, unblocking registers, cleaning the coil, etc.) or repairs (duct upsizing, adding ducts, etc) can be made.

External static readings of 0.8” or more will generally result in substandard system flow for PSC fans (which will be noticed in the TrueFlow test); ECM fans will pass the flow test in this case (unless there is some other problem) but will use more energy to get this flow and may fail within a few heating seasons.

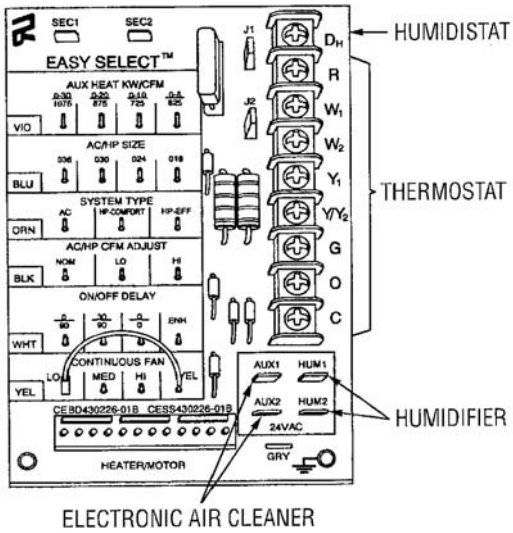
It is important to make sure there are no obstructions near the TrueFlow. These can include coil brackets, top of the cooling coil, and other items. Another problem can be with downflow systems that have non-radius entering ductwork. If the control board is set to deliver at least 350 CFM/ton and the reading is still very low, it may be necessary to use the Duct Blaster matching method to confirm flow. See the worksheet in this section or in the Forms tab to use this procedure.

What about adjusting fan flow? In standard PSC systems, this is usually accomplished by checking which fan tap wire is energized during a normal heating call and changing the wire as needed to get a different flow. The old color conventions were usually Red-low speed; yellow-medium low speed; Blue-medium high speed; Black-high speed.

ECM fans are generally controlled by a set of DIP or pin settings found on the main system printed circuit board (as shown in the next picture). In this context, it is important to make sure the board is set up with the right combination of settings. First, make sure to set the “size” pin to the right capacity for the outdoor unit. Next, note many manufacturers start with a factory default of 350 CFM/ton for the heat pump “efficiency” setting; the “comfort” setting default is usually about 325 CFM/ton. The “high” and “low” adjustment pins go about 10% above/below the nominal flow. So if you leave the system on a “comfort” setting and also use the “low” bias pin, your system may only be moving about 300 CFM/air. This is too low for the PTCS program.

If testing a heat pump system which incorporates a zoning control, make sure all zones are open when the testing is done. You will have to educate yourself about the system by looking at installation instructions. See the appendix in this book for some of the more common zoning control systems. If the ductwork contains a bypass damper, make sure you take this into account when testing. This matters more with duct testing but can occasionally complicate airflow tests. Note systems which use zoning controls and ECM fans should not require a bypass damper.

Figure 9-28.
Accessory Wiring Terminals on a Typical Fan Coil Unit Control Board



Measuring System Airflow with Duct Blaster

(alternate procedure if TrueFlow cannot be used)

1. Turn on air handler (by using fan-only switch or by turning on heat/AC). It is best to call for the flow that will be used during heating.
2. Drill access hole as needed and point hooked end of static tap into airflow**. Do not drill into the duct at any point where you are concerned with hitting something.** Note if fan is variable speed and note expected flow given size of unit and DIP or other settings on system control board.
3. Record normal system operating pressure (NSOP) as described in flow plate test.
4. Next, install split between supply and return so that all air flowing through Duct Blaster will go into supply side.
5. Install Duct Blaster on furnace. Ingenuity with cardboard and duct tape is often needed.
6. ***Turn on air handler to heating speed.***
7. Turn Duct Blaster on and slowly increase flow until the supply plenum pressure is the same as NSOP.
8. Check to make sure the pressure in the return system is 0 or very close to 0 (to confirm system split is good).
9. Record Duct Blaster flow pressure, ring#, and CFM.

NSOP _____Pa

Ring # _____

Flow pressure _____Pa

Air Handler flow _____CFM

Note: if highest pressure reached is not NSOP, a correction is needed.

Record highest pressure reached (HPR)_____

Correction: take square root of (NSOP/HPR) _____

And multiply by Air Handler flow (from above) _____

This is the corrected flow: _____

TABLE 3
FILTER DIMENSIONS

UNIT MODEL NO.	FILTER SIZE Inches (mm)
CB31MV-41	20 x 22 (508 x 559)
CB31MV-51, -65	20 x 24 (508 x 610)

Sealing the Unit

The unit must be sealed to prevent warm air from entering. If air is allowed to penetrate the unit, problems with water blow-off may occur. This is especially important when the unit is installed in an unconditioned area. Make sure the liquid and suction line entry points are sealed with either the provided Armaflex material or with Permagum. Permagum may also be used to seal around the main and auxiliary drains and around open areas of electrical inlets.

BDC3 Blower Control Board

CB31MV units are equipped with a variable speed motor that is capable of maintaining a specified CFM throughout the external static range. A particular CFM can be obtained by positioning jumpers (**COOL**, **HEAT**, and **ADJUST**) on the BDC3 control board. The jumpers are labeled 1, 2, 3, and 4. Each of the numbers corresponds with an air volume (CFM) setting. The **ADJUST** jumper is labeled Test, -, +, and Norm. The + and - pin settings are used to add or subtract a percentage of the CFM selected. The Test jumper is used to operate the motor in the test mode. The delay jumper controls the timing for the fan delay.

Figure 17 shows the BDC3 control board. Use tables 5 and 6 to determine the correct air volume for heat and cool speed taps.

Diagnostic LEDs located on the BDC3 control board are provided to aid in identifying the unit's mode of operation. Certain scenarios will arise depending on the jumper positions. Read through the jumper settings sections before adjusting blower speed. Refer to figure 17 for identification.

Blower Speed Adjustments

Diagnostic LEDs

"RUN"

RUN LED indicates there is a demand for the blower motor to run.

"CFM"

CFM LED indicates the CFM at which the unit is operating. The light flashes once for approximately every 100 CFM. For example, if the unit is operating at 1000 CFM, **CFM** LED will flash 10 times. If the CFM is 1150, **CFM** LED will flash 11 full times plus one fast or half flash.

At times the light may appear to flicker or glow. This takes place when the control is communicating with the motor between cycles. This is normal operation.

The appropriate speed according to application and CFM need is selected by moving jumper pins.

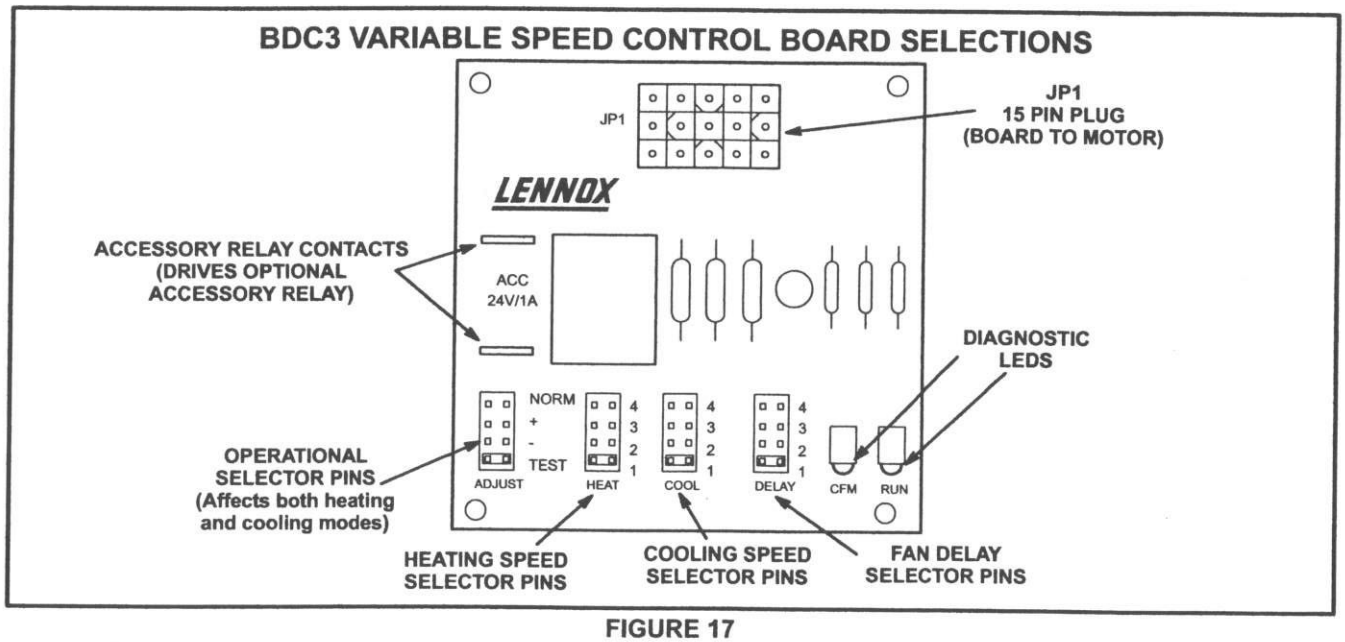


FIGURE 17

Jumper Settings

⚠ IMPORTANT

Before changing jumper setting, make sure the motor has completely stopped. Any jumper setting change will not take place while the motor is running.

Table 4 shows the recommended factory blower speed tap selections for CB31MV series units. These settings are for nominal tonnage match-ups with the CB31MV. When matched with other sizes, it is recommended that the CFM be adjusted to approximately 400 CFM per ton.

TABLE 4
RECOMMENDED BLOWER SPEED TAP SELECTION

CB31MV BLOWER COIL	SPEED TAP SELECTION			
	"COOL"		"HEAT"	
	CONDENSING UNIT	HEAT PUMP	*CONDENSING UNIT WITH ELECTRIC HEAT ONLY	*HEAT PUMP WITH ELECTRIC HEAT
-41	COOL PIN #3	COOL PIN #3	HEAT PIN #4	HEAT PIN #4
-51	COOL PIN #2	COOL PIN #2	HEAT PIN #1	HEAT PIN #1
-65	COOL PIN #3	COOL PIN #3	HEAT PIN #1	HEAT PIN #1

***Minimum setting for heat.**

To change jumper positions, gently pull the jumper off the pins and place it on the desired set of pins. The following section outlines the different jumper selections available and conditions associated with each one. Refer to figure 17.

After the CFM for each application has been determined, the jumper settings must be adjusted to reflect those given in tables 5 and 6. From the tables, determine which row of CFM volumes most closely matches the desired CFM. Once a specific row has been chosen (+, NORMAL, or -), CFM volumes from other rows cannot be used. Below are descriptions of the jumper selections.

"ADJUST"

The **ADJUST** pins allow the motor to run at normal speed, approximately 10% higher, or approximately 10% lower than normal speed. Table 5 gives three rows (+, NORMAL, and -) with their respective CFM volumes. Notice that the normal adjustment setting for heat speed position #3 is 1315 CFM. The + adjustment setting for that position is 1445 CFM and for the - adjustment setting is 1185 CFM. After the adjustment setting has been determined, chose the remainder speed jumper settings from those offered in the table in that row.

The TEST pin is available to bypass the BDC3 control and run the motor at approximately 70% to test that the motor is operational. This is beneficial primarily in troubleshooting. G must be energized for motor to run.

"COOL"

The **COOL** jumper is used to determine the CFM during either 1) cooling or 2) heat pump operation without a call for electric heat. These jumper selections are activated for cooling when Y2 and DS terminals in the CB31MV are energized and for heating when Y2 is energized.

Applications without the Efficiency*Plus*™ CCB1 humidity control will provide either 70% of the **COOL** CFM during first-stage cooling for two-speed outdoor units. 100% of **COOL** CFM is provided for systems with a single-speed outdoor unit.

Applications with the Efficiency*Plus* CCB1 humidity control create different CFM volumes. For example, during a first-stage cooling call (two-speed outdoor unit) with demand from the CCB1, the air volume is 40% of the **COOL** jumper selection. For a normal **COOL** (Pin #2 setting for CB31MV-41), the CFM is 1125; the reduced speed is 450 CFM (1125 x 40% = 450). This arrangement provides for additional dehumidification during standard first stage cooling. See tables 7 and 8 for various scenarios concerning use of the CCB1 humidity control and the CB31MV series unit.

For applications with Harmony II® zone control, the blower CFM volume is determined by the Harmony II control center. The minimum blower speed is predetermined at 650 CFM for -41 series units and 850 CFM for -51 and -65 series units. This speed is not adjustable. See footnotes in tables 5 and 6.

With the thermostat set for "Continuous Fan" and without a call for heating or cooling, the CB31MV will provided 50% of the **COOL** CFM selected.

*NOTE - For two-speed heat pumps, blower will operate at 70% of the **COOL** selection until supplemental electric heat is demanded. At that time, the blower will operate at the **HEAT** speed selected. This arrangement provides for warmer supply air during second-stage heating.*

TABLE 5
CB31MV-41 BLOWER PERFORMANCE
0 through 0.80 in. w.g. (0 Through 200 Pa) External Static Pressure Range

"ADJUST" Jumper Setting	BDC3 Jumper Speed Positions															
	"HEAT" Speed								"COOL" Speed*							
	1		2		3		4		1		2		3		4	
	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s
+	1230	580	1335	630	1445	680	1545	730	1090	515	1225	580	1380	650	1545	730
NORM	1120	530	1215	575	1315	620	1400	660	975	460	1125	530	1275	600	1400	660
—	1010	475	1200	565	1185	560	1265	595	900	425	1000	470	1135	535	1265	595

*First Stage (two-speed units only) cooling is approximately 70% of the COOL speed rating.
Continuous fan speed is approximately 50% of COOL speed rating.
Lennox Harmony II® Zone Control Applications - Minimum blower speed is approximately 380cfm (180 l/s)
NOTE — The effect of static pressure, filter and electric heater resistance is included in the air volumes listed.

TABLE 6
CB31MV-51 AND CB31MV-65 BLOWER PERFORMANCE
0 through 0.80 in. w.g. (0 Through 200 Pa) External Static Pressure Range

"ADJUST" Jumper Setting	BDC3 Jumper Speed Positions															
	"HEAT" Speed								"COOL" Speed*							
	1		2		3		4		1		2		3		4	
	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s	cfm	L/s
+	1850	875	1960	925	2090	985	2150	1015	1625	765	1820	860	2055	970	2145	1010
NORM	1705	805	1800	850	1900	895	2005	945	1425	670	1625	765	1805	850	2005	945
—	1560	735	1625	765	1720	810	1770	835	1205	570	1375	650	1555	735	1725	815

*First Stage (two-speed units only) cooling is approximately 70% of the COOL speed rating.
Continuous fan speed is approximately 50% of COOL speed rating.
Lennox Harmony II® Zone Control Applications - Minimum blower speed is approximately 400 cfm (190 l/s).
NOTE — The effect of static pressure, filter and electric heater resistance is included in the air volumes listed.

TABLE 7
TYPICAL CB31MV, CCB1 and SINGLE SPEED OUTDOOR UNIT OPERATING SEQUENCE

OPERATING SEQUENCE		SYSTEM DEMAND		SYSTEM RESPONSE	
System Condition	Step	Thermostat Demand	*Relative Humidity (Efficiency*Plus* Lights)	Blower CFM (COOL)	Comments
Normal operation	1	Y1	Acceptable (None)	COOL	Compressor demand and indoor blower speed follow thermostat demand.
Call for humidity removal during call for cooling	1	Y1	Acceptable (None)	COOL	Dehumidification mode begins when relative humidity is greater than setpoint.
	2	Y1	Change over setpoint	60%/65% of COOL	
Humidity demand satisfied during thermostat demand.	1	Y1	Over setpoint	60%/65% of COOL	When humidity demand is satisfied, blower immediate shifts to the COOL CFM in order to hasten the end of the cycle.
	2	Y1	Change to acceptable (None)	COOL	
*Call for cooling after call for humidity removal.	1	None	Over setpoint	Off	Dehumidification mode begins when relative humidity is greater than setpoint.
	2	Y1	Over setpoint	60%/65% of COOL	
Humidity demand satisfied between thermostat demands (unit off cycle).	1	None	Over setpoint (1 or more)	Off	While unit is not operating (no thermostat demand), slide switch is moved down and back up. Blower operates at COOL CFM.
	2	Y1	Change to acceptable	COOL	

Note - When changing unit mode of operation from cooling to heating, indicating lights that are on will stay on until the first thermostat heating demand.

** Reduced blower speed is 65% of COOL for the -41 units; 60% of COOL for -51 and -65 series units.*

VIII-TYPICAL OPERATING CHARACTERISTICS

A-Blower Operation and Adjustment

NOTE- The following is a generalized procedure and does not apply to all thermostat controls.

1- Blower operation is dependent on thermostat control system.

2- Generally, blower operation is set at thermostat subbase fan switch. With fan switch in ON position, blower operates continuously. With fan switch in AUTO position, blower cycles with demand.

3- In all cases, blower and entire unit will be off when the system switch is in OFF position.

B-External Static Pressure

1. Measure tap locations as shown in figure 26.

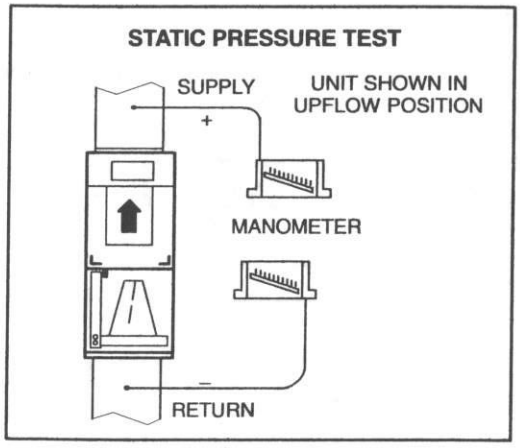


FIGURE 26

2. Punch a 1/4" (6mm) diameter hole in supply and return air plenums. Insert manometer hose flush with inside edge of hole or insulation in the supply plenum only. Seal around the hose with permagum. Connect the other end of the hose to the zero end of the manometer. Leave the other end of the manometer open to the atmosphere.
3. With only the blower motor running and the evaporator coil dry, observe and take note of the manometer reading.
4. Repeat step 2 for the return air plenum. Insert manometer hose to the opposite end of the zero side of the manometer. Leave the zero side of the manometer open to atmosphere.
5. Repeat step 3.

6- Add the **absolute** values of the supply air reading and the return air reading to get the external static pressure of the unit. For example -.20 in.wg. on the return and +.30 in.wg. on the supply result in external static pressure of .50 in.wg. External static should not exceed .80" w.g. (200Pa) Adjust blower motor speed to deliver the air desired according to job requirements.

7- Seal around the holes when the check is complete.

IX-MAINTENANCE

At the beginning of each heating/cooling season, the system should be checked as follows:

A-Filters

⚠ IMPORTANT

Filter access panel must be in place during unit operation. Excessive warm air entering the unit may result in water blow-off problems.

To remove filter, loosen the thumb screws holding the filter panel in place. Slide filter out of the guides on either side of cabinet, insert new filter and replace panel. Some models come with a spacer so standard size filters can be used. Filters should be inspected monthly and must be replaced when dirty to ensure proper blower coil operation. See table 10 for replacement filter sizes or see the sticker located on the filter access door specifying the size of the standard throw-away filter which is used with the unit.

TABLE 10

CB31MV FILTER SIZES	
Unit	Filter Size
CB31MV-41	20" X 20" (508mm X 508mm)
CB31MV-51,-65	20" X 24" (508mm X 610mm)

B-Supply Air Blower

1- Check and clean blower wheel.

2- Motors are prelubricated for extended life; no further lubrication is required.

C-Electrical

1- Check all wiring for loose connections.

2- Check circuit breaker located in unit control box.

3- Check for correct voltage at unit (unit operating).

4- Check amp-draw using a True RMS ampmeter. Typical clamp-on ammeters do not read current accurately.
Motor Nameplate_____Actual_____

5- Check to see that heat (if applicable) is operating.

D-Insulation

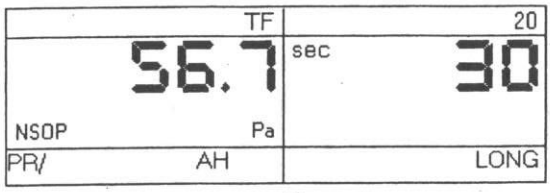
Outdoor piping insulation should be inspected yearly for deterioration. If necessary, replace with same materials.

Quick Guide TF2 – Using the TrueFlow Air Handler Flow Meter and the DG-700 Gauge

1. **Measure the Normal System Operating Pressure (NSOP) with the existing filter in place.**
   a) Locate the air handler system filter and replace if it is dirty.
   b) Install a static pressure probe into the ductwork at one of the 3 locations listed below:

   - Insert the static pressure probe into the side surface of the supply plenum. The side of the supply plenum chosen should not have trunk line, distribution duct or supply register connected to it. The static pressure probe should point into the airstream.
   - Or, insert the tip of the static pressure probe into a "dead-end" corner of the supply plenum. A "dead-end" corner is a corner of the plenum that does not have a trunk line connection, distribution duct connection or supply register within 8 inches of the corner.
   - Or, insert the static pressure probe in the side surface of the return plenum. The side of the return plenum chosen should not have a trunk line, return duct or return register connected to it. The location chosen should also be at least 24 inches upstream from the TrueFlow Metering Plate, and at least 24 inches downstream from any 90 degree corners or return trunk line connections. The static pressure probe should point into the airstream. **Note:** if the Metering Plate will be installed at a remote filter grille, the static pressure probe may not be installed in the return plenum (i.e. install it in the supply plenum).

   c) Connect a piece of tubing between the static pressure probe and the **Channel A Input** tap. If the gauge is in the house during the test procedure, leave the **Reference** tap on **Channel A** open. If the gauge is not in the house during the test procedure (e.g. attic, crawlspace), run additional tubing from the **Channel A Reference** tap to inside the house.
   d) Turn on the air handler fan to the desired speed. Now turn on the gauge and put it the **PR/ AH** mode by pressing the **MODE** button 4 times. The icon "**NSOP**" will begin to flash in the **Channel A** display. At this point, the gauge is monitoring the real-time **Channel A NSOP** pressure, but is not recording the reading. The **Channel B** display is not active at this time.
   e) Press the **START** button to begin the **NSOP** measurement procedure on **Channel A**. Once the **START** button is pressed, the **NSOP** icon stops flashing and the gauge begins recording a long term average **NSOP** pressure reading on **Channel A**. During the measurement procedure, the **Channel B** display is used as a timer to let the user know how long (in seconds) the **NSOP** measurement has been active. The longer the measurement time, generally the more stable the reading typically becomes. In the screen to the right, the measured **NSOP** pressure is 56.7 Pascals (measured over the past 30 seconds).



   f) Once you are satisfied with the **NSOP** reading, press the **ENTER** key to accept and enter the reading into the gauge. Turn off the air handler fan, and leave the static pressure probe in place and connected to the gauge on **Channel A**.

2. **Install the TrueFlow Metering Plate in an Existing Filter Slot.**
   a) Remove the existing filter and set it aside.
   b) Choose and assemble the metering plate and spacers needed to match the filter slot size.

Filter Slot (in. x in.)	Flow Metering Plate	Spacer Dimension (in. x in.)	
		Spacer 1	Spacer 2
14 x 20	#14	------	------
14 x 25	#14	5 x 14	------
16 x 20	#14	2 x 20	------
16 x 24	#14	2 x 20	4 x 16
16 x 25	#14	2 x 20	5 x16
18 x 20	#14	4 x 20	------
20 x 20	#20	------	------
20 x 22	#20	2 x 20	------
20 x 24	#20	4 x 20	------
20 x 25	#20	5 x 20	------
20 x 30	#20	10 x 20	------
24 x 24	#20	4 x 20	4 x 24

   c) Install the assembled metering plate into the filter slot. Be sure the front side of the metering plate is facing into the air flow (front side has two diamond shaped labels on it). The H-channel gasket should provide a seal around the metering plate - all of the air flow should pass through the metering plate and not around it. Be sure that the ends of the flexible tubing connections attached to the plate's pressure sensing grids remain out of the filter slot. Occasionally, drilling holes into the ductwork may be required as a pathway for the ends of the flexible tubing. The flexible tubing can be passed through one of the plate's metering holes if this helps in getting the tubing ends outside of the filter slot.

   - Obstructions within 6 inches upstream or 2 inches downstream of the metering plate that are blocking air flow through any of the metering holes may reduce the accuracy of the device.
   - If there is an obstruction and there is a spacer attached to the metering plate, try to install the metering plate so that the spacer is directly in front of the obstruction (this will minimize the effect of the obstruction on the flow measurement).

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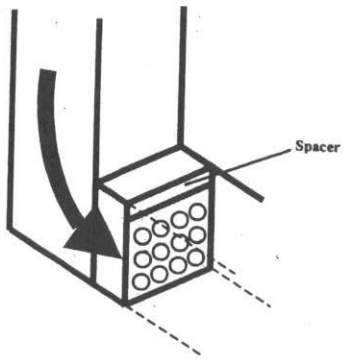
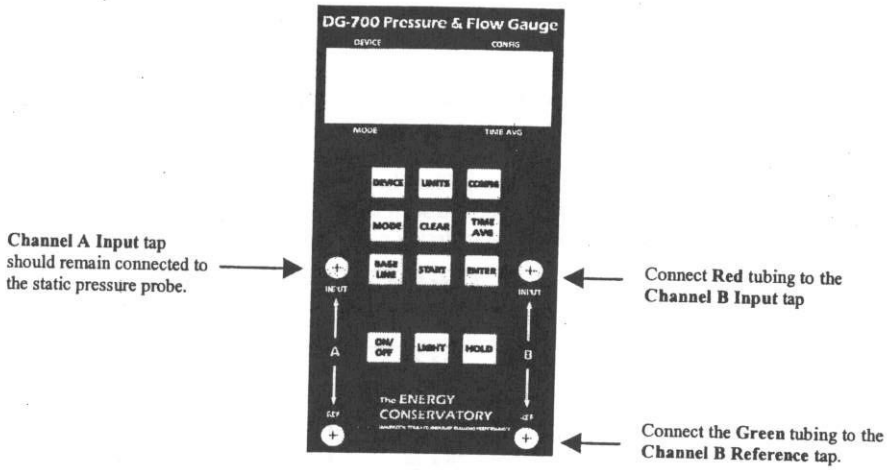
- If the metering plate is installed directly downstream of a 90 degree bend in the duct system, and there is a spacer attached to the plate, install the metering plate so that the spacer is on the inside corner of the bend (see diagram to right).



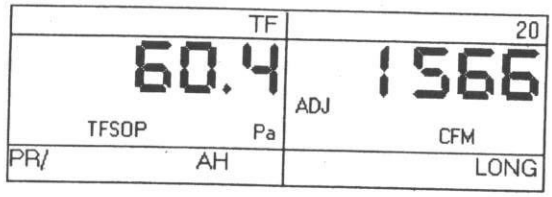
d) Close the filter access opening. Be careful not to pinch off the flexible tubing connections. Temporarily seal around the filter slot cover with masking tape to prevent air leakage.

Note: If you are installing the metering plate at the filter grille of a single return duct system, simply push the plate into the empty filter rack. Make sure that the front of the metering plate is facing out (into the air flow). Keep the filter grille door open for the remainder of the test.

3. **Connect the Metering Plate to the DG-700.**
a) Connect the tubing from the installed metering plate to the DG-700. Connect the Red ("total pressure grid") tubing connection to the **Channel B Input** pressure tap. Connect the Green ("static pressure grid") tubing connection to the **Channel B Reference** pressure tap.



4. **Measure the TrueFlow System Operating Pressure (TFSOP) and Adjusted Total Air Handler Flow.**
a) Check and adjust if necessary the selected test Device and Configuration shown in the upper part of the gauge display to match the metering plate installed in **Step 2** above. When using the TrueFlow Metering Plates, the Device icon should always be set to **TF**, and the Configuration icon should be set to **14** or **20** depending on which metering plate is installed. Changes to the selected Device and Configuration are made by pressing the **DEVICE** and **CONFIG** buttons.
b) Turn the air handler fan back on to the same speed as used in **Step 1** above. **Channel A** will now display the **TFSOP** reading from the static pressure probe, and **Channel B** will display adjusted air handler flow. The static pressure probe should be in exactly the same position as it was in **Step 1** above. The air handler flow rate estimate shown on **Channel B** is determined by continuously adjusting the measured air flow from the TrueFlow Metering Plate using a flow resistance correction factor calculated from the **NSOP** and **TFSOP** pressure readings. If the readings are fluctuating, change the time averaging setting to ***5 second, 10 second,*** *or* ***Long-Term*** average using the **TIME AVG** button.



c) Record the adjusted air flow reading from **Channel B**. In the screen to the right, the adjusted air flow reading is 1,566 CFM. This result is the estimated air flow at the measurement location with the existing filter in place. Turn off the air handler fan.

Note: When the TrueFlow Air Handler Flow Meter is installed at a remote filter grille, it is possible to make a correction to the measured flow through the metering plate which increases the accuracy of the flow measurement. See **Appendix C** of the TrueFlow manual for more details.

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Quick Guide – Using the TrueFlow Air Handler Flow Meter and the DG-3 Gauge

1. **Measure the Normal System Operating Pressure (existing filter in place)**
   a) Locate the air handler system filter and replace if it is dirty.
   b) Install a static pressure probe into the ductwork at one of the 3 locations listed below:
      - Insert the static pressure probe into the side surface of the supply plenum. The side of the supply plenum chosen should not have a trunk line, distribution duct or supply register connected to it. The static pressure probe should point into the airstream.
      - Or, insert the tip of the static pressure probe into a "dead-end" corner of the supply plenum. A "dead-end" corner is a corner of the plenum that does not have a trunk line connection, distribution duct connection or supply register within 8 inches of the corner.
      - Or, insert the static pressure probe in the side surface of the return plenum. The side of the return plenum chosen should not have a trunk line, return duct or return register connected to it. The location chosen should also be at least 24 inches upstream from the TrueFlow Metering Plate, and at least 24 inches downstream from any 90 degree corners or return trunk line connections. The static pressure probe should point into the airstream. **Note:** if the Metering Plate will be installed at a remote filter grille, the static pressure probe may not be installed in the return plenum (i.e. install it in the supply plenum).

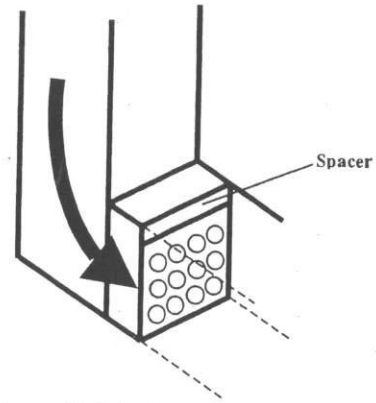
   c) Connect a piece of tubing between the static pressure probe and the ***Channel A* Input** tap. If the gauge is in the house during the test procedure, leave the **Reference** tap on ***Channel A*** open. If the gauge is not in the house during the test procedure (e.g. attic, crawlspace), run additional tubing from the ***Channel A* Reference** tap to inside the house.
   d) Turn the **CHANNEL** knob to ***"A"***, the **RANGE** switch to ***Low (200.0 Pa)*** and the **MODE** switch to ***Pressure***.
   e) Turn on the air handler fan to the desired speed and record the "normal system operating pressure" (**NSOP**) from the gauge. You may want to use the 5 second or long-term time-average setting if the reading is fluctuating.
   f) After recording the **NSOP**, turn off the air handler fan. Leave the static pressure probe in place and connected to the gauge.

2. **Install the TrueFlow Metering Plate in an Existing Filter Slot.**
   a) Remove the existing filter and set it aside.
   b) Choose and assemble the metering plate and spacers needed to match the filter slot size.

Filter Slot (in. x in.)	Flow Metering Plate	Spacer Dimension (in. x in.)	
		Spacer 1	Spacer 2
14 x 20	#14	------	------
14 x 25	#14	5 x 14	------
16 x 20	#14	2 x 20	------
16 x 24	#14	2 x 20	4 x 16
16 x 25	#14	2 x 20	5 x16
18 x 20	#14	4 x 20	------
20 x 20	#20	------	------
20 x 22	#20	2 x 20	------
20 x 24	#20	4 x 20	------
20 x 25	#20	5 x 20	------
20 x 30	#20	10 x 20	------
24 x 24	#20	4 x 20	4 x 24

   c) Install the assembled metering plate into the filter slot. Be sure the front side of the metering plate is facing into the air flow (front side has two diamond shaped labels on it). The H-channel gasket should provide a seal around the metering plate - all of the air flow should pass through the metering plate and not around it. Be sure that the ends of the flexible tubing connections attached to the plate's pressure sensing grids remain out of the filter slot

      - Obstructions within 6 inches upstream or 2 inches downstream of the metering plate that are blocking air flow through any of the metering holes may reduce the accuracy of the device.
      - If there is an obstruction and there is a spacer attached to the metering plate, try to install the metering plate so that the spacer is directly opposite the obstruction (this will minimize the effect of the obstruction on the flow measurement).
      - If the metering plate is installed directly downstream of a 90 degree bend in the duct system, and there is a spacer attached to the plate, install the metering plate so that the spacer is on the inside corner of the bend (see diagram to right).



   d) Close the filter access opening. Be careful not to pinch off the flexible tubing connections. Temporarily seal around the filter slot cover with masking tape to prevent air leakage.

   Note: If you are installing the metering plate at the filter grille of a single return duct system, simply push the plate into the empty filter rack. Make sure that the front of the metering plate is facing out (into the air flow). Keep the filter grille door open for the remainder of the test.

3. **Re-Measure the System Operating Pressure (TrueFlow Plate Installed).**
   a) Turn the air handler fan back on to the same speed as **Step #1** above.
   b) Measure and record the new system operating pressure (**TF SOP**) using the static pressure probe and DG-3. The static pressure probe should be in the exact same position as **Step #1** above.

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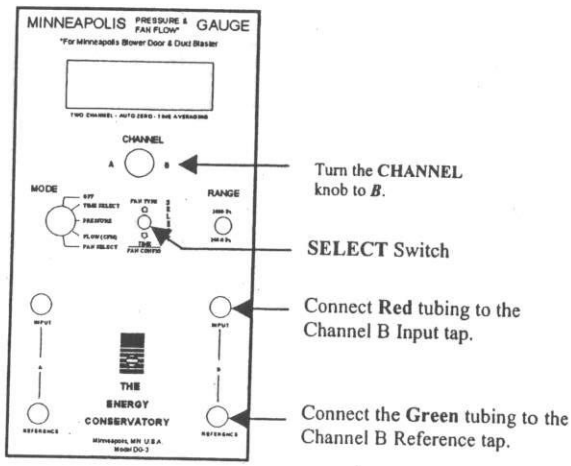
4. **Measure the Air Flow Through the TrueFlow Metering Plate**
   a) Connect the flexible tubing connections from the metering plate to ***Channel B*** as shown in the diagram.
   b) In order for the DG-3 gauge to directly display air flow in CFM from the metering plate, the installed metering plate must be selected in the gauge. To select the metering plate being used in your test, first turn the **MODE** knob to the ***Fan Select*** position. The gauge display will show "-SEL" to indicate that a flow measurement device has not been selected. The selected flow measurement device is chosen by toggling **up** the **SELECT** Switch.



   Toggle up 3 times to select the **#14** Metering Plate.
   Toggle up 4 times to select the **#20** Metering Plate.

   PL 14 This indicates that you have chosen the #14 TrueFlow Metering Plate.

   PL 20 This indicates that you have chosen the #20 TrueFlow Metering Plate.

Once the proper plate has been selected, turn the **MODE** switch to ***Flow***. With the **CHANNEL** knob set to ***B***, the gauge will now display the air flow through the metering plate in CFM. You may want to use the 5 second or long-term time-average setting if the flow reading is fluctuating.

Note: DG-3 gauges sold prior to March 2001 do not have the ***PL14*** or ***PL20*** options when selecting a flow measurement device. These gauges can be retrofitted with a new EPROM by The Energy Conservatory (call for more information). Flow can also be determined by measuring the pressure signal from the metering plate, and using the Flow Conversion Table

5. **Look up the Flow Resistance Correction Factor**
   a) The Flow Resistance Correction Factor can be determined using the correction factor table provided with the manual, and the two system operating pressure measurements (**Steps #1** and **#3**). The Flow Resistance Correction Factor is used to adjust the measured air flow through the metering plate for differences in resistance between the existing filter and the TrueFlow Meter.

6. **Calculate the Adjusted Air Flow**
   b) Multiply the measured air flow through the metering plate (**Step #4**) by the Flow Resistance Correction Factor (**Step #5**) to determine the final adjusted air flow amount.

If you are using the Magnehelic® gauges.

When using the Magnehelic gauges instead of the DG-3 gauge, please note the following differences in the test procedure:

Step #1:
a) Mount the magnetic gauge board on a vertical metal surface (e.g. the air handler cabinet or supply plenum). Adjust both gauges to read zero.
b) Connect a piece of tubing between the static pressure probe and the 60 Pascal gauge using the following scheme:
- If the static pressure probe is inserted into the supply plenum, connect the tubing to the top tap on the 60 Pascal gauge.
- If the static pressure probe is inserted into the return plenum, connect the tubing to the bottom tap on the 60 Pascal gauge.
- If the gauge is located inside the house during the test, leave the remaining pressure tap on the gauge open. If the gauge is not in the house during the test (e.g. attic, crawlspace); run additional tubing from the remaining pressure tap to inside the house.

c) If the **NSOP** reading is greater than 60 Pa, switch tubing connections from the 60 Pa gauge to the 250 Pa gauge.

Step #3:
a) If the **TF SOP** reading is greater than 60 Pa, switch tubing connections from the 60 Pa gauge to the 250 Pa gauge.

Step #4:
a) Disconnect the tubing connecting the Magnehelic gauge to the static pressure probe. Re-zero both gauges.
b) Connect the **Red** tubing from the metering plate to the top tap on the 60 Pa gauge. Connect the **Green** tubing from the metering plate to the bottom tap on the 60 Pa gauge.
c) If the pressure reading from the metering plate is greater than 60 Pa, switch tubing connections to the 250 Pa gauge.
d) Convert the metering plate pressure to air flow in CFM using the Flow Conversion Table.

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TrueFlow Meter Flow Conversion Table (In. H20)

Plate Pressure (In. H_20)	Plate #14 (CFM)	Plate #20 (CFM)
0.040	362	485
0.045	384	515
0.050	405	543
0.055	425	569
0.060	444	594
0.065	462	619
0.070	479	642
0.075	496	665
0.080	513	686
0.085	528	708
0.090	544	728
0.095	559	748
0.100	573	767
0.105	587	786
0.110	601	805
0.115	615	823
0.120	628	841
0.125	641	858
0.130	653	875
0.135	666	892
0.140	678	908
0.145	690	924
0.150	702	940
0.155	713	955
0.160	725	971
0.165	736	986
0.170	747	1001
0.175	758	1015
0.180	769	1030
0.185	779	1044
0.190	790	1058
0.195	800	1072
0.200	810	1085
0.172	752	1007
0.176	760	1018
0.180	769	1030
0.184	777	1041
0.188	786	1052
0.192	794	1063
0.196	802	1074
0.200	810	1085
0.205	821	1099
0.210	830	1112
0.215	840	1125
0.220	850	1138
0.225	860	1151
0.230	869	1164
0.235	879	1176
0.240	888	1189
0.245	897	1201
0.250	906	1213
0.255	915	1226
0.260	924	1237
0.265	933	1249
0.270	942	1261
0.275	950	1273

Plate Pressure	Plate #14	Plate #20
0.280	959	1284
0.285	967	1296
0.290	976	1307
0.295	984	1318
0.300	993	1329
0.305	1001	1340
0.310	1009	1351
0.315	1017	1362
0.320	1025	1373
0.325	1033	1384
0.330	1041	1394
0.335	1049	1405
0.340	1057	1415
0.345	1064	1425
0.350	1072	1436
0.355	1080	1446
0.360	1087	1456
0.365	1095	1466
0.370	1102	1476
0.375	1110	1486
0.380	1117	1496
0.385	1124	1506
0.390	1132	1516
0.395	1139	1525
0.400	1146	1535
0.405	1153	1544
0.410	1160	1554
0.415	1167	1563
0.420	1174	1573
0.425	1181	1582
0.430	1188	1591
0.435	1195	1601
0.440	1202	1610
0.445	1209	1619
0.450	1216	1628
0.455	1222	1637
0.460	1229	1646
0.465	1236	1655
0.470	1242	1664
0.475	1249	1673
0.480	1256	1681
0.485	1262	1690
0.490	1269	1699
0.495	1275	1707
0.500	1281	1716
0.505	1288	1725
0.510	1294	1733
0.515	1301	1742
0.520	1307	1750
0.525	1313	1758
0.530	1319	1767
0.535	1326	1775
0.540	1332	1783
0.545	1338	1792
0.550	1344	1800
0.555	1350	1808
0.560	1356	1816
0.565	1362	1824
0.570	1368	1832
0.575	1374	1840

Plate Pressure	Plate #14	Plate #20
0.580	1380	1848
0.585	1386	1856
0.590	1392	1864
0.595	1398	1872
0.600	1404	1880
0.605	1410	1888
0.610	1415	1895
0.615	1421	1903
0.620	1427	1911
0.625	1433	1919
0.630	1438	1926
0.635	1444	1934
0.640	1450	1942
0.645	1455	1949
0.650	1461	1957
0.655	1467	1964
0.660	1472	1972
0.665	1478	1979
0.670	1483	1986
0.675	1489	1994
0.680	1494	2001
0.685	1500	2009
0.690	1505	2016
0.695	1511	2023
0.700	1516	2030
0.705	1522	2038
0.710	1527	2045
0.715	1532	2052
0.720	1538	2059
0.725	1543	2066
0.730	1548	2074
0.735	1554	2081
0.740	1559	2088
0.745	1564	2095
0.750	1569	2102

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Flow Resi[illegible]e Correction Factors

Normal System Operating Pressure (NSOP) In. H_2O

TrueFlow System Operating Pressure (TF SOP) In. H_2O

	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24
0.04	1.00	1.12	1.22	1.32	1.41	1.50	1.58	1.66	1.73	1.80	1.87	1.94	2.00	2.06	2.12	2.18	2.24	2.29	2.35	2.40	2.45
0.05	0.89	1.00	1.10	1.18	1.26	1.34	1.41	1.48	1.55	1.61	1.67	1.73	1.79	1.84	1.90	1.95	2.00	2.05	2.10	2.14	2.19
0.06	0.82	0.91	1.00	1.08	1.15	1.22	1.29	1.35	1.41	1.47	1.53	1.58	1.63	1.68	1.73	1.78	1.83	1.87	1.91	1.96	2.00
0.07	0.76	0.85	0.93	1.00	1.07	1.13	1.20	1.25	1.31	1.36	1.41	1.46	1.51	1.56	1.60	1.65	1.69	1.73	1.77	1.81	1.85
0.08	0.71	0.79	0.87	0.94	1.00	1.06	1.12	1.17	1.22	1.27	1.32	1.37	1.41	1.46	1.50	1.54	1.58	1.62	1.66	1.70	1.73
0.09	0.67	0.75	0.82	0.88	0.94	1.00	1.05	1.11	1.15	1.20	1.25	1.29	1.33	1.37	1.41	1.45	1.49	1.53	1.56	1.60	1.63
0.10	0.63	0.71	0.77	0.84	0.89	0.95	1.00	1.05	1.10	1.14	1.18	1.22	1.26	1.30	1.34	1.38	1.41	1.45	1.48	1.52	1.55
0.11	0.60	0.67	0.74	0.80	0.85	0.90	0.95	1.00	1.04	1.09	1.13	1.17	1.21	1.24	1.28	1.31	1.35	1.38	1.41	1.45	1.48
0.12	0.58	0.65	0.71	0.76	0.82	0.87	0.91	0.96	1.00	1.04	1.08	1.12	1.15	1.19	1.22	1.26	1.29	1.32	1.35	1.38	1.41
0.13	0.55	0.62	0.68	0.73	0.78	0.83	0.88	0.92	0.96	1.00	1.04	1.07	1.11	1.14	1.18	1.21	1.24	1.27	1.30	1.33	1.36
0.14	0.53	0.60	0.65	0.71	0.76	0.80	0.85	0.89	0.93	0.96	1.00	1.04	1.07	1.10	1.13	1.16	1.20	1.22	1.25	1.28	1.31
0.15	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00	1.03	1.06	1.10	1.13	1.15	1.18	1.21	1.24	1.26
0.16	0.50	0.56	0.61	0.66	0.71	0.75	0.79	0.83	0.87	0.90	0.94	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.17	1.20	1.22
0.17	0.49	0.54	0.59	0.64	0.69	0.73	0.77	0.80	0.84	0.87	0.91	0.94	0.97	1.00	1.03	1.06	1.08	1.11	1.14	1.16	1.19
0.18	0.47	0.53	0.58	0.62	0.67	0.71	0.75	0.78	0.82	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.05	1.08	1.11	1.13	1.15
0.19	0.46	0.51	0.56	0.61	0.65	0.69	0.73	0.76	0.79	0.83	0.86	0.89	0.92	0.95	0.97	1.00	1.03	1.05	1.08	1.10	1.12
0.20	0.45	0.50	0.55	0.59	0.63	0.67	0.71	0.74	0.77	0.81	0.84	0.87	0.89	0.92	0.95	0.97	1.00	1.02	1.05	1.07	1.10
0.21	0.44	0.49	0.53	0.58	0.62	0.65	0.69	0.72	0.76	0.79	0.82	0.85	0.87	0.90	0.93	0.95	0.98	1.00	1.02	1.05	1.07
0.22	0.43	0.48	0.52	0.56	0.60	0.64	0.67	0.71	0.74	0.77	0.80	0.83	0.85	0.88	0.90	0.93	0.95	0.98	1.00	1.02	1.04
0.23	0.42	0.47	0.51	0.55	0.59	0.63	0.66	0.69	0.72	0.75	0.78	0.81	0.83	0.86	0.88	0.91	0.93	0.96	0.98	1.00	1.02
0.24	0.41	0.46	0.50	0.54	0.58	0.61	0.65	0.68	0.71	0.74	0.76	0.79	0.82	0.84	0.87	0.89	0.91	0.94	0.96	0.98	1.00

Normal System Operating Pressure (NSOP) In. H_2O

TrueFlow System Operating Pressure (TF SOP) In. H_2O

	0.20	0.22	0.24	0.26	0.28	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60
0.20	1.00	1.05	1.10	1.14	1.18	1.22	1.26	1.30	1.34	1.38	1.41	1.45	1.48	1.52	1.55	1.58	1.61	1.64	1.67	1.70	1.73
0.22	0.95	1.00	1.04	1.09	1.13	1.17	1.21	1.24	1.28	1.31	1.35	1.38	1.41	1.45	1.48	1.51	1.54	1.57	1.60	1.62	1.65
0.24	0.91	0.96	1.00	1.04	1.08	1.12	1.15	1.19	1.22	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.50	1.53	1.55	1.58
0.26	0.88	0.92	0.96	1.00	1.04	1.07	1.11	1.14	1.18	1.21	1.24	1.27	1.30	1.33	1.36	1.39	1.41	1.44	1.47	1.49	1.52
0.28	0.85	0.89	0.93	0.96	1.00	1.04	1.07	1.10	1.13	1.16	1.20	1.22	1.25	1.28	1.31	1.34	1.36	1.39	1.41	1.44	1.46
0.30	0.82	0.86	0.89	0.93	0.97	1.00	1.03	1.06	1.10	1.13	1.15	1.18	1.21	1.24	1.26	1.29	1.32	1.34	1.37	1.39	1.41
0.32	0.79	0.83	0.87	0.90	0.94	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.17	1.20	1.22	1.25	1.27	1.30	1.32	1.35	1.37
0.34	0.77	0.80	0.84	0.87	0.91	0.94	0.97	1.00	1.03	1.06	1.08	1.11	1.14	1.16	1.19	1.21	1.24	1.26	1.28	1.31	1.33
0.36	0.75	0.78	0.82	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.05	1.08	1.11	1.13	1.15	1.18	1.20	1.22	1.25	1.27	1.29
0.38	0.73	0.76	0.79	0.83	0.86	0.89	0.92	0.95	0.97	1.00	1.03	1.05	1.08	1.10	1.12	1.15	1.17	1.19	1.21	1.24	1.26
0.40	0.71	0.74	0.77	0.81	0.84	0.87	0.89	0.92	0.95	0.97	1.00	1.02	1.05	1.07	1.10	1.12	1.14	1.16	1.18	1.20	1.22
0.42	0.69	0.72	0.76	0.79	0.82	0.85	0.87	0.90	0.93	0.95	0.98	1.00	1.02	1.05	1.07	1.09	1.11	1.13	1.15	1.18	1.20
0.44	0.67	0.71	0.74	0.77	0.80	0.83	0.85	0.88	0.90	0.93	0.95	0.98	1.00	1.02	1.04	1.07	1.09	1.11	1.13	1.15	1.17
0.46	0.66	0.69	0.72	0.75	0.78	0.81	0.83	0.86	0.88	0.91	0.93	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14
0.48	0.65	0.68	0.71	0.74	0.76	0.79	0.82	0.84	0.87	0.89	0.91	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12
0.50	0.63	0.66	0.69	0.72	0.75	0.77	0.80	0.82	0.85	0.87	0.89	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10
0.52	0.62	0.65	0.68	0.71	0.73	0.76	0.78	0.81	0.83	0.85	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.07
0.54	0.61	0.64	0.67	0.69	0.72	0.75	0.77	0.79	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.05
0.56	0.60	0.63	0.65	0.68	0.71	0.73	0.76	0.78	0.80	0.82	0.85	0.87	0.89	0.91	0.93	0.94	0.96	0.98	1.00	1.02	1.04
0.58	0.59	0.62	0.64	0.67	0.69	0.72	0.74	0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.96	0.98	1.00	1.02
0.60	0.58	0.61	0.63	0.66	0.68	0.71	0.73	0.75	0.77	0.80	0.82	0.84	0.86	0.88	0.89	0.91	0.93	0.95	0.97	0.98	1.00

TrueFlow Meter Flow Conversion Table (Pascals)

Plate Pressure (Pascals)	Plate #14 (CFM)	Plate #20 (CFM)
10	364	487
11	381	511
12	398	533
13	415	555
14	430	576
15	445	596
16	460	616
17	474	635
18	488	653
19	501	671
20	514	689
21	527	706
22	539	722
23	552	739
24	563	754
25	575	770
26	586	785
27	598	800
28	609	815
29	619	829
30	630	843
31	640	857
32	651	871
33	661	885
34	671	898
35	680	911
36	690	924
37	700	937
38	709	949
39	718	962
40	727	974
41	736	986
42	745	998
43	754	1010
44	763	1022
45	771	1033
46	780	1044
47	788	1056
48	797	1067
49	805	1078
50	813	1089
51	821	1100
52	829	1111
53	837	1121
54	845	1132
55	853	1142
56	861	1152
57	868	1163
58	876	1173
59	883	1183
60	891	1193
61	898	1203
62	906	1213
63	913	1222
64	920	1232
65	927	1242

Plate Pressure	Plate #14	Plate #20
66	934	1251
67	941	1261
68	948	1270
69	955	1279
70	962	1288
71	969	1298
72	976	1307
73	983	1316
74	989	1325
75	996	1334
76	1003	1343
77	1009	1351
78	1016	1360
79	1022	1369
80	1029	1377
81	1035	1386
82	1041	1395
83	1048	1403
84	1054	1411
85	1060	1420
86	1066	1428
87	1073	1436
88	1079	1445
89	1085	1453
90	1091	1461
91	1097	1469
92	1103	1477
93	1109	1485
94	1115	1493
95	1121	1501
96	1127	1509
97	1133	1517
98	1138	1525
99	1144	1532
100	1150	1540
101	1156	1548
102	1161	1555
103	1167	1563
104	1173	1570
105	1178	1578
106	1184	1586
107	1190	1593
108	1195	1600
109	1201	1608
110	1206	1615
111	1212	1622
112	1217	1630
113	1222	1637
114	1228	1644
115	1233	1651
116	1239	1659
117	1244	1666
118	1249	1673
119	1255	1680
120	1260	1687
121	1265	1694
122	1270	1701
123	1275	1708
124	1281	1715
125	1286	1722

Plate Pressure	Plate #14	Plate #20
126	1291	1729
127	1296	1735
128	1301	1742
129	1306	1749
130	1311	1756
131	1316	1763
132	1321	1769
133	1326	1776
134	1331	1783
135	1336	1789
136	1341	1796
137	1346	1803
138	1351	1809
139	1356	1816
140	1361	1822
141	1366	1829
142	1370	1835
143	1375	1842
144	1380	1848
145	1385	1854
146	1390	1861
147	1394	1867
148	1399	1873
149	1404	1880
150	1408	1886
151	1413	1892
152	1418	1899
153	1422	1905
154	1427	1911
155	1432	1917
156	1436	1923
157	1441	1930
158	1446	1936
159	1450	1942
160	1455	1948
161	1459	1954
162	1464	1960
163	1468	1966
164	1473	1972
165	1477	1978
166	1482	1984
167	1486	1990
168	1491	1996
169	1495	2002
170	1499	2008
171	1504	2014
172	1508	2020
173	1513	2026
174	1517	2031
175	1521	2037
176	1526	2043
177	1530	2049
178	1534	2055
179	1539	2060
180	1543	2066
181	1547	2072
182	1551	2078
183	1556	2083
184	1560	2089
185	1564	2095

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Flow Resistance Correction Factors

Normal System Operating Pressure (NSOP) in Pascals

TrueFlow System Operating Pressure (TF SOP) in Pascals

	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
10	1.00	1.10	1.18	1.26	1.34	1.41	1.48	1.55	1.61	1.67	1.73	1.79	1.84	1.90	1.95	2.00	2.05	2.10	2.14	2.19	2.24
12	0.91	1.00	1.08	1.15	1.22	1.29	1.35	1.41	1.47	1.53	1.58	1.63	1.68	1.73	1.78	1.83	1.87	1.91	1.96	2.00	2.04
14	0.85	0.93	1.00	1.07	1.13	1.20	1.25	1.31	1.36	1.41	1.46	1.51	1.56	1.60	1.65	1.69	1.73	1.77	1.81	1.85	1.89
16	0.79	0.87	0.94	1.00	1.06	1.12	1.17	1.22	1.27	1.32	1.37	1.41	1.46	1.50	1.54	1.58	1.62	1.66	1.70	1.73	1.77
18	0.75	0.82	0.88	0.94	1.00	1.05	1.11	1.15	1.20	1.25	1.29	1.33	1.37	1.41	1.45	1.49	1.53	1.56	1.60	1.63	1.67
20	0.71	0.77	0.84	0.89	0.95	1.00	1.05	1.10	1.14	1.18	1.22	1.26	1.30	1.34	1.38	1.41	1.45	1.48	1.52	1.55	1.58
22	0.67	0.74	0.80	0.85	0.90	0.95	1.00	1.04	1.09	1.13	1.17	1.21	1.24	1.28	1.31	1.35	1.38	1.41	1.45	1.48	1.51
24	0.65	0.71	0.76	0.82	0.87	0.91	0.96	1.00	1.04	1.08	1.12	1.15	1.19	1.22	1.26	1.29	1.32	1.35	1.38	1.41	1.44
26	0.62	0.68	0.73	0.78	0.83	0.88	0.92	0.96	1.00	1.04	1.07	1.11	1.14	1.18	1.21	1.24	1.27	1.30	1.33	1.36	1.39
28	0.60	0.65	0.71	0.76	0.80	0.85	0.89	0.93	0.96	1.00	1.04	1.07	1.10	1.13	1.16	1.20	1.22	1.25	1.28	1.31	1.34
30	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00	1.03	1.06	1.10	1.13	1.15	1.18	1.21	1.24	1.26	1.29
32	0.56	0.61	0.66	0.71	0.75	0.79	0.83	0.87	0.90	0.94	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.17	1.20	1.22	1.25
34	0.54	0.59	0.64	0.69	0.73	0.77	0.80	0.84	0.87	0.91	0.94	0.97	1.00	1.03	1.06	1.08	1.11	1.14	1.16	1.19	1.21
36	0.53	0.58	0.62	0.67	0.71	0.75	0.78	0.82	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.05	1.08	1.11	1.13	1.15	1.18
38	0.51	0.56	0.61	0.65	0.69	0.73	0.76	0.79	0.83	0.86	0.89	0.92	0.95	0.97	1.00	1.03	1.05	1.08	1.10	1.12	1.15
40	0.50	0.55	0.59	0.63	0.67	0.71	0.74	0.77	0.81	0.84	0.87	0.89	0.92	0.95	0.97	1.00	1.02	1.05	1.07	1.10	1.12
42	0.49	0.53	0.58	0.62	0.65	0.69	0.72	0.76	0.79	0.82	0.85	0.87	0.90	0.93	0.95	0.98	1.00	1.02	1.05	1.07	1.09
44	0.48	0.52	0.56	0.60	0.64	0.67	0.71	0.74	0.77	0.80	0.83	0.85	0.88	0.90	0.93	0.95	0.98	1.00	1.02	1.04	1.07
46	0.47	0.51	0.55	0.59	0.63	0.66	0.69	0.72	0.75	0.78	0.81	0.83	0.86	0.88	0.91	0.93	0.96	0.98	1.00	1.02	1.04
48	0.46	0.50	0.54	0.58	0.61	0.65	0.68	0.71	0.74	0.76	0.79	0.82	0.84	0.87	0.89	0.91	0.94	0.96	0.98	1.00	1.02
50	0.45	0.49	0.53	0.57	0.60	0.63	0.66	0.69	0.72	0.75	0.77	0.80	0.82	0.85	0.87	0.89	0.92	0.94	0.96	0.98	1.00

Normal System Operating Pressure (NSOP) in Pascals

TrueFlow System Operating Pressure (TF SOP) in Pascals

	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
50	1.00	1.05	1.10	1.14	1.18	1.22	1.26	1.30	1.34	1.38	1.41	1.45	1.48	1.52	1.55	1.58	1.61	1.64	1.67	1.70	1.73
55	0.95	1.00	1.04	1.09	1.13	1.17	1.21	1.24	1.28	1.31	1.35	1.38	1.41	1.45	1.48	1.51	1.54	1.57	1.60	1.62	1.65
60	0.91	0.96	1.00	1.04	1.08	1.12	1.15	1.19	1.22	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.50	1.53	1.55	1.58
65	0.88	0.92	0.96	1.00	1.04	1.07	1.11	1.14	1.18	1.21	1.24	1.27	1.30	1.33	1.36	1.39	1.41	1.44	1.47	1.49	1.52
70	0.85	0.89	0.93	0.96	1.00	1.04	1.07	1.10	1.13	1.16	1.20	1.22	1.25	1.28	1.31	1.34	1.36	1.39	1.41	1.44	1.46
75	0.82	0.86	0.89	0.93	0.97	1.00	1.03	1.06	1.10	1.13	1.15	1.18	1.21	1.24	1.26	1.29	1.32	1.34	1.37	1.39	1.41
80	0.79	0.83	0.87	0.90	0.94	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.17	1.20	1.22	1.25	1.27	1.30	1.32	1.35	1.37
85	0.77	0.80	0.84	0.87	0.91	0.94	0.97	1.00	1.03	1.06	1.08	1.11	1.14	1.16	1.19	1.21	1.24	1.26	1.28	1.31	1.33
90	0.75	0.78	0.82	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.05	1.08	1.11	1.13	1.15	1.18	1.20	1.22	1.25	1.27	1.29
95	0.73	0.76	0.79	0.83	0.86	0.89	0.92	0.95	0.97	1.00	1.03	1.05	1.08	1.10	1.12	1.15	1.17	1.19	1.21	1.24	1.26
100	0.71	0.74	0.77	0.81	0.84	0.87	0.89	0.92	0.95	0.97	1.00	1.02	1.05	1.07	1.10	1.12	1.14	1.16	1.18	1.20	1.22
105	0.69	0.72	0.76	0.79	0.82	0.85	0.87	0.90	0.93	0.95	0.98	1.00	1.02	1.05	1.07	1.09	1.11	1.13	1.15	1.18	1.20
110	0.67	0.71	0.74	0.77	0.80	0.83	0.85	0.88	0.90	0.93	0.95	0.98	1.00	1.02	1.04	1.07	1.09	1.11	1.13	1.15	1.17
115	0.66	0.69	0.72	0.75	0.78	0.81	0.83	0.86	0.88	0.91	0.93	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14
120	0.65	0.68	0.71	0.74	0.76	0.79	0.82	0.84	0.87	0.89	0.91	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12
125	0.63	0.66	0.69	0.72	0.75	0.77	0.80	0.82	0.85	0.87	0.89	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10
130	0.62	0.65	0.68	0.71	0.73	0.76	0.78	0.81	0.83	0.85	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.07
135	0.61	0.64	0.67	0.69	0.72	0.75	0.77	0.79	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.05
140	0.60	0.63	0.65	0.68	0.71	0.73	0.76	0.78	0.80	0.82	0.85	0.87	0.89	0.91	0.93	0.94	0.96	0.98	1.00	1.02	1.04
145	0.59	0.62	0.64	0.67	0.69	0.72	0.74	0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.96	0.98	1.00	1.02
150	0.58	0.61	0.63	0.66	0.68	0.71	0.73	0.75	0.77	0.80	0.82	0.84	0.86	0.88	0.89	0.91	0.93	0.95	0.97	0.98	1.00

Notes on Refrigerant Charge and Performance Check

The PTCS specifications assume industry-standard procedures will be used in selection and fabrication of refrigeration lines, placement of the outdoor unit, treatment of sys tem components during brazing, operation of the crankcase heater before normal operation, and so forth. The assurance of quality installation rests firmly on the shoulders of the skilled installation technician.

A detailed outline of suggested procedures is found after Tab 7 and examples of fully installation procedures are found after Tabs 9 and 10. This Tab will only provide a quick reminder of tests that must be performed and recorded on the PTCS forms.

Note since many of the new systems use R410A, it is very important to protect the sys tem from moisture during installation. Take special care in evacuating the system to get rid of any possible moisture.

Also, use care when brazing. Use approved brazing alloy material and purge with dry nitrogen. Protect sensitive components from excessive heat during brazing.

Test system for leaks by pressurizing to at least 450 psig (R410a) or 360 psig (R-22) for 24 hrs.

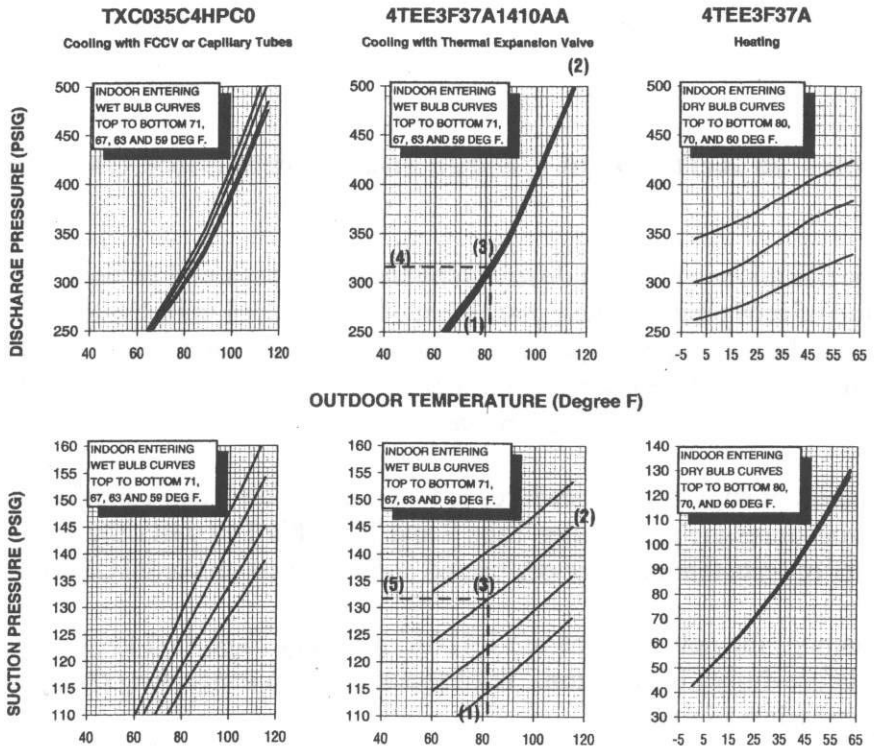
Adjust system charge as needed for non-standard line sets and other components as needed. Use reliable scale with new battery (when applicable); scale should have resolution of at least 0.5 oz.

After system is charged, but before standard operation, make sure crankcase heater (if required) operates for at least one hour.

When checking system performance, operate for at least 15 minutes before recording operating pressures. Compare pressures with manufacturer's recommended values. If not within manufacturers' tolerance, consider adjusting charge (or return when system can be checked in cooling mode and re-test with cooling season procedure).

PTCS specifications strongly suggest the temperature split in heating mode be measured and reported to the home's occupants. If this is done, it can be recorded on the bottom of the form.

PRESSURE CURVES FOR 4TWX4036B1000A



COOLING PERFORMANCE CAN BE CHECKED WHEN THE OUTDOOR TEMP IS ABOVE 65 DEG F.

TO CHECK COOLING PERFORMANCE, SELECT THE PROPER INDOOR CFM, ALLOW PRESSURES TO STABILIZE. MEASURE INDOOR WET BULB TEMPERATURE, OUTDOOR TEMPERATURE, DISCHARGE AND SUCTION PRESSURES. ON THE PLOTS LOCATE OUTDOOR TEMPERATURE (1); LOCATE INDOOR WET BULB (2); FIND INTERSECTION OF OD TEMP. & ID W.B. (3); READ DISCHARGE OR SUCTION PRESSURE IN LEFT COLUMN (4).

EXAMPLE: (1) OUTDOOR TEMP. 82 F.
(2) INDOOR WET BULB 67 F.
(3) AT INTERSECTION
(4) DISCHARGE PRESSURE @ 1170 CFM IS 316 PSIG
(5) SUCTION PRESSURE @ 1170 CFM IS 132 PSIG.

ACTUAL:
DISCHARGE PRESSURE SHOULD BE +/- 10 PSI OF CHART
SUCTION PRESSURE SHOULD BE +/- 3 PSIG OF CHART

INTERCONNECTING LINES
GAS - 3/4" O.D.
LIQUID - 3/8" O.D.

DWG.NO. 4TWX4036B1

ALTERNATE INDOOR UNITS WITH FCCV OR TXV

INDOOR UNIT	CFM	PRESSURE CURVE CORRECTION PSIG —COOLING— SUCT. PRESS	—COOLING— HEAD PRESS	—HEATING— SUCT. PRESS	—HEATING— HEAD PRESS
TU/DD060R9V3+TXH033A4	1200	4	6	0	7
TU/DD060R9V3+TXH041A4	1200	7	10	-1	-17
TU/DD080R9V3+TXH033A4	1125	3	4	0	16
TU/DD080R9V3+TXH041A4	1140	6	8	0	-11
TU/DD100R9V5+TXH033A4	1130	3	4	0	15
TU/DD100R9V5+TXH041A4	1200	7	10	-1	-17
TU/DY060R9V3+TXH033A4	1070	2	2	1	23
TU/DY060R9V3+TXH041A4	1025	3	5	0	3
TU/DY080R9V3+TXH033A4	1000	0	0	1	34
TU/DY080R9V3+TXH041A4	1025	3	5	0	3
TU/DY100R9V4+TXH033A4	1050	1	2	1	26
TU/DY100R9V4+TXH041A4	1050	4	6	0	-1
TVF030A14	1125	4	6	0	-2
TVF036A14	1200	7	10	-1	-23
TWE030C14	949	-4	-6	2	62
TWE036C14	1200	2	3	0	10
TWE042C14	1350	7	11	-1	-20
TWE048C14	1350	9	13	-1	-36
TXA,TXC030C4,D4	1100	0	0	1	42
TXA,TXC031C4,D4	1100	1	2	0	10
* TXA,TXC035C4,D4	1100	0	0	1	42
TXA,TXC036C4,D4	1200	4	6	0	-16
TXA,TXC037C4	1200	4	6	0	-16
TXA,TXC042C4	1200	5	8	-1	-23
TXA,TXC043C4	1350	7	11	-1	-36
TXA,TXC048C4	1350	9	15	-1	-46
TXA,TXC049C4	1350	9	15	-1	-46
TXA,TXC050C4	1350	9	15	-1	-46
TXH033A4	1125	3	4	0	9
TXH041A4	1350	9	14	-1	-36

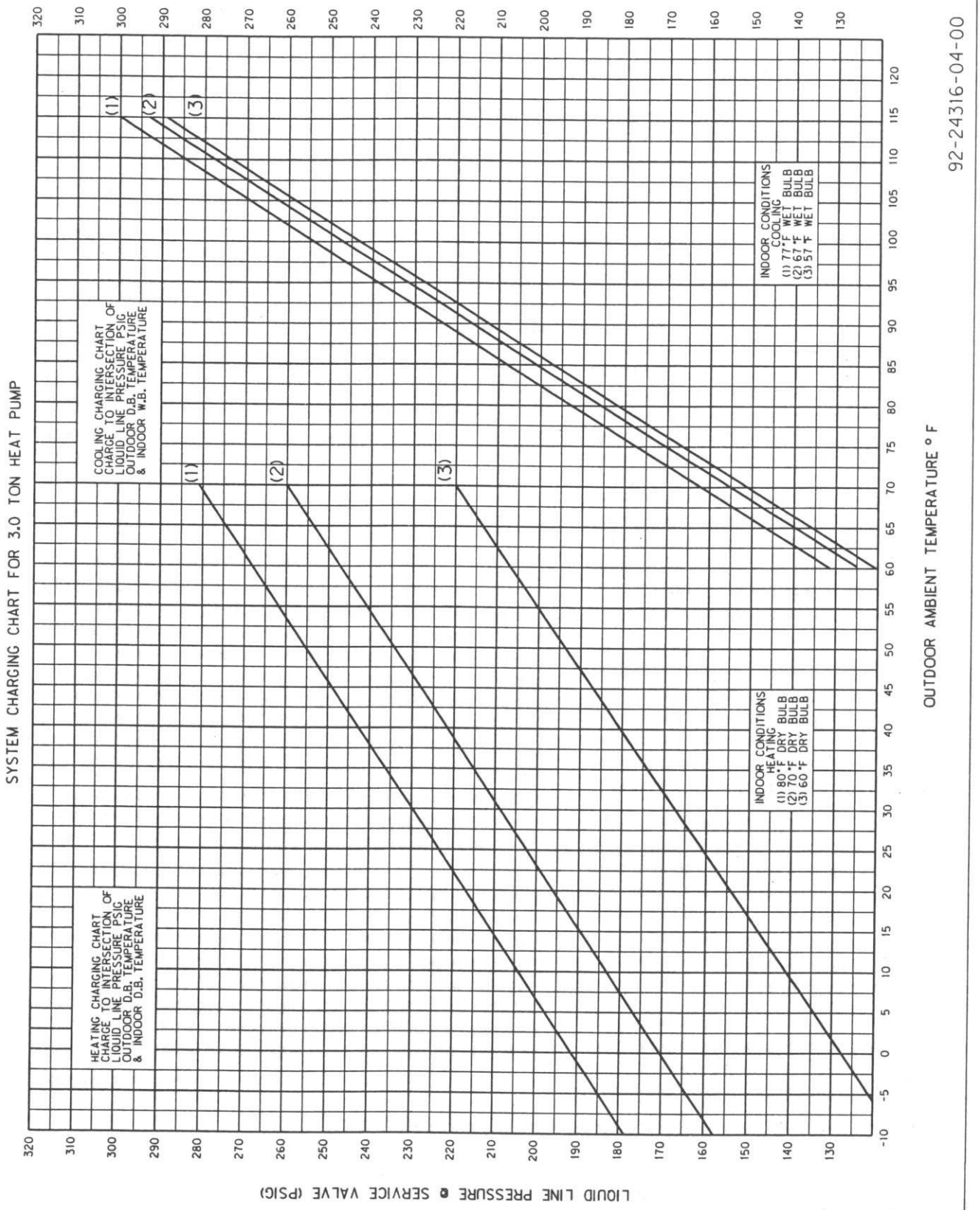
ALTERNATE INDOOR UNITS WITH THERMAL EXPANSION VALVE

INDOOR UNIT	CFM	PRESSURE CURVE CORRECTION PSIG —COOLING— SUCT. PRESS	—COOLING— HEAD PRESS	—HEATING— SUCT. PRESS	—HEATING— HEAD PRESS
4TEE3F31A	1220	0	0	0	8
* 4TEE3F37A	1150	0	0	0	0
4TEE3F40A	1200	7	4	-1	-47
4TEE3F49A	1200	8	4	-2	-57
4TEP3F30A	940	-5	-2	1	48
4TEP3F36A	1200	0	0	0	-6
4TEP3F42A	1350	6	3	-1	-36
4TEP3F48A	1350	11	5	-2	-67
RXC031S3	1110	0	0	0	-6
RXC036S3	1200	5	2	-1	-34
RXC037S3	1200	5	2	-1	-34
RXC054S3	1350	7	3	-1	-53
TU/DD060R9V3+RXC031S3	1200	2	1	0	-10
TU/DD060R9V3+RXC036S3	1200	5	2	-1	-29
TU/DD080R9V3+RXC031S3	1200	2	1	0	-10
TU/DD080R9V3+RXC036S3	1200	5	2	-1	-29
TU/DD100R9V5+RXC037S3	1200	5	2	-1	-29
TU/DY060R9V3+RXC031S3	1050	-1	-1	0	8
TU/DY060R9V3+RXC036S3	1050	2	1	0	-14
TU/DY080R9V3+RXC031S3	1040	-1	-1	0	9
TU/DY080R9V3+RXC036S3	1040	1	1	0	-13
TU/DY100R9V4+RXC037S3	1060	2	1	0	-15

* BASE INDOOR UNIT(S) CURVES ON 4TWX4036B1

NOTES:
① For a field installed TXV kit, apply the factor listed with the FCCV model to the TXV curve.

FIGURE 168
(-)PNJ-036/037 AND (-)PPA-036/037 — 13 AND 14 SEER REMOTE HEAT PUMP SYSTEM CHARGING CHART



LENNOX REFRIGERANT PIPING

APPLICATION ENGINEERING & SERVICE

MISCELLANEOUS
OCTOBER 1993
#450119
Corp.9351-L9
Litho U.S.A.

DESIGN AND FABRICATION GUIDELINES

I–INTRODUCTION

Lennox split system condensing units and heat pumps (four tons and under) match with line sets of varying lengths of up to 50 feet (linear). These applications offer quick and simple installations that are trouble free if the line sets are properly installed. On split commercial applications and residential installations beyond 50 feet, special design considerations must be followed to assure satisfactory system performance. An improperly designed system could result in a serious loss of capacity or even compressor failure.

This manual does not include piping information for Zonemaster systems. Refer to the Zonemaster installation instructions for further information about the Zonemaster system.

The intent of this manual is to represent generally accepted safe engineering practices. Specifications and limits outlined in this manual are subject to change. System design should conform to all codes, laws and regulations applying at the site at the time of installation. In addition, the procedures and limits outlined in this manual do not supersede local, state or national codes under any circumstances. If you have questions or comments about any of this information, contact Lennox Application (Technical Support) in Dallas, Texas.

II–GENERAL INFORMATION

Four prime considerations in designing refrigeration lines are:
1) cost of tubing, refrigerant and installation;
2) pressure drop in lines;
3) oil return; and
4) amount of refrigerant in the system.

Cost is an obvious consideration which dictates that the smallest tubing possible be used that will result in a system with acceptable pressure drop.

Pressure drop is important from a performance standpoint. The following general statements point out the effects of pressure drop in the various components of the refrigeration piping system:

1) *Pressure drop in the suction line* reduces capacity and increases power consumption. For air conditioning systems, a one pound drop in the suction line reduces capacity approximately one percent. A suction line pressure drop of up to 3psi (3% capacity loss) is generally acceptable. A higher pressure drop may be necessary in some applications to achieve adequate velocity for oil return even though this will result in higher capacity loss.

2) *Pressure drop in the liquid line* produces no significant capacity loss as long as 100% liquid is delivered to the expansion valve and the pressure available is adequate to produce the required flow. Pressure drop due to lift must be added to the friction losses to determine total pressure drop. At normal liquid temperatures, R22 pressure drops 1/2 pound per foot of vertical liquid lift.

Oil return is a major consideration since some oil is continually being circulated with the liquid refrigerant and separates in the evaporator. Oil must be returned to the compressor by entrainment with the refrigerant vapor. *Minimum* velocity must be 800 fpm (approximately) in horizontal runs, 1500 fpm (approximately) in vertical suction risers.

Subcooling should be at least 10°F leaving the outdoor unit. All Lennox equipment is designed so that the charge may be adjusted to provide at least 10°F subcooling. This will allow a 30 to 35 pound drop in the liquid line (including pressure drop due to friction loss and vertical lift).

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If heat pump refrigerant lines must exceed 100 feet, contact Lennox Application Department for further assistance. This application is not recommended and should be avoided.

Special consideration must be given to heat pump systems when there is a difference in elevation between the outdoor and indoor units. Due to the reversal of refrigerant flow from heating to cooling cycle, there is always a liquid and suction lift to consider when sizing the refrigerant lines.

Maximum liquid lift should not exceed 50 linear feet (due to the static pressure drop of 25psi). Additional pressure drop due to friction will result in total pressure drop approaching the 30psi maximum that could produce flashing.

Likewise, maximum suction lift must not exceed 50 feet due to limitations placed on the liquid line. (When refrigerant flow is reversed, a liquid drop will become a liquid lift). The vapor line must be sized as a suction riser with adequate velocity for oil return if there is any difference in elevation between the indoor and outdoor units.

In applications where *cooling* operation below 50°F is anticipated and an economizer is not being used, low ambient (head pressure) controls must be installed.

Solenoid valves are uni-directional devices. Since solenoid valves are uni-directional, they are seldom used on heat pump systems. If used, they require a check valve to bypass refrigerant around the solenoid during the heating cycle. Never install a pump-down cycle on a heat pump system.

V–PIPE SIZING, LINE LAYOUT AND DESIGN (A/C and Heat Pump Systems)

The first step in the design of a piping system is to layout the entire system (i.e. relative location of the condensing unit and the evaporator, length of each segment of the piping system, length of suction risers and liquid risers etc...) Start by making a sketch of the system including lengths of pipe, number of elbows, tees, valves, and any other irregular piping and fittings needed. This information will be used to determine total "equivalent" length for calculating pressure drop due to friction.

The same methods apply to both A/C and heat pump systems. A suction line sized to produce adequate velocity for oil entrainment and pressure drop with minimum capacity reduction will function properly as a hot gas discharge line during a heating cycle. Also, if there is a vertical difference in height between the outdoor and indoor units, there is always a vapor and liquid lift to consider in sizing due to the reversal of refrigerant flow.

A–Liquid Line Design

Considerations

The purpose of the liquid line is to convey a full column of 100% liquid from the condenser to the metering device at the evaporator without flashing. The amount of liquid line pressure drop which can be tolerated is dependent on the number of degrees of liquid subcooling leaving the condenser and the saturated condensing temperature. If the condensing temperature and subcooling are known, the maximum allowable pressure drop can be calculated.

Lennox equipment is designed to hold a charge allowing 10°F subcooling at 95°F ambient. High efficiency equipment five tons capacity and under typically operates at a saturated condensing temperature of 115°F, (245psi) (see footnote 1). Equipment above five tons capacity typically operates at a saturated condensing temperature of 125°F, (280psi) (footnote 1).

Maximum Allowable Pressure Drop, Example 1

A high efficiency unit operating at 10°F subcooling and 115°F (245psi) condensing temperature, find the maximum allowable pressure drop in the liquid line. Refer to the pressure/temperature chart (figure 16) in the appendix. 115°F condensing temperature minus 10°F subcooling equals 105°F subcooled liquid temperature (212psi - see footnote 2). 245psi condensing pressure minus 212psi subcooled pressure equals 33psi. The maximum allowable pressure drop is 33psi.

Maximum Allowable Pressure Drop, Example 1

A mid efficiency unit operating at 10°F subcooling and 125°F (280psi) condensing temperature, find the maximum allowable pressure drop in the liquid line. Refer to the pressure/temperature chart (figure 16) in the appendix. 125°F condensing temperature minus 10°F subcooling equals 115°F subcooled liquid temperature (245psi - see footnote 2). 280psi condensing pressure minus 245psi subcooled pressure equals 35psi. The maximum allowable pressure drop is 35psi.

Two factors must be considered when sizing liquid lines:

Pressure Drop in Lines

First, the pressure drop through the liquid line is not especially critical provided that 100% liquid is available entering the expansion device. For the most part, the generation of flash gas will be determined by the amount of pressure drop in the liquid line. To calculate total pressure drop in liquid lines, the following must be determined then added together:

1) Pressure drop due to friction in pipe (figure 2), fittings and field installed accessories such as a drier, solenoid valve or other devices (table 1). The pressure drop due to friction is usually smaller than pressure drop due to lift but must be considered. The pressure drop ratings of field installed devices is usually supplied by the manufacturer of the device and should be used if available.

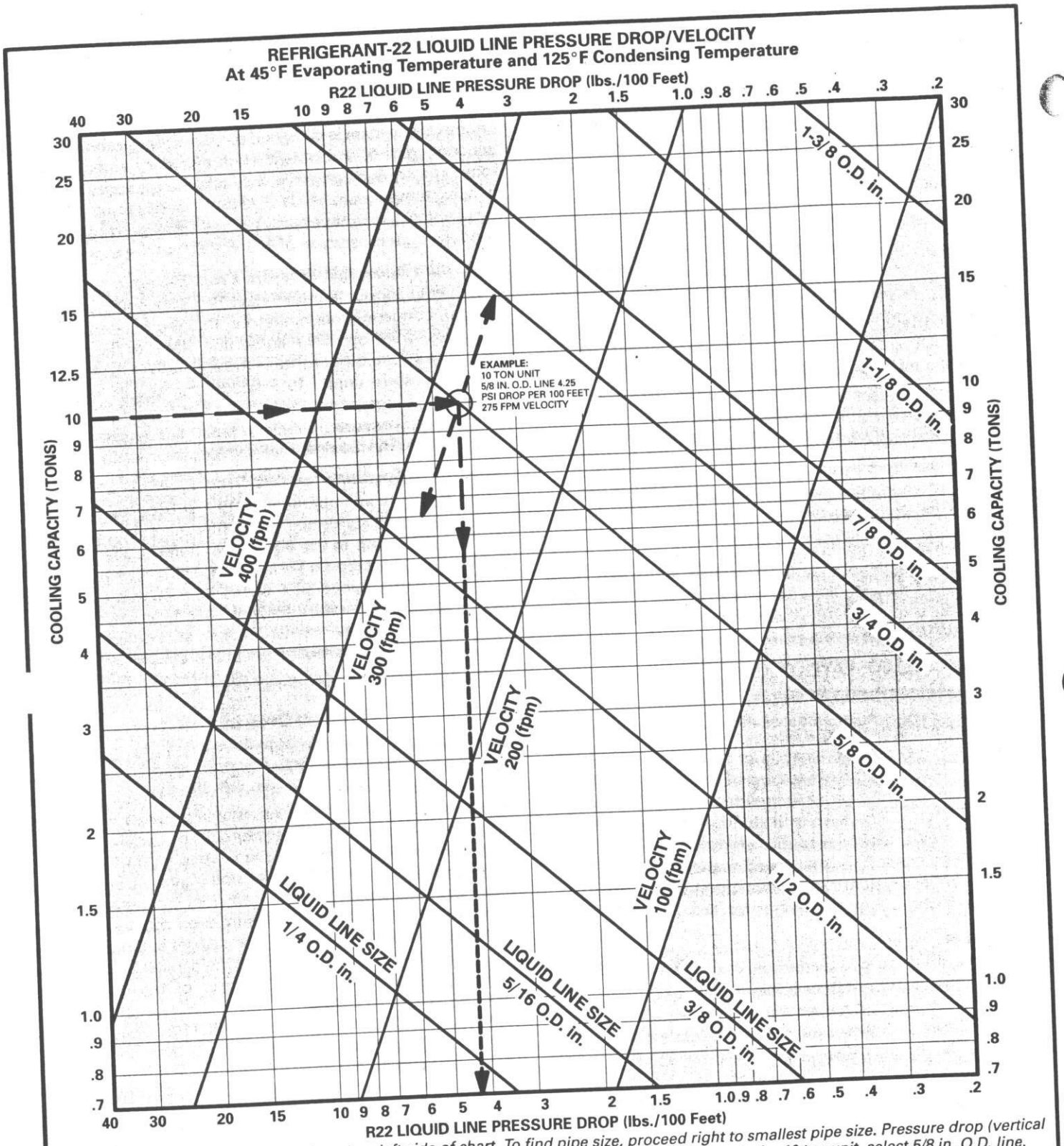
2) Pressure drop due to vertical liquid lift (1/2 pound per foot) is usually large and may be a limiting factor in the ultimate design of the system.

Pressure Across Expansion Device and Distributor

Next, the pressure entering the expansion device must be sufficient to produce the required flow through the expansion device. A pressure drop of 100 psi across the expansion valve and distributor is necessary to produce full refrigerant flow at rated capacity. Therefore, it is necessary for liquid refrigerant (free of flash gas) to be delivered to the expansion valve at a minimum of 175 psi.

Footnote 1 – The temperature listed here is an arbitrary number chosen to represent summer operating conditions. The condensing temperature at summer operating conditions is used to calculate maximum allowable pressure drop. This number may vary with regional climate.

Footnote 2 – This is the pressure below which subcooled liquid will begin to form flash gas.



To use this chart, first find capacity (tons) on left side of chart. To find pipe size, proceed right to smallest pipe size. Pressure drop (vertical line) and velocity (diagonal lines) can then be determined for the pipe size selected. For example, for 10 ton unit, select 5/8 in. O.D. line.

NOTE—Shaded area denotes unacceptable velocity range.

FIGURE 2

Sizing Procedure – First Example Simple System

Given: 10 ton (single speed) condensing unit on ground level with a 10 ton evaporator on the third level above ground and a total of 96 feet (linear) of piping. Unit is charged with 10°F subcooling at 125°F condensing temperature (280 psi R22 liquid). See figure 3.

Find: Select tube size from figure 2.

Figure 2 illustrates the relationship between liquid line sizing, pressure drop per 100 feet, velocity range and tonnage. When using liquid line solenoid valves, velocities should not exceed 300 fpm to avoid liquid hammer when closing. Enter figure 2 from left and extend to the right to the smallest tube size that will not exceed 300 fpm velocity.

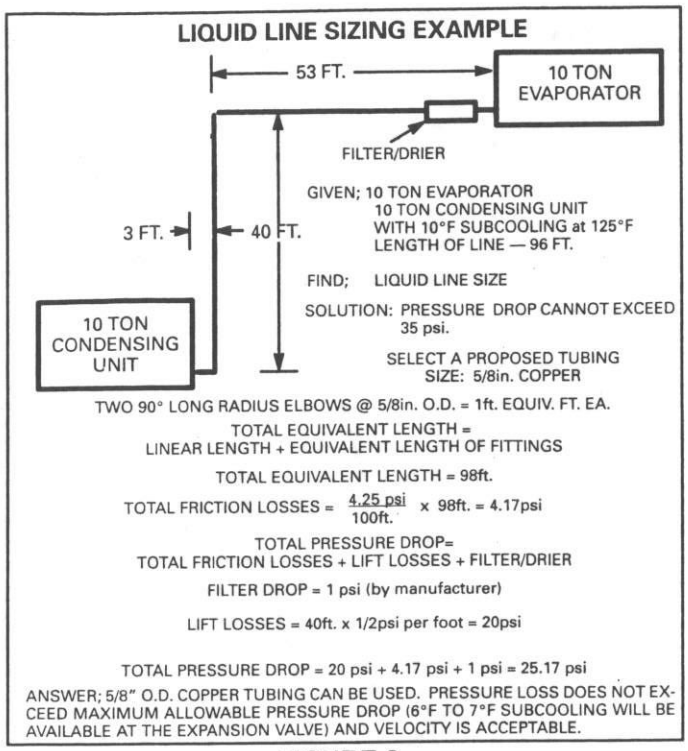


FIGURE 3

Solution: For a 10 ton system, 5/8 inch O.D. line with 4.25 psi per 100 feet drop is selected. Now, calculate pressure drop due to friction and liquid lift to determine if this is a good selection.

The pressure lost to two elbows must be added to the equation. The total friction drop for 96 feet of 5/8 inch O.D. pipe plus (from table 2) 1 equivalent foot per elbow = 98 equivalent feet.

Figure 2 shows that, in a 10 ton system, we can expect 4.25 psi drop per 100 feet of 5/8 inch O.D. copper. When we multiply 4.25/100 by 98 equivalent feet, we see that the total friction loss is 4.17 psi.

Now, we must add the pressure drop for vertical lift. R22 pressure drop is 1/2 psi per foot of vertical lift. When multiplied by 40 feet vertical lift we find that pressure drop due to lift = 20 psi.

Finally, we have added a filter drier to the liquid line which has 1psi drop (this number provided by manufacturer).

Add the three components of pressure drop together to find that the total pressure drop in this 5/8 inch line = 25.17 psi.

Now, by comparing 25.17 psi to our maximum allowable pressure drop we find that this setup falls well within the acceptable range. The 5/8 inch line, therefore, is a good selection because it is well below the maximum allowable pressure drop, is in a satisfactory velocity range, uses minimum refrigerant and provides sufficient pressure at the expansion valve.

First Example
Alternative Pipe Size

Suppose 3/4 inch O.D. line with 1.6 psi drop per 100 feet had been selected. The total equivalent length is computed by adding the linear length (96 ft.) plus the equivalent length of the fittings (from table 2, two 90° ells at 1.25 ft. each). The total equivalent length is 98.5 feet. The total friction drop would have been 1.6/100 multiplied by 98.5 = 1.57 psi. When the pressure drop due to lift (20 psi) and the filter drier (1 psi) are added we find that the total pressure drop for 3/4 inch line = 22.57 psi.

Yet, 3/4 inch line is a less desirable choice. Why?

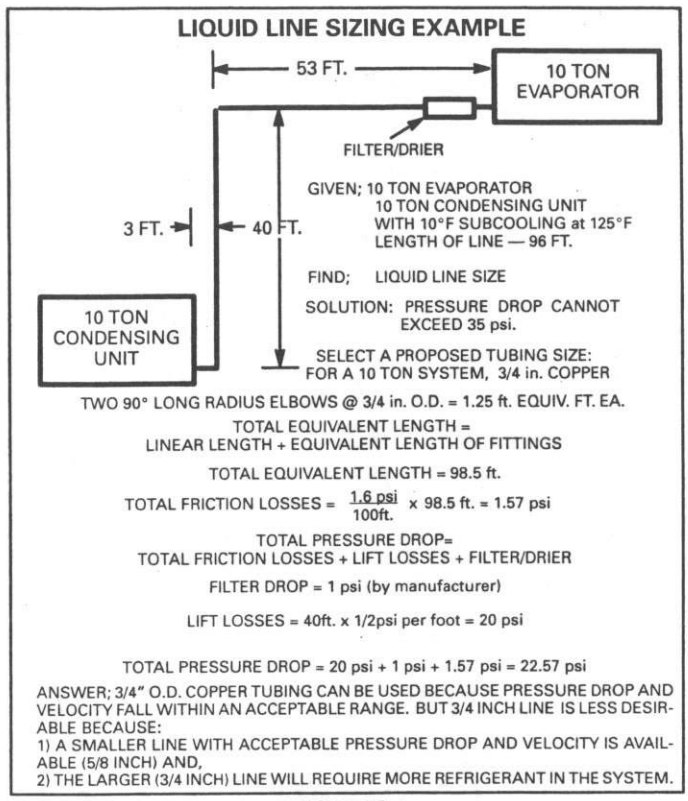


FIGURE 4

The difference in pressure drop between 5/8 inch line and 3/4 inch line is only 2.35 psi. But, the larger line adds 5.5lbs. more refrigerant into the system (see table 1). The risk of refrigerant slugging is increased and the smaller line will be less costly. The smaller line should be used.

B–Suction Line Design

Principles

The purpose of the suction line is the return of refrigerant vapor and oil from the evaporator to the compressor. The sizing of vertical risers is extremely important. Movement of oil droplets up the inner surface of the tubing is dependant on the mass velocity of the gas at the wall surface.

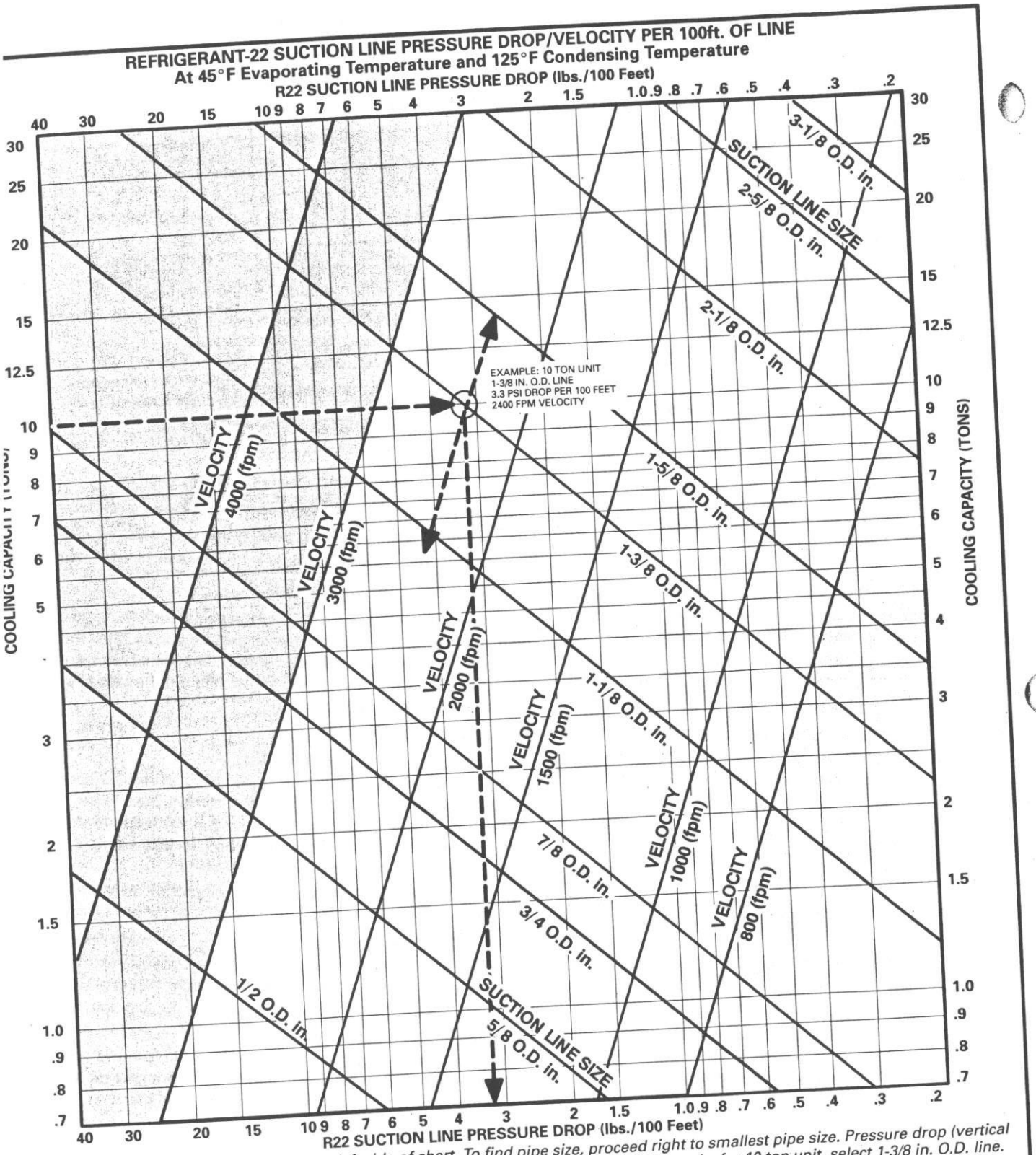
The larger the pipe the greater the velocity required at the center of the pipe to maintain a given velocity at the wall surface.

Suction line design is critical. The design must minimize pressure loss to achieve maximum unit efficiency and yet provide adequate oil return to the compressor under all conditions.

Because oil separates from the refrigerant in the evaporator, the suction velocity must be adequate to sweep the oil along. Horizontal suction lines require a minimum of 800 fpm velocity for oil entrainment. Suction risers require 1200 fpm minimum and preferably1500 fpm regardless of the length of the riser.

Figure 5 illustrates the relationship between suction line sizing, pressure drop per 100 feet, velocity and cooling tonnage. This chart is used to determine suction line pressure drop which can then be used to determine suction line capacity loss. This chart can also be used to determine suction line velocity to assure oil return to the compressor.

Vertical lift does not significantly affect pressure drop. However, systems will lose approximately 1% capacity for every pound of pressure drop due to friction in the suction line. This "1%" factor is used to estimate the capacity loss of refrigerant lines. To use the "1%" factor, first you must use figure 5 to estimate the pressure drop in the "total equivalent length" of the lines you choose.



To use this chart, first find capacity (tons) on left side of chart. To find pipe size, proceed right to smallest pipe size. Pressure drop (vertical line) and velocity (diagonal lines) can then be determined for the pipe size selected. For example, for 10 ton unit, select 1-3/8 in. O.D. line. NOTE—Shaded area denotes unacceptable velocity range.

FIGURE 5

Th ngineering Handbook) capacity ratings of Lennox split sy equipment show the capacity when matched with a particular indoor coil and 25 ft. of refrigerant line. These capacity ratings have the loss for a 25ft. refrigerant line already deducted. When you use this manual to estimate the capacity loss due to friction, you must calculate the pressure drop of the entire refrigerant line then subtract the pressure drop of a 25ft. line. See figure 6. Remember, the objective is to hold refrigerant line capacity loss to a minimum.

Considerations

When an evaporator is located above or on the same level as the condensing unit, the suction line must rise to the top of the evaporator. See figure 7. This helps prevent liquid from migrating to the compressor during the off cycle. Traps should also be installed at the bottom of all vertical risers.

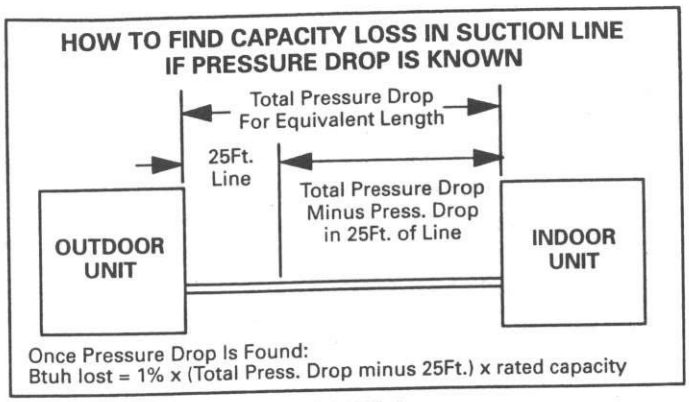


FIGURE 6

In air conditioning systems, horizontal suction lines should be level or slightly sloped toward the condensing unit. In air conditioning and heat pump systems, pipe must avoid dips or low spots that can collect oil. For this reason, hard copper should be used, especially on long horizontal runs.

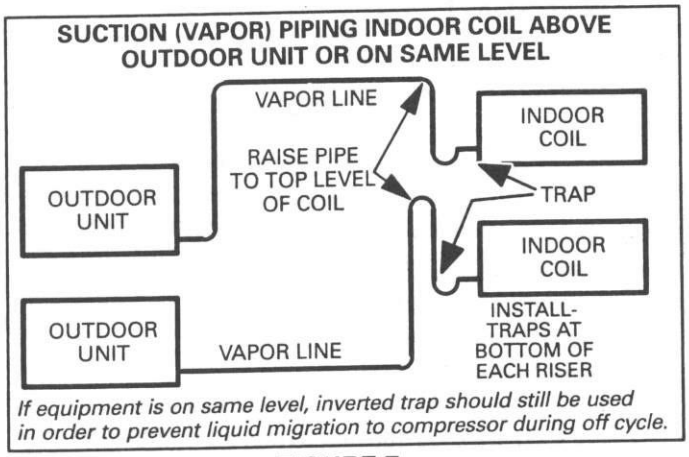


FIGURE 7

To aid in the return of oil, a trap should be installed at the bottom of any suction riser (remember, a heat pump vapor line can act as a suction riser when refrigerant flow is reversed).

When selecting suction/vapor line sizes, the following points must be remembered:

1) Velocity must be maintained in order to provide adequate oil return to the compressor.

2) Capacity loss must be held within the job requirements.

Field installed components, such as suction line driers, mufflers etc. contribute to both pressure drop and capacity loss. The resultant pressure drop must be considered (see manufacturer's data for pressure drop information).

Sizing Procedure

Before selecting pipe size, make a sketch of the layout complete with fittings, driers, valves etc. Measure the linear length of each line and determine the number of ells, tees, valves, driers etc. Add equivalent length of fittings (table 2) to linear length of pipe to get total equivalent length used in determining friction loss.

Suction Line Sizing Procedure – First Example

Given: Five ton (60,000Btuh) condensing unit on same level with condenser, with 65 feet of piping and 8 ells (as in figure 7).

Find: Select tube size from figure 5.

Figure 5 illustrates the relationship between suction line sizing, pressure drop per 100 feet, velocity range and tonnage.

Solution: Enter figure 5 from left (tons capacity) and extend to the right to the smallest tube size with velocity less than 3000 fpm.

Suction line velocity should not exceed 3000 fpm in order to avoid possible noise complaints. This rule may be slightly exceeded when added velocity is required to entrain oil vertically.

1-1/8 inch O.D. line with 2.8 psi per 100 feet pressure drop and 1950 fpm velocity is selected. Now calculate pressure drop due to friction loss to determine if this is a good selection.

65 feet of pipe, plus 8 ells (1.8 equivalent feet each, from table 2) = 79.4 feet equivalent length.

When we multiply 2.8/100 by 79.4 equivalent feet, we see that the total friction loss is 2.22 psi.

1-1/8 inch line appears to meet the requirements in figure 5. Find the capacity loss in 1-1/8 in. line to determine net capacity.

Air Conditioning and Heat Pump system capacities are based on matched systems with 25 equivalent feet of refrigerant line operating at ARI conditions. As figure 6 shows, the pressure drop in 25 feet of line must be subtracted from the total equivalent length.

The pressure drop in 25 feet of 1-1/8 inch line is:
2.8/100 multiplied by 25 = 0.7psi
The total pressure drop for the line is:
2.22psi minus 0.7psi = 1.52 psi

The capacity loss (figure 6) is:
0.01 x 1.52 x 60,000 = 912 Btuh or approximately 1.5%.

First Example
Alternative Pipe Size

Suppose 7/8 inch O.D. line with a pressure drop of 12 psi per 100 feet had been selected. 65 feet of pipe, plus 8 ells (1.5 equivalent feet each, from table 2) = 77 feet equivalent length. The total friction drop would be 12/100 multiplied by 77 = 9.24 psi.

The pressure drop in 25 feet of 7/8 inch line is:
12/100 multiplied by 25 = 3psi
The total pressure drop for the line is:
9.24psi minus 3psi = 6.24 psi

The capacity loss (figure 6) is:
0.01 x 6.24 x 60,000 = 3744 Btuh or approximately 6.24%.

This is a poor selection for two reasons:
1) The high velocity may cause excess suction line noise.
2) The capacity loss may not be acceptable if the system is designed with close tolerance.

Suction Line Sizing Procedure – Second Example

Given: 7-1/2 ton condensing unit with evaporator lower than condenser, with 112 feet of piping and 4 ells. The piping includes 20 feet of vertical lift and 92 feet of horizontal run.

Find: Select tube size from figure 5.

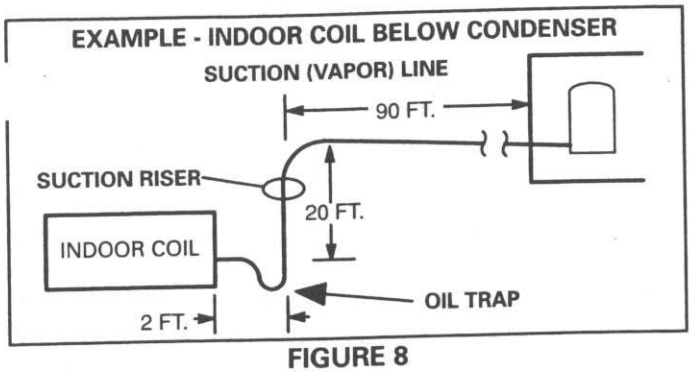


FIGURE 8

Solution: 1-1/8 inch O.D. line with 6 psi per 100 feet pressure drop and 2900 fpm velocity is selected. Now, calculate pressure drop due to friction to determine if this is a good selection.

From table 2, four ells at 1.8 equivalent feet each = 7.2 equivalent feet. When added to the 112 feet of pipe, the total equivalent feet becomes 119.2 feet (round up to 120 feet).

When we multiply 6/100 by 120 equivalent feet, we see that the total friction loss is 7.2 psi.

Use figure 5 to calculate the pressure drop in 25 feet of 1-1/8 inch line. When we multiply 6/100 by 25 feet, we see that the friction loss is 1.5 psi.

The capacity lost in the "total equivalent length" of the refrigerant line (using figures 5 and 6) = 1% x (7.2 – 1.5) x 90,000.
Btuh lost= 0.01 x (5.7) x 90,000
Btuh lost = 5130
Capacity loss for the line selected is approximately 5.7%.

'he preceding calculation shows that this is a workable system but will result in a loss of capacity and efficiency.

Second Example
Alternative Pipe Size

Using the same (7-1/2 ton) example, this time select 1-3/8 inch O.D. line. 1-3/8 inch O.D. line with 2 psi per 100 feet pressure drop has 1760 fpm velocity. Now calculate pressure drop due to friction loss to determine if this is a better selection.

From figure 5, four ells at 2.4 equivalent feet each = 9.6 equivalent feet. When added to the 112 feet of pipe, the total equivalent feet becomes 121.6 feet (round up to 122 feet).

When we multiply 2/100 by 122 equivalent feet, we see that the total friction loss is 2.4 psi.

Use table 5 to calculate the pressure drop in 25 feet of 1-3/8 inch line. When we multiply 2/100 by 25 feet, we see that the friction loss is 0.5 psi.

The capacity lost in the "total equivalent length" of the refrigerant line (using figures 5 and 6) = 1% x (2.4 – 0.5) x 90,000.
Btuh lost= 0.01 x (1.9) x 90,000
Btuh lost = 1710
Capacity loss for the line selected is approximately 1.9%.

The conditions in this example will allow either 1-1/8 inch or 1-3/8 inch suction line to be used since capacity loss is minimized and velocity is sufficient to return oil to the compressor.

Third Example - Suction Sizing with Variable Capacity Two Speed Condensing Unit

Some variable capacity installations may use a single suction riser for minimum load conditions without serious penalty at design load. Lennox units with two speed compressors have approximately 60% capacity at low speed and normally do not require double suction risers (Zonemaster not included).

Given: 15 ton two-speed condensing unit with a single 15 ton (dual circuit) evaporator.
High Speed Capacity = 15 tons and,
Low Speed Capacity = 9 tons.

The system is plumbed with the evaporator 60 feet below the condensing unit and 40 feet horizontally away from the condensing unit. A trap is plumbed at the bottom of the riser. The trap is composed of 90° ells.

Find: Determine if single suction riser is suitable or if double suction riser must be used.

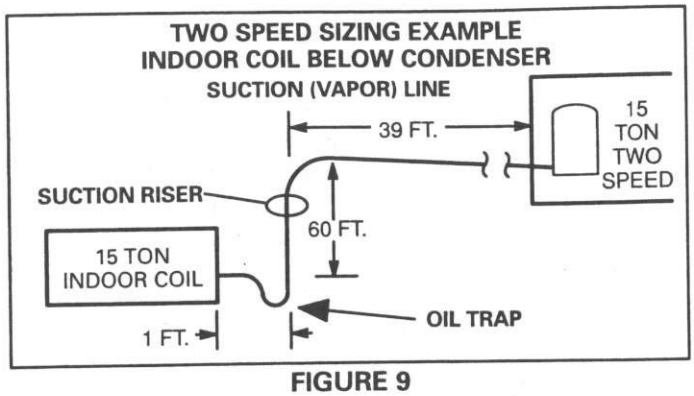


FIGURE 9

Solution: Select the line size based on full unit capacity (15 tons). 1-5/8 inch O.D. line with 3 psi per 100 feet pressure drop and 2600 fpm velocity (at full capacity) is selected. Then determine the equivalent length of the segment to calculate the pressure drop.

60 feet of pipe (vertical), plus 40 feet of pipe (horizontal), plus four 90° elbows (2.8 equivalent feet each) = 111.2 equivalent feet length (round to 111).

From figure 5, 1-5/8 inch O.D. suction line with 15 tons capacity has 3 psi drop per 100 feet. When we multiply 3/100 by 111 equivalent feet, we see that the total friction loss is 3.3 psi.

Use table 5 to calculate the pressure drop in 25 feet of 1-5/8 inch line. When we multiply 3/100 by 25 feet, we see that the friction loss is 0.75 psi.

The capacity lost in the "total equivalent length" of the refrigerant line (using figures 5 and 6) = 1% x (3.3 – 0.75) x 180,000.
Btuh lost= 0.01 x (2.55) x 180,000
Btuh lost = 4590
Capacity loss for the line selected is approximately 2.55%.

Low Speed Capacity

1-5/8 inch line appears to be appropriate for this system operating at full (15 ton) capacity. Now we must check the low speed (9 ton) capacity to determine if 1-5/8 inch line is appropriate.

Lennox two speed units operate at approximately 60% capacity when operating on low speed:
15 tons x 0.6 = 9 tons (if an engineering data sheet is available use the actual capacities rather than this approximation).

9 tons capacity when used with 1-5/8 inch pipe (figure 5) indicates a velocity of 1500 fpm. This is sufficient to return oil to the compressor and meets the requirement of maintaining at least 1500 fpm in vertical risers.

When comparing high speed to low speed performance in this case we find that a single 1-5/8 inch suction riser may be used and double suction risers are not required.

Systems on the Fringe

Many two speed applications will require a reduction in suction riser size to maintain adequate velocity for oil return at low speed. For example, a 5 ton two speed system will normally use a 1-1/8 inch suction line (figure 5). A suction riser in this system may be reduced to 7/8 inch pipe size while the horizontal runs may use 1-1/8 inch pipe size.

Figure 5 shows the tradeoffs that will result from downsizing the riser. The disadvantage is that the riser will exceed 3000 fpm when operating at full capacity (potential for sound transmission). In addition, the pressure drop in the smaller line will result in significantly greater pressure drop (capacity loss). The advantage is that the smaller line will guarantee sufficient velocity for oil return when operating at reduced capacity.

If, by reducing the riser pipe size, the pressure drop (capacity loss) becomes unacceptable, the system must be designed with double suction risers.

Fourth Example
Suction Sizing Variable Capacity - Hot Gas Bypass

There are two basic types of hot gas bypass kits. The most desirable is the type that feeds the hot gas from the compressor discharge line to a side tap on the distributor in the evaporator coil. When installed in this manner, full flow of suction gas is maintained in the suction line and suction piping should follow standard procedures as outlined in the previous sections.

The second type of hot gas bypass is installed and connected within the condensing unit. This is known as a "run-around" hot gas bypass in that hot compressor discharge gas and liquid from the liquid line are circuited to the hot gas bypass valve and directly into the suction line.

This method reduces flow through the evaporator and suction line. Special handling of suction risers is required.

When to Use Double Suction Risers

If a condensing unit can unload more than 50% either by a hot gas bypass (run-around cycle) or other mechanical means, double suction risers may be required.

If the condensing unit unloads less than 50%, suction lines can be generally sized in accordance with the previous sections. If the suction velocity is high enough to entrain oil when the unit is operating at reduced capacity, double suction risers are generally not required.

In general, double suction risers are required any time the minimum load on the compressor does not create sufficient velocity in vertical suction risers to return oil to the compressor. Double suction risers are also generally required any time the pressure drop or velocity in a single suction riser is excessive.

How Double Suctions Risers Work

Figure 10 shows a typical double suction riser installation. A trap is installed between the two risers as shown. During partial load operation (figure 11) when gas velocity is not sufficient to return oil through both risers, the trap gradually fills with oil until the second riser is sealed off. When this occurs, the vapor travels up the first riser only. With only the first riser being used, there is enough velocity to carry the oil. ***This trap must be close coupled to limit the oil holding capacity to a minimum.*** Otherwise, the trap could accumulate enough oil on a partial load to seriously lower the compressor crankcase oil level.

The second suction riser must enter the main suction line from the top to avoid oil draining down the second riser during a partial load. See Figure 11.

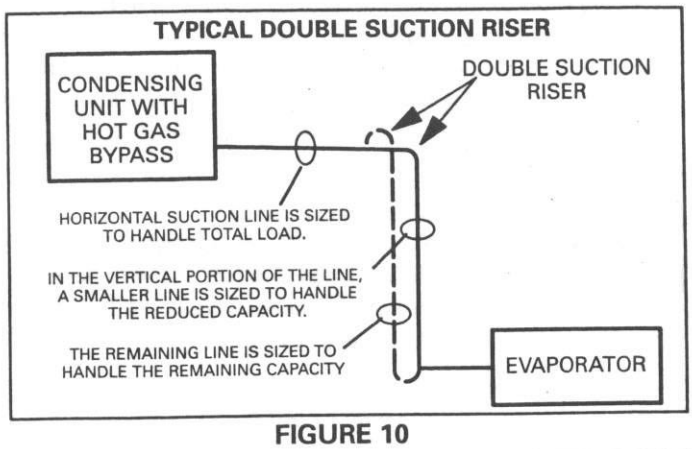


FIGURE 10

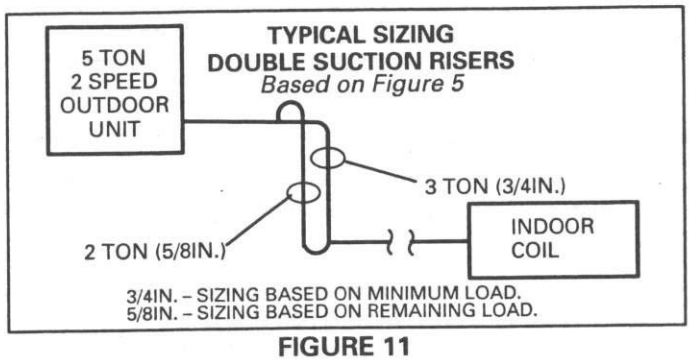


FIGURE 11

Sample Calculation

Given: 10 ton condensing unit with hot gas bypass (run-around type) or mechanical unloaders capable of 65% unloading. Matched evaporator is located below condensing unit. Piping will require 57 (linear) feet of pipe (figure 12). Construction without double suction risers will only require 2 ells.

Find: 1) Select tube sizes for horizontal runs and risers (figure 5).
2) Determine if double suction risers are needed.
3) Size double suction riser for proper system performance.

Solution: Size each segment based on the tons of refrigerant that will flow in the segment.

Full load capacity = 10 tons. Minimum load capacity is 35% of 10 tons = 3.5 tons. The difference between full capacity and part load capacity is 6.5 tons.

From figure 5, select a pipe size for full load capacity. 1-3/8 inch O.D. pipe with 3.3 psi drop per 100 feet and 2400 fpm velocity is selected. Now, by using figure 5, find the velocity for the selected pipe size at part load capacity. The part load velocity is approximately 850 fpm. 850 fpm is sufficient to return oil in horizontal runs but not in vertical risers.

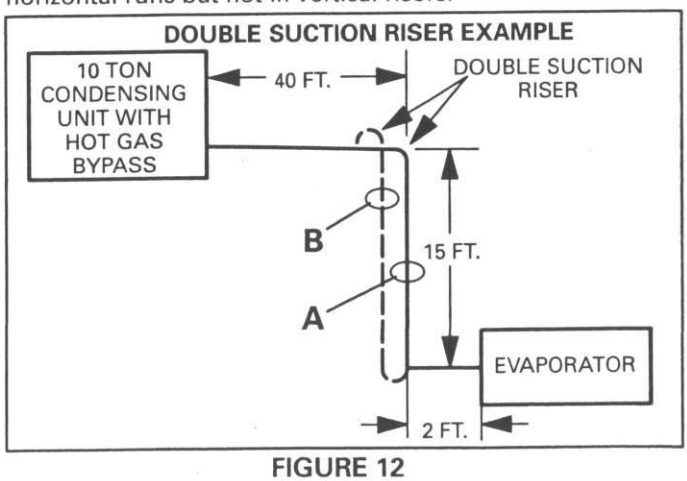


FIGURE 12

If we tried to size this system by simply reducing the riser size to 1-1/8 inch, we would find the velocity in the riser to be excessive (3800 fpm) when the system is operating at full capacity. As a result of these obstacles, this system will require construction of double suction risers. Construction of double suction riser vill require five ells and two tees total for a system.

Size small riser
(Riser carrying smallest part of load)

The unit produces 3.5 tons capacity at minimum load. Select from figure 5 a 7/8 inch O.D. line (smallest line with acceptable velocity). When operating at 3.5 tons capacity, this line will operate at 2500 fpm and will produce 6 psi drop per 100 ft.

Size large riser
(Riser carrying largest part of load)

The larger line carries 6.5 tons capacity at full load. Select from figure 5 a 1-1/8 inch O.D. line (smallest line with acceptable velocity). When operating at 6.5 tons capacity, this line will operate at 2500 fpm and will produce 4.5 psi drop per 100 ft.

Putting the Segments Together

Next, we must determine if the line sizes we selected will result in satisfactory pressure drop between the condensing unit and the evaporator.

Start by finding the total equivalent feet of the large (B) riser. 15 feet of pipe, plus two tees (branch side of tee at 4.5 equivalent feet each), plus four ells (1.8 equivalent feet each) = 31.2 equivalent feet length.

Now, find the total equivalent feet of the small (A) riser. 15 feet of pipe, plus one ell (1.5 equivalent feet), plus one tee (branch side of tee at 3.5 equivalent feet), plus one tee (line side of tee at 1.0 equivalent feet) = 21.0 equivalent feet length.

Use the total equivalent length of each riser to compute the pressure drop of each riser. For the large (B) riser, 1-1/8 inch O.D. suction line with 6.5 tons capacity has 4.5 psi drop per 100 feet. When we multiply 4.5/100 by 31.2 equivalent feet, we see that the total friction loss is 1.4 psi.

For the small (A) riser, 7/8 inch O.D. suction line with 3.5 tons capacity has 6 psi drop per 100 feet. When we multiply 6/100 by 21 equivalent feet, we see that the total friction loss is 1.26 psi.

The total pressure drop for the riser is equal to the average of the pressure drop in both risers:
1.4 (B riser pressure drop) + 1.26 (A riser pressure drop) = 2.66
2.66 ÷ 2 = 1.33 (average pressure drop through A and B risers).

Find the pressure drop for the horizontal run of pipe. 1-3/8 inch pipe at 10 tons capacity has 3.3 psi drop per 100 feet. When we multiply 3.3/100 by 61 equivalent feet, we see that the total friction loss is 2.01 psi.

The pressure drop through the risers is added to the pressure drop through the horizontal run to find the total pressure drop for the system:
2.01 psi (horiz. run) + 1.33 psi (avg. riser) = 3.34 psi.

Use table 5 to calculate the pressure drop in 25 feet of 1-3/8 inch line. When we multiply 3.3/100 by 25 feet, we see that the friction loss is 0.825 psi.

The capacity lost in the "total equivalent length" of the refrigerant line (using figures 5 and 6) = 1% x (3.34 – 0.825) x 120,000.
Btuh lost= 0.01 x (2.515) x 120,000
Btuh lost = 3018
Capacity loss for the line selected is approximately 2.5%.

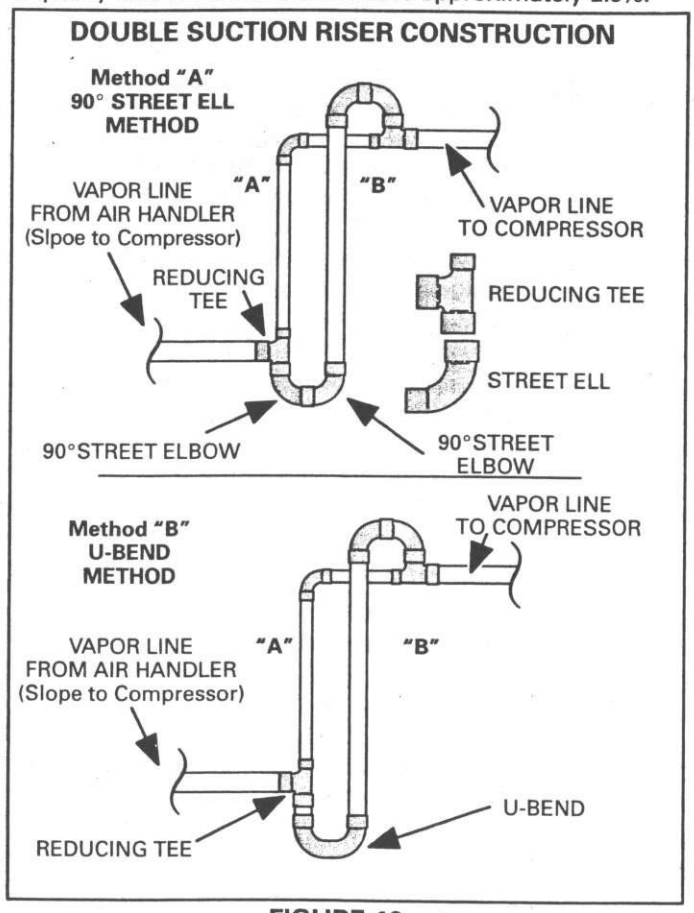


FIGURE 13

VI–Appendix

A– Refrigerant Capacity in Lines

TABLE 1

Refrigerant Charge (lbs.) in Various Lengths of Type L Copper Tubing for R-22 Air Conditioning Systems @ 45°F Suction and 125°F Liquid

Length of Lines (ft.)	Line Size (O.D. in.)											
	3/8	1/2	5/8		3/4		7/8		1-1/8	1-3/8	1-5/8	2-1/8
	Liquid	Liquid	Liquid	Suction	Liquid	Suction	Liquid	Suction	Suction	Suction	Suction	Suction
10	0.378	0.702	1.128	0.0293	1.683	0.0437	2.34	0.0608	0.1037	0.1579	0.223	0.388
20	0.756	1.404	2.256	0.0586	3.366	0.0874	4.68	0.1216	0.2074	0.3158	0.446	0.776
30	1.134	2.106	3.384	0.0879	5.049	0.1311	7.02	0.1824	0.3111	0.4737	0.669	1.164
40	1.512	2.808	4.512	0.1172	6.732	0.1748	9.36	0.2432	0.4148	0.6316	0.892	1.552
50	1.890	3.510	5.640	0.1465	8.415	0.2185	11.70	0.3040	0.5185	0.7895	1.115	1.940
60	2.268	4.212	6.768	0.1758	10.098	0.2622	14.04	0.3648	0.6222	0.9474	1.338	2.328
70	2.646	4.914	7.896	0.2051	11.781	0.3059	16.38	0.4256	0.7259	1.1053	1.561	2.716
80	3.024	5.616	9.024	0.2344	13.464	0.3496	18.72	0.4864	0.8296	1.2632	1.784	3.104
90	3.402	6.318	10.152	0.2637	15.147	0.3933	21.06	0.5472	0.9333	1.4211	2.007	3.492
100	3.780	7.020	11.280	0.2930	16.830	0.4370	23.40	0.6080	1.0370	1.579	2.230	3.880

PTCS Installation Guidelines for Air Source Heat Pumps

Note: any detailed manufacturer's procedure (American Standard, Carrier, Lennox, Rheem, etc.) will contain all the information needed to successfully install an air-to-air heat pump. This guideline is meant to summarize the salient points concisely ***and list documentation steps*** *needed for PTCS certification.*

Equipment ratings (for outdoor and indoor unit) and duct sizing documentation must be provided upon request as part of the installation process. This documentation is described fully in the PTCS heat pump specifications.

Outdoor Unit

- Level/stable pad; make provisions for condensate runoff and snow depth.
- No overhangs, vegetation, etc. shall impinge on airflow.
- Make sure conductors and service disconnect breakers are properly sized per manufacturer's requirements and current NEC.
- Maintain code-required clearances to electrical panels.
- Make sure refrigerant service ports/valves are readily accessible after installation.

Refrigerant Piping Specifications/Procedures

- Use the right type of piping (Type K or L; Type M not allowed).
- Use right pipe size: check manufacturer's tables; keep total suction line drop to an equivalent of 2° F (approximately 3 PSI for R-22); keep discharge drop to between 5-10 psig)). If in doubt, slightly oversize liquid line and undersize suction line. *Keep track of the amount of elbows and vertical rise in sizing lines.*
- Use care in handling, cutting, flaring, deburring, and brazing copper tubing.
- Blow out tubing with dry nitrogen (at 5 PSIG) if there is a concern of contamination.
- Use care in working with service valves.
- Install piping with as few bends as possible; use tube bender.
- Support lines every 6-10 feet; supports needed within 2 feet of bends.
- Use oil traps as needed (e.g. indoor coil below compressor and more than 3 feet of vertical displacement).
- Horizontal lines should have a downward pitch of at least ½ inch in 10 feet to aid in oil drainage.
- Use proper insulation for vapor line, typically 3/8" closed cell insulation.
- Do not insulate liquid and vapor line together.
- R-410A systems: limit time that system interior can be exposed to atmosphere; *aim for no time at all*. POE oil is extremely hygroscopic (water-loving) and will absorb many times its weight in water. This can cause grave problems for system components (short-term TXV failure; long term compressor failure).

System Components (Electrical and Brazed-In)

- Use correct metering device (double check manufacturer's specifications for selection and installation procedure).
- Follow manufacturers' procedures carefully in installing metering device (positioning, attachment of sensing bulb).
- Ensure oil is of the proper type for the refrigerant used.
- *Highly recommended*: purge dry nitrogen through piping to prevent oxidation during brazing.
- Install factory-approved liquid line filter-drier. Double-check instructions for R-410A systems, in terms of type, size, location.
- Install crankcase heater if part of package or if there are excessively long (over 36 inch) runs in colder spots. (Note manufacturers generally recommend not burying more than 36 inches of refrigerant tubing.)
- Protect metering devices, valve seats, etc from excessive heat when brazing (use heat sink or wrap lines with wet cloths, etc.) *Do not leave system open during this process.*
- Ensure compressor protection devices are installed and operational.
- Install suction-side accumulator if standard manufacturer option.
- Use liquid line solenoid for long line sets if required by manufacturer (typically if piping equivalent length is >50 feet or elevation between indoor and outdoor unit is ≥20 ft.)
- Install hard start kit if recommended by manufacturer.

Indoor Unit

- Install required amount of backup element capacity (from Design Heating Load calculation).
- Plumb condensate line to permanent drain. Install trap on primary drain. Run secondary drain to an obvious, visible, non-destructive location if indoor unit installed in attic. If condensate pump used, verify operation and adequate removal of liquid from drain reservoir.
- If the heat pump uses fossil fuel for back up heat, make sure the indoor coil is downstream from the heat exchanger.

Pressure Test/Evacuation Procedure (for systems not using pre-charged line sets)

- Pressurize system to 150 psig with all valves open; check for leaks with soap solution. Repair leaks (after removing nitrogen) and retest.
- When no leaks found, pressurize R-22 system to 360 psig with dry nitrogen and leave for 24 hrs to confirm system holds pressure. Systems using R-410A should be pressurized to at least 450 psig for 24 hrs; consult local jurisdiction if a higher test pressure is required.

Evacuation Procedure

- Make sure manifold set is air tight
- Evacuate field-assembled piping to 500 microns or as directed by mfr. (Fastest evacuation occurs with short, bigger diameter hoses and with Schrader cores removed; evacuate through both sides of the system. Analog micron gauge is preferred because needle action

can be observed to evaluate presence of moisture or leak. Make sure vacuum pump has clean oil at start.)

- Close valve to vacuum pump; look at gauge. Gauge should rise no more than 200 microns in 3 minutes.
- When satisfied system is tight (see above pressure-testing procedure), release refrigerant into system.

Airflow and Charging Checks

- Weigh in charge; use digital refrigerant gauge with at least 0.5 oz resolution.
- Make proper adjustments for line set length if field-assembled (standard line set length is 25 feet (R-22) or 15 feet (R-410A)); make sure to read documentation for system. ***Record adjustment made.***
- Install system filter and verify evaporator airflow is within mfr's recommended levels; adjust fan speed, use different filter, and/or adjust duct damper positions as needed to achieve at least 350 CFM/ton of capacity; ***document flow with TrueFlow or other approved method.***
- ***Measure temperature at outdoor unit with reliable thermocouple temperature gauge and record.***
- If testing in heating mode: run system for at least 15 minutes in <u>compressor-only</u> mode and measure operating pressures. Note which stage of heating is tested if system has multiple stages; the stage tested must match with the airflow measured (above). Compare measured pressures with expected values from manufacturer's information. ***Record expected/measured values***; generally a 10 psig tolerance is allowed.
- If testing in cooling mode: run system for at least 15 minutes, measure wet-bulb temperature of air entering evaporator with reliable thermocouple and temperature gauge.
- Use calibrated manifold gauges to check operating pressures.
- For either mode, adjust charge as needed; retest and ***record results***.
- Tighten all service valves to manufacturer's recommendation.

Electrical Startup Checks

- Make sure crankcase heater works and is run for the mfr's recommended amount of time before system is operated (typically 24 hours). *This is very important*.
- Check line and control voltage under normal operation.
- Check temperature split across reversing valve; if more than 10° F, valve must be examined for repair or replacement (solenoid or other part is to blame)
- Make sure outdoor fan rotation is correct.
- Ensure system pressure control device(s) work properly.
- Check running amps of compressor, indoor fan, outdoor fan**..** If values are more than 10% above manufacturer's recommendations, troubleshoot problem and repair/replace faulty component(s).
- Check operation of back-up elements.

Controls

- Make sure thermostat is intended for heat pump control.

- Install indoor thermostat according to manufacturer's specifications and check operation. Ensure reversing valve switches to proper condition for heating, cooling, and defrost.
- Note auxiliary (strip) heat is <u>not</u> allowed to operate in Stage 1 heating under the PTCS specifications.
- Install outdoor thermostat or enable this feature at indoor thermostat if there is an outdoor temperature sensor/lockout option in installer's setup. An aggressive setting (35º F) is required. ***Record*** setting. ***Confirm*** elements are locked out at warmer temperatures. Make sure elements come on when indoor thermostat calls for emergency heat.
- For systems that use discharge air sensors to control auxiliary heat: these sensors must be disabled for single-capacity systems (one compressor and/or compressor stage). For multi-stage systems, the staging control must be set no warmer than 85° F.
- Check operation of defrost system using manufacturers' procedure; pay careful attention to location of outdoor and coil sensors.
- Set defrost interval (60 min or longer if not demand defrost) and check operation using test pins or ice. ***Record*** system works okay.
- If the heat pump uses fossil fuel for back up heat, make absolutely sure the fossil fuel side of the equipment operates within manufacturers' specifications for gas valve pressure (where applicable), draft pressure, stack emissions, and other relevant factors.

Explain operation of system to homeowner

- Indoor thermostat (programming periods, "smart recovery" etc)
- Outdoor thermostat (effect on air temperature plus savings)
- Defrost (causes steam, puddles)
- Filter location/type/change schedule
- Keep outdoor coil free of vegetation and other debris; explain need to keep clean
- Duct/register management (including the return side – keep system open as much as possible)

Performance Tested Comfort Systems - Air-Source Heat Pump System Installation Standards[1]

December 13, 2005

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1.0 INTRODUCTION

1.1 "Should and Shall" will be interpreted as follows:

1.1.1 Where shall or shall not is used for a provision, that provision is mandatory if compliance with the standard is claimed.

1.1.2 Where should is used it will indicate provisions which are not mandatory but which are desirable as good practice.

2.0 EQUIPMENT REQUIREMENTS

2.1 Approved Manufacturer

Equipment shall be manufactured by a company appearing in the ARI Unitary Directory.

2.2 Ratings

Heat pump equipment shall meet the performance, safety, and rating requirements as given in the latest revision of Air Conditioning and Refrigeration Institute (ARI) Standard 240. Units shall be listed by Underwriters' Laboratories, or equal, and shall display the ARI symbol of certification.

2.3 Performance

Site Built Housing - Air Source Heat Pumps shall have an HSPF rating of not less than 8.5 and SEER ratings of not less than 14.0, as certified by ARI.

2.4 Protective Devices

Equipment should be provided with a crankcase heater and a liquid-line filter drier. Delay timers to protect against damage from short cycling of the compressor and compressor motor start-assist kits shall be installed when recommended by the manufacturer. The compressor shall be protected from abnormal operating pressures, temperatures, and loss of refrigerant by suitable pressure or temperature overload devices.

If a low ambient temperature compressor cutout option is installed, it shall not cutout the compressor at temperatures above 0°F.

To prevent floodback of liquid refrigerant to the compressor, a suction line accumulator shall be installed, unless not recommended by the manufacturer.

3.0 PARTICIPATING INSTALLER REQUIREMENTS

3.1 Training

Participating Installer shall be responsible for the technical competence and qualifications of his salespeople, installers, and service mechanics. These personnel should participate in at least one manufacturer's training session on heat pump application, installation, or service annually or equivalent training. At least one fourth of all the Participating Installer's installers

should be Refrigeration Service Engineers Society (RSES) or North American Technicial Excellence (NATE) heat pump certified or have equivalent certification. At least one System Installer or Technician on each HVAC Contractor job shall be certified in Air Conditioning Contractors of America (ACCA) Manual D. System Designers shall be certified in ACCA Manual D and Manual J.

Alternately, duct design, heat pump sizing, and installations may be certified by the utility if the utility has staff that is certified in ACCA's Manual D and Manual J.

3.2 Certification

Each system installed shall have the heat pump installation certified by an RTF approved PTCS Service Provider as a "Certified PTCS Heat Pump Installation". This requires testing and documentation of auxiliary heat controls, airflow across indoor coil, and refrigerant charge by an RTF approved PTCS Service Provider certified "Heat Pump Technician".

Systems installed in houses with a substantial amount of ductwork in unconditioned space shall have the duct system certified by an RTF approved PTCS Service Provider as a "Certified PTCS Duct System". This requres duct testing and may require sealing by an RTF approved PTCS Service Provider certified "Duct Technician" according to the "PTCS Duct System Diagnostic Field Guide, Program Standards, Testing Procedures and Reporting Forms".

Applicable heat pump installation and duct system PTCS certifications shall be submitted to the utility. The utility shall maintain record of certifications and make them available to BPA, the RTF, or the RTF approved PTCS Service Provider upon request.

3.3 Warranty

The participating Installer shall provide to the consumer in writing the manufacturer's warranty. Heat pump equipment shall be warranted by the manufacturer against defects in material and workmanship for a minimum of five years from the date of start-up of the equipment. In addition, the compressor shall be warranted by the manufacturer against defects in material and workmanship for a minimum of five years from the date of start-up. Warranties shall cover parts and labor. Participating Installers may offer to consumers the manufacturer's extended warranty or service agreement to comply with the warranty requirements. This warranty should not be considered to cover equipment failure caused by failure to perform normal maintenance, abuse, or external causes beyond the control of the installing Participating Installer.

3.3 Consumer Instruction

Participating Installer shall instruct the consumer in proper operation and maintenance of the heat pump system. Participating Installer shall provide the consumer with the manufacturer's owner's manual, demonstrate filter replacement (or cleaning), and demonstrate the operation of all indoor thermostat controls and indicator lights to the consumer. Participating Installer shall explain to the consumer the different operating modes of the heat pump system (e.g., heating, emergency heat, defrost, and the effects of obstructing registers). All this information shall be provided in an operation manual given to the owner.

4.0 EQUIPMENT SELECTION

4.1 Heating and Cooling Calculations

4.1.1 Heating loss and cooling gain calculations shall be made using 70°F indoor design temperature for heating and 75°F for cooling.

4.1.2 The recommended ASHRAE winter design temperature and cooling design temperature for the nearest weather station representative of the installation shall be used.

4.1.3 The recommended method and form for calculations is available in the Air Conditioning Contractors of America (ACCA) Manual J. Alternate computer or manual methods of calculating heating and cooling loads may be used if approved in advance by the utility.

4.1.4 Component U-values and F-values used in the heat loss and heat gain coefficients shall reflect the actual construction of the building and be generally consistent with those found in ACCA Manual J 7th Edition, or later.

4.1.5 A copy of the whole house heating and cooling load calculations shall be submitted to the utility. The utility shall hold the calculations on file and make them available to BPA, the RTF, or the RTF approved PTCS Service Provider upon request.

4.1.6 An infiltration rate of 0.5 or 0.8 air changes per hour shall be used for houses built in or after 1980 or before 1980, respectively, in sizing calculations unless a house (de)pressurization test has been performed and an estimate is made using the result.

4.1.7 Where available, the results of duct pressurization testing shall be used to estimate the duct system efficiency used in sizing calculations. If a duct pressurization test has not been performed on the house, a default duct system loss of 25% shall be used. Exception: If the air handler and all ductwork are within the thermal envelope of the house, 0% shall be used as the duct system loss in sizing calculations.

4.2 Heat Pump System Sizing

The heat pump system shall be sized using either of the following methods, rounding up or down to the nearest 6000 Btu/hr capacity at ARI rating conditions:

1. Heat pumps shall be sized using a 30°F Balance Point
2. Heat pumps shall be sized in accordance with the sizing method specified by the utility.

However, in no case shall the Balance Point used for sizing be higher than 35°F. A Balance Point Worksheet shall be submitted to the utility. The utility shall hold the Balance Point Worksheet on file and make it available to BPA, the RTF, or the RTF approved PTCS Service Provider upon request.

4.3 Auxiliary Heat Sizing and Staging

Installed auxiliary heat capacity shall not exceed 125% of the heating design load. All resistance heaters greater than 5 kW shall be staged.

4.4 Control of Auxiliary Heat

Auxiliary heat shall be controlled in the following manner depending on system type:

1. For systems with a single stage of compression and for systems with multiple stages of compression but without supply air temperature sensor control: Auxiliary heat shall be controlled in such a manner that it does not engage when the outdoor air temperature is above 35 ^{o}F, except when supplemental heating is required during a defrost cycle or when emergency heating is required during a refrigeration cycle failure. Exception: If the minimum setting available for auxiliary cutout on the indoor thermostat is 40 °F, 40 °F may be used.
2. For systems with multiple stages of compression and supply air temperature sensor control: Auxiliary heat shall be controlled in such a manner that it does not engage when the supply air temperature is above 85 °F.

Method of controlling auxiliary heat shall be documented using the "PTCS Heat Pump Startup Form: Controls Page" and submitted to the RTF approved PTCS Service Provider.

5.0 EQUIPMENT INSTALLATION

5.1 Access

Equipment shall be located to allow easy service access and adequate working space for servicing any component without removal of piping, duct work, or other permanently installed fixtures. Special care shall be taken in locating components which require frequent attention, such as filters.

5.2 Location and Support of Indoor Units

Indoor units shall be located to permit smooth duct transitions and shall be adequately supported or placed in a suitable platform in accordance with manufacturer's instructions and recommendations.

5.3 Location and Support of Outdoor Units

Outdoor units shall be located to avoid restrictions in the outdoor airstream. Units shall be mounted on an adequate, solid, secure pad which provides proper drainage and prevents a buildup of water, snow, or ice. A minimum clearance shall be provided as per manufacturer's instructions and recommendations. In any installation there shall be a minimum of 3 inches of free and clear area under the outdoor coil drainage area. Condensate shall not drain onto areas where ice formation may create a hazard (e.g. walkways).

5.4 Refrigerant Charge

Particpating Installer shall follow manufacturer's guidelines when charging system and make any needed adjustments for non-standard line set lengths or mismatched coils.

Refrigerant charge shall be:

a. tested using Proctor's CheckMe program, Honeywell's ACRx handtool, or other approved Performance Tested Comfort Systems methods; OR
b. documented using the "PTCS Heat Pump Startup Form".

Results from refrigerant charge test or documentation of refrigerant charge shall be submitted to the RTF approved PTCS Service Provider.

6.0 DUCT WORK

6.1 Design Requirements

All new duct work (including the addition of duct systems to existing housing) should be designed and installed in accordance with recommended practice as outlined in Air Conditioning Contractors of America (ACCA) Manual G, "Selection of Distribution Systems"; Manual E, "Room Air Distribution Consideration" and Manual D, "Residential Duct Design and Equipment Selection" or Sheet Metal and Air Conditioning Contractors National Association (SMACNA) "HVAC Duct System Design" or American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) handbooks. Installation of balancing dampers is recommended in order to easily adjust distribution of air to rooms.

6.1.1 Flex Duct

Flex duct shall not be used for main supply trunks in crawl spaces or areas that could be subject to physical damage from normal occupant activities, weather or animals. When flex duct is used for main trunks or run outs the size shall be determined by using the "Wire Helix Flexible Duct" scale on an ACCA Duct Sizing Slide Rule, or equivilent and all other requirements in Section 6.0 of these specifications shall be met.

6.1.2 Building Cavities and Ducts

In newly installed ductwork, building cavities shall not be used as ducts to convey return or supply air.

6.1.3 Static Losses

Supply and return ducts shall be designed on the basis of not more than 0.10 and 0.08 inches loss per 100 feet, respectively. Supply and Return Ducts shall be designed so that the total system static pressure does not exceed the available static pressure provided by the air handler at design CFM. Flex duct shall be supported in a manner that does not create restrictions in air flow and located to minimize bending.

6.1.4 Maximum Velocities

New duct work shall be designed so air velocities do not exceed the following:

<u>Supply Ducts</u>

Main Ducts	900 FPM
Branch Ducts	600 FPM
Supply Outlet Face Velocity	700 FPM
Return Grills Face Velocity	500 FPM
Filter Grille Face Velocity	300 FPM

Velocity shall not create unaceptable noise levels and return air shall be sufficient size to meet requirements of installed systems.

6.1.7 Duct Connections

All new and all readily accessible existing duct joints, plenum drives, metal joints to include all slips and drives shall be mechanically fastened with screws. Flexible ducts shall be attached using nylon/plastic straps tightened with a manufacturer approved tool (hand tightening is not acceptable) or stainless steel worm drive clamps. Mastic and/or tape shall not be used as mechanical fasteners.

6.1.8 Zonal Pressure Relief

In new system construction, sufficient return pathways shall be provided between axial zones (e.g. bedrooms) and the main body of the dwelling. Return pathways include return ducts, pass-through grilles, pressure-relief ducts, or similar devices. Return pathways should limit pressurization of axial zones to 3 Pa or less with reference to the main body of the house when the system is operating at maximum system airflow, tested with all doors closed.

6.2 Duct Installation

6.2.2 Insulation

6.2.2.1 All newly installed rigid ducts and plenums and accessible uninsulated existing rigid ductwork outside the heated space shall be insulated to an installed value of at least R-8. A vapor barrier meeting a flame spread rating of 25 or less and smoke developed rating of 50 or less (in accordance with ASTM E-84) shall be installed on the outside surface of the insulation.

6.2.2.2 All newly installed flexible HVAC ducts outside the heated space shall have an Air Diffusion Council (ADC) certified minimum R-value of R-8.

6.2.2.3 All newly installed HVAC ducts routed within exterior wall cavities shall be insulated to a minimum installed value of R-8 between the duct and the exterior wall sheathing.

6.2.2.4 All duct insulation shall be installed and supported using mechanical fasteners such as permanent plastic straps or nylon twine. Tape is not a mechanical fastener. Approved tape may be used at insulation seams to provide a continuous barrier.

6.2.3 Air Tightness

See section 3.2 for duct sealing requirements.

6.3 System Air Flow

6.3.1 All existing ductwork shall be inspected by the HVAC Contractor for conditions which will affect the efficiency or proper operation of the new heat pump system. It

is the Participating Installer's responsibility to ensure existing ductwork is compatible with the equipment that is installed.

6.3.2 The air distribution system design and installation shall be such that air flow across the indoor coil is as specified in the heat pump manufacturer's literature, or is between 350 and 425 cubic feet per minute (CFM) per 12000 BTU/hr output at ARI rating conditions if the manufacturer's literature is not specific.

6.3.3 After installation and start-up, total airflow in the heat pump mode (in cubic feet per minute, or CFM) across the heat pump coil shall be measured using a TrueFlow plate or using duct pressurization fan matching method per plate or fan manufacturer's instructions. This shall be reported to the RTF approved PTCS Service Provider using the "PTCS Heat Pump Startup Form".

6.3.4 The total external static pressure acting on the system air handler shall be tested with approved instruments and recorded at time of startup and submitted to the RTF approved PTCS Service Provider using the "PTCS Heat Pump Startup Form". A measured external static pressure of more than 0.8" (200 Pa) should cause installer to consider taking corrective measures with system ductwork.

7.0 FILTERS

7.1 Location

Air filters shall be installed in the return air system in a location that will be easily accessible to the user for filter servicing and in a position where all return air and outside air will pass through the filters before crossing the indoor coil. Filters should not be installed in crawl spaces or attics.

7.2 Type and Size

Filter types and sizes shall meet the standard manufacturer's instructions and recommendations. Filters and/or air cleaners that are not an intregal part of the equipment and selected by the manufacturer shall be accepted if the total CFM is within the range as specified by the manufactuer. Any filter that exceeds 0.22 inches pressure drop as installed shall not be allowed.

8.0 REFRIGERANT PIPING

8.1 Materials

Field-supplied refrigerant piping shall be clean, dehydrated, and sealed Types K and L seamless copper tubing or the manufacturer's pre-charged tubing. Fittings shall be wrought copper. Field supplied tubing shall be evacuated to 500 microns and purged and pressure tested as per manufacturer's recommendation; soft solders shall not be permitted.

8.2 Sizing

To maintain oil return to the compressor and avoid inefficiency and capacity loss, refrigeration piping or refrigeration line set shall be sized and installed in accordance with the manufacturer's instructions and recommendations. Piping between the two sections of split units shall not exceed the manufacturer's maximum recommended length, horizontally or vertically, and shall be run parallel to building lines and in a straight and workmanlike manner to prevent oil traps.

8.3 Support

Refrigerant piping shall be properly supported in accordance with manufacturer's specifications, ARI, and IMC (International Mechanical Code).

8.4 Penetrations

Refrigerant piping passing through openings in the unit cabinet or the building structure shall be installed to prevent wear or sound generation due to contact with the cabinet or building structure. All penetrations shall be properly sealed.

8.5 Insulation

Suction lines shall be insulated with a minimum of 1/2” thick continuous closed-cell foam rubber. Where insulation is exposed to the elements, it should have a weatherproof covering. Vapor and liquid lines shall be separated so that heat exchange does not take place. Factory insulated pre-charged lines will be accepted.

8.6 Exposed Piping

All refrigerant piping exposed to possible damage from foot traffic around or near an outdoor unit shall be protected or buried in PVC or other corrosion-resistant pipe, in accordance with the manufacturer's instructions, to prevent damage to piping or pipe insulation or injury to people, and to permit replacement if necessary.

8.7 Leak Testing, Evacuation, and Charging

Factory, as well as field joints, shall be checked and any leaks found shall be repaired. Evacuation and charging shall be done in accordance with the manufacturer's instructions and recommendations.

9.0 CONDENSATE PIPING

9.1 Manufacturer's Recommendations

Condensate drain piping shall meet IMC and should be copper, plastic, or other corrosion-resistant material.

9.2 Drains

Condensate drain lines shall be trapped and run to an open drain or outside of the building foundation. Under no circumstances may condensate be drained into a crawl space or direct connected into a sewer line. When indoor units are located in attics, the installation should

include a secondary drain pain to collect condensate when a problem exists in the primary drain line. The secondary drain pan should be connected to a drain line that will drip at a location that will draw attention to the problem in the primary drain line.

9.3 Condensate Pump

Condensate drain lines shall be pitched in the direction of flow to prevent backup of overflow of water in the drain pan. If the indoor unit is lower than the floor drain or dry well, a condensate pump shall be installed to pump condensate to the level of the drain or dry well. An automatic control to shut down system in case of pump failure should be installed. A check valve shall be installed if pump is not equipped with one.

10.0 ELECTRICAL

10.1 Field Wiring

All field wiring, line and low-voltage, shall comply with the manufacturer's recommendations, the National Electrical Code, and all local codes and ordinances.

11.0 INDOOR THERMOSTATS

11.1 Installation

Indoor thermostats shall be located and installed according to the manufacturer's instructions and recommendations. Thermostats generally are installed 5 feet off the floor on an inside wall in the return airflow pattern, and where they are not in the sun or any other heat source at any time.

11.2 Auxiliary Heat Indicator

Thermostat shall provide a visible indication when the auxiliary stage or emergency heat are operating.

11.3 Heating and Cooling

Thermostats used for both heating and cooling shall have a manual changeover feature or heating/cooling lockout to prevent cross-cycling between heating and cooling.

11.4 Emergency Heat Relay

All indoor thermostats shall include a manual selector switch to permit all supplemental heaters or the furnace to be energized under control of the indoor thermostat (with the compressor and outdoor thermostats bypassed).

12.0 ADD-ON HEAT PUMP TO GAS, PROPANE OR OIL FURNACE

12.1 Indoor Coil

For an add-on heat pump, the indoor coil shall be installed in the downstream air from the heat exchanger according to the International Mechanical Code.

12.2 Furnace Operation

The furnace shall lock out the heat pump when it operates on second-stage heat, unless heat pump manufacturer's special add-on heat pump control permits operation of both.

12.3 Emergency Heat Operation

Emergency heat switch shall activate the furnace and bypass the heat pump.

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