PTCS Heat Pump Commissioning Trainee Manual

Updated December 2022

Training Presented by:



Trainer Email: Trainer Phone: PTCS Program Staff: <u>ResHVAC@bpa.gov</u> or 1.800.941.3867 Welcome to your PTCS Heat Pump Training! This training is designed to prepare you for installing and commissioning air source heat pumps to PTCS specifications. We encourage you to use this manual in the field for reference. The in-class quiz, Certified Technician Application, equipment discount form, optional handwritten form, and class evaluation included at the end.

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Performance Tested Comfort Systems® Air Source Heat Pump Technical Specification

The Regional Technical Forum (RTF) provides guidance on installation specifications and the Bonneville Power Administration (BPA) determines when to adopt their specifications. Individual utilities may have additional requirements. Please check with your local utility for more information.

For more information on the RTF and the development of program specifications, please contact the Residential HVAC team by calling (800) 941-3867 or emailing ResHVAC@bpa.gov.



PTCS Air Source Heat Pump Installation Specification

1. Equipment Selection and Sizing

The new Air-Conditioning, Heating, and Refrigeration Institute (AHRI) rated air source heat pump (ASHP) and variable speed heat pump (VSHP) must meet the minimum efficiency requirements of at least 9.0 HSPF or 7.6 HSPF2, and 14 SEER or 13.4 SEER2 for PTCS projects. For Commissioning, Controls, and Sizing ASHP and VSHP projects (I.e. Heat pumps below 9.0 HSPF or 7.6 HSPF2), they must meet the federal minimum efficiency standards. The system must be sized using a balance point of 30°F or less. A 70°F indoor design temperature for heating and 75°F for cooling load calculations using ASHRAE winter design temperature and cooling design temperature for the nearest weather station representative of the installation shall be used.

The method for calculating heating and cooling loads shall be consistent with or equivalent to ACCA Manual J 8th edition, or newer. Alternate computer or manual methods of calculating heating and cooling loads may be used if approved in advance by the utility.

2. External Static Pressure

The total external static pressure acting on the system air handler must not exceed 0.8 inches of water (200 Pa).

VSHP Requirement Only – External Static Pressure: Must be as specified in the heat pump manufacturer's documentation.

3. Air Flow

Air flow across the indoor coil must be as specified in the heat pump manufacturer's documentation, or at least 325 to no more than 500 cubic feet per minute (CFM) per 12,000 Btu/hr output at AHRI rating conditions if the manufacturer's documentation is not specific. Approved measurement methods are;

- a. TrueFlow plate
- b. External static pressure CFM manufacturer lookup table
- c. Duct Blaster pressurization fan matching

VSHP Requirement Only – Air Flow: Must be as specified in the heat pump manufacturer's documentation. Does not need to be measured using methods a, b, or c above.

4. Refrigerant Charge

- a. Heating. If the outdoor temperature is 65°F or less, test in heating mode after operating the heat pump for a recommended 15 minutes, if not specified by manufacturer, with auxiliary back-up heat off. Temperature change across the air handler indoor coil must be at or above the minimum temperature split shown in the R-410A Temperature Split Table (https://www.bpa.gov/EE/Sectors/Residential/Documents/HP_Temp_Split_Table.pdf).
- b. Cooling. If the outdoor temperature is greater than 65°F, test in cooling mode after operating the heat pump for a recommended 15 minutes if not specified by manufacturer. The subcooling (liquid saturation temp.. liquid line temp.) must meet manufacturer's documented requirements. See R-410A Pressure-temperature chart (<u>https://www.bpa.gov/EE/Sectors/Residential/Documents/R-410A_Pressure_Temperature_Chart.pdf</u>) for liquid line pressures and corresponding temperatures.

VSHP Requirement Only – Refrigerant Charge: Must be as specified in the heat pump manufacturer's documentation. Does not need to be measured using methods a or b above.

Other alternative refrigerant measuring methods approved and documented by the manufacturer are also acceptable.

5. Controls

a. Auxiliary Heat Control. Auxiliary heat must be controlled in such a manner that it does not engage when the outdoor air temperature is above 35°F, except when supplemental heating is required during a defrost cycle or when emergency heating is required during a refrigeration cycle failure.

PTCS ASHP Installation Best Practices

The program <u>recommends</u> but does not require the following as Air Source Heat Pump installation best practices:

- Check with the local utility about any requirements they may have about sizing auxiliary heat.
- Make sure openings in the unit cabinet or building structure are properly sealed.
- Sizing

- If a house (de)pressurization test has not been performed, use a default infiltration rate of:
 - 0.8 air changes per hour (ACH) for homes built before 1980,
 - 0.5 ACH for homes built between 1980 1990,
 - 0.35 ACH for homes built after 1990,
- o If a duct pressurization test has not been performed, use a default duct system loss of:
 - Up to 25% if ducts are insulated and fully located in the attic and/or crawlspace.
 - Up to 15% if ducts are insulated, sealed, and fully located in the attic and/or crawlspace
 - If the air handler and all ductwork are within the thermal envelope of the house, use 0%.
 - Use a value between 0% 25% if some ducts are inside conditioned space
 - Use window U-Values provided below if NFRC values are not available:
 - Double-Pane Vinyl: 0.30 0.40
 - Double-Pane Wood: 0.35 0.55
 - Double-Pane Metal: 0.60 0.70
 - Single-Pane Wood: 0.80 0.95
- o Include basements as conditioned space in sizing calculations in most cases
- For dual fuel systems (gas backed up heat pumps), a switchover point of 35°F 40°F should be used.

5. Measure Plate Pressure



- **6.** Enter Raw Flow CFM; refer to plate pressure and plate size (based on H20 or Pascal) on Flow Conversion table to locate Raw Flow
- Calculate Corrected Flow (CFM=Correction Factor x Raw Flow CFM)
- 8. Calculate CFM/ton (CFM/ unit tonnage)
- 9. Enter data in PTCS registry

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Perform Refrigerant Charge

Check. Run in heating mode if outdoor temperature is <65°F and run in cooling mode if >65°F.

- Run unit for at least 15 minutes in compressor-only mode
- 2. Take Readings
- **3.** Enter data in PTCS registry



Verify Control Settings; Strip Heat = 35°, Thermostat Make/ Model, multiple capacity compressor (Y/N) and enter data in PTCS Registry.



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Enter all data onto mobile device or computer at ptcs.bpa.gov using the certified technician's account.

Submit the Registry Installation Report and additional required documents to the customer utility. Check with utility if the PTCS Air Source Heat Pump Form is required.

		14.022	⊙ a		
		PTCS Heat Pt	Imp #1786054		
		Heat	Pump		
1	AHRI Number:	7161547	Outdoor Unit Model: HL88024F4		
1	Outdoor Unit Make:	LUXAIRE BY JOHNSON	Indoor Unit Model: C(A,C,D,E)		
	Outdoor Linit Canacity	2	30C44+MV12 Mast Pump Stanalsk: Non Variable	2D+TDR Sneed	
	,		Balance Point: 30	.,	· ·
	SEER:	18.0000	HSPF: 10.4000		
	EER:	13.8000			
			-		
	All bosts in Test Onbel	Truers	iw rest		
	Check Charge Mode:	Yes	Return Static Pressure: 100		
	Unit Tested In:	Pa	Supply Static Pressure: 100		
	Plate:	20	Ext. Static Pressure: 200		
	Plate Pressure:	30	NSOP: 100		
	CFM / Ton:	421.75	TFSOP: 100		
	Plate Location:	Air Handler			
		Perform	nce Test	1000	
	Outside Ambient Temp:	35			
	Mode Tested:	Heating			
A second second					
	Discharge Pressure:		10000		
and the second s	Liquid Line Temp:				
	Supply Temp:	97	Return Temp: 79		
		Con	trols		
	Low Ambient Lockout:	No	Aux Heat Temp: Belo		
	Thermostat Make:	sikdljodid	Thermostat Model: sikdif		
	Multiple Capacity	No			1
A State of State	Compressor System:				(
		Technici	an Notes		
	This is a test.				
		Gr-	hur		Section of the
	Date	Status Undated By	Status		
	4/8/2018 5/26 PM	aturie	PPA Account		
	5/4/2017 12-30 PM	anterico.	Rejected		11172
	5/4/2017 12-28 PM	adurka	in Promess	100000000000000000000000000000000000000	11/22
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11111111110					



Contact PTCS at ResHVAC@bpa.gov or 1.800.941.3867

How To: PTCS Test for a Ducted Air Source Heat Pump



COMPANY 6 LOGO

UTILITY NAME UTILITY PHONE UTILITY ADDRESS LINE 1 UTILITY ADDRESS LINE 2 UTILITY WEBSITE

Instructions continued on next page...

Install the Heat Pump





Enter Site Information and Heat Pump Equipment Data at ptcs.bpa.gov using the certified account login while performing the tests.





Perform External Static Pressure Test*

1. Measure Return Static Pressure (after the filter)



2. Measure Supply Plenum Static Pressure



- Calculate External Static Pressure (Return Static Pressure + Supply Static Pressure)
- 4. Enter data in PTCS registry





Perform TrueFlow Test**

1. Measure Normal System Operating Pressure (NSOP)



2. Check TrueFlow Plate Size and Location



3. Measure True Flow System Operating Pressure (TFSOP)



4. Calculate Correction Factor (from table or the $\sqrt{NSOP/TFSOP}$)

**See www.energyconservatory.com for Digital True Flow instructions or see Estimating Airflow Using Static Pressure Measurements & Flow Tables method at ptcs.bpa.gov/SupportMaterials.aspx. See program specifications for variable speed systems.

*Refer to the registry entry screen or installation form for detailed instructions. See program specifications for variable speed systems.

Estimating Airflow Using Static Pressure Measurements & Flow Tables

Using Static Pressure to Measure Airflow

- Static pressure measurements can be used with manufacturer fan tables to estimate airflow. Proper airflow and fan settings can ensure comfort and energy efficiency, and may extend the life of the heat pump.
- Use of a flow plate is the preferred method to determine airflow; however, the external static pressure-airflow lookup table approach is also approved by PTCS.

Proper Pressure Tap Placement

- Most manufacturer fan tables note testing return static pressure between the filter and air handler, and supply static pressure in the supply plenum with enough distance to avoid turbulence.
- PTCS requires the return static pressure to be measured downstream from the coil when reporting external static pressure. If the manufacturer specifies drilling upstream of the filter and notes a pressure drop for the filter, be careful as this drop is often lower than the filter you're using. Contact your filter manufacturer for applicable pressure-drop data.
- A static pressure probe is required for external static pressure measurements. Taking
 pressure measurements without a static pressure probe will give non-valid results.

Identifying Airflow

 Using the information in the table below, if you have a blower motor speed at medium and an external static pressure of 0.40, the total airflow is 1175 CFM. If you have a 3-ton heat pump attached to the air handler, this would be close to the optimal airflow of 400 CFM/ton (1175 CFM/3 tons = 392 CFM/ton).

Additional Tips

- If your readings seem higher or lower than expected, take static pressure measurements at another location or on another side of the plenum, ensure your probe is past any duct liner or use a longer static pressure probe.
- Many systems are rated with a dry coil. If you are taking static pressure measurements with a wet coil, your airflow may be lower than shown in the fan table.
- PTCS allows external static pressures up to 0.8 inches of water column or 200 pascals. Most manufacturers suggest 0.5 inches of water column (125 pascals) or less.

Example of a Manufacturer-Provided External Static Pressure-Airflow Lookup Table (showing total CFM at intersection)

Blower Motor	External Static Pressure (Inches of Water Column)								
Speed Setting	0.10	0.20	0.30	0.40	0.50	0.60	0.70		
High	1606	1566	1524	1480	1450	1412	1376		
Medium-high	1511	1467	1430	1387	1353	1309	1274		
Medium	1300	1250	1210	1175	1134	1078	1009		
Medium-low	1104	1060	1029	987	912	841	784		
Low	913	886	832	765	694	569	530		



Contact PTCS at ResHVAC@bpa.gov or 1.800.941.3867



Steps to Measure Airflow Using External Static Pressure Measurements

Fig. 1

Drill hole at appropriate location and measure return static pressure with static pressure probe pointing into the airflow. Avoid drilling into cabinet.





Blov

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Spe Sett

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Medium

Medium-lov

Low

Mediur



CONFIG

Fig. 2

Drill hole at appropriate location and measure supply static pressure with static pressure probe pointing into the airflow.





- **2.** Measure supply plenum static pressure (0.34 inches of water column in this example). (See Fig. 2)
- **3.** Calculate external static pressure (return static pressure + supply static pressure; 0.28 + 0.34 = 0.62 inches of water column in this example).
- **4.** Round the external static pressure to the nearest pressure in the manufacturer's table (0.62 rounds to 0.60 in this example).
- Find where the external static pressure and blower speed settings intersect on the manufacturer's airflow table, 1078 CFM (shown on the table).
- Confirm the CFM/ton meets PTCS specification of 325–500 CFM/ton or manufacturer specified airflow requirements. Example: This is an airflow of 359 CFM/ton if this is a 3-ton heat pump, meeting PTCS specifications.
- **7.** If the airflow does not meet PTCS specifications or manufacturer specified airflow requirements, change the speed setting and restart the process at step 1.

DEVICE UNITS CONFIG MODE CLEAR TIME AVG									
ver tor		E: (In	xternal iches o	Static I f Water	Pressur Colum	e n)			
ing	0.10	0.20	0.30	0.40	0.50	0.60	0.70		
gh	1606	1566	1524	1480	1450	1412	1376		
n-high	1511	1467	1430	1387	1353	1309	1274		

DEVICE

	1300	1230	1210	1175	1134	1076	1009
V	1104	1060	1029	987	912	841	784
	913	886	832	765	694	569	530

1000 1050 1010 1175 110

Contact PTCS at ResHVAC@bpa.gov or 1.800.941.3867



Equipment Discounts

A discount is available to PTCS Technicians to purchase TrueFlow testing equipment. The discount form is included at the end of this manual.

- > 12.5% discount for The Energy Conservatory
- > 8% discount for TruTech

Submit this form to **Eli Caudill** at CLEAResult for processing: Eli.Caudill@clearesult.com. He can also be reached at **503.248.4636** with questions.

	RY CLEAResult						
Performance Tested Comfort Systems (PTCS) Equipment Discount List							
In partnership with CLEAResult Consulting, Inc., the Energy Conservatory is pleased to extend the following discounds to Verifiers/Raters and Rating Field Inspectors partnicipating in the Performance Tested Comfort Systems (PTCS) program. Please send completed forms by email to: Eli Caudil@clearesult.com							
Billing Address:	Shipping Address (if different than Billing Address):						
Billing Address: Contact Name:	Shipping Address (if different than Billing Address): Contact Name:						
Billing Address: Contact Name: Company Name:	Shipping Address (if different than Billing Address): Contact Name: Company Name:						
Billing Address: Contact Name: Company Name: Street Address:	Shipping Address (if different than Billing Address): Contact Name: Company Name: Street Address:						
Billing Address: Contact Name: Company Name: Street Address: City, State, Zip:	Shipping Address (if different than Billing Address): Contact Name: Conpany Name: Street Address: City, State, Zip;						

Required Documentation

The installation data can be entered in the field on a mobile device with internet access. An optional form is available for use when no internet or mobile device is accessible. The customer's utility may provide their own incentive forms at their discretion and may require additional paperwork. Please contact them for more information.

The following forms/documents are required by BPA for air source heat pumps.

- ✓ Registry Installation Report
- ✓ Documentation of sizing
 - Both heat load/heat loss calculations and a "Balance Point Worksheet", OR "PTCS Heat Pump and Central Air Conditioner Sizing Calculator"
- ✓ Equipment/Contractor Invoice
- ✓ Ground Source Heat Pumps: Handwritten form required

Registry Installation Report

Report found online on https://ptcs.bpa.gov.

To access:

- 1. Sign in using installing technician's or company admin's account
- 2. Search for job
- 3. Click on measure ID link in result

or

1. Click on the measure ID link after data entry.

This report contains all the entered data and electronic acknowledgement.

			PTCS Heat	t Pump #1786054
		AHPI Numbe	r: 7161547	Outdoor Unit Model: HI 88024E4
		Outdoor Unit Mak	CONTROLS	50N Indoor Unit Model: C(A,C,D,E) 30C44+MV12D+TDR
		Outdoor Unit Capacit	ty: 2	Heat Pump Stage(s): Non Variable Speed
			la l	Balance Point: 30
DTOD US A	#1700054		t: 18.0000	HSPF: 10.4000
PICS Heat P	ump #1786054		13.8000	
Site	Owner Address		Tru	JeFlow Test
999 TEST AVENUE	999 TEST AVENUE		V. Yas	Dature Statis Deserves 100
Portland, OR 99999	Portland, OR 99999		At Pa	Supply Static Pressure: 100
			* 20	Ext Static Pressure: 200
Si	e Info		1 20	NEOP: 100
Heated Area	2000		401.75	TECOP: 100
House Type	EXIST		to 421.75	TFBOF: 100
Existing Heating System Type Being Replaced	Electric Forced Air	r w/out AC	a: Air Handler	
Foundation Type	Crawlspa	ce	Perf	ormance Test
Backup Heat System Type	None		»: 35	
Country front of stores () by			s: Heating	
	Leftile -			
	unty			
Electricity	Rocky Mountain	n Power		
			. 07	Poturo Temp: 70
				Controls
Tec	hnician			Controls
Technician Name: Burke. Amy			E NO	Aux near remp: Below 35 Degrees
PTCS ID: 10458			at sikarjsakt	i nermostat model: sikd/fksdf
Co	mpany		¥ NO	
Company: Borneville Power Admir	istration			
Portland OP			Tech	nician Notes
Forsano, OR	asuro			
Service Date: 5/1/2017				Status
Entered Date: 4/9/2018			e Status Updated By	Status
Citeres Care, 413/2010			Maaburke	BPA Approved
Proces	sing Notes		Pagedand	Acknowlednement
Date Entered By	Note		Required	or entering data on baball of the certified technicie
4/9/2018 aaburke	Measure status changed to 'B	PA Approved' through	following:	or ensering case on penalt of the certified technicia
and the second se	PTCS website by aaburke		accompanying docum	nentation are complete and accurate.
			fressed in the require	ty Assurance (WA) inspection and any necessary d timeframe.
			ged this: Certified Tech	hnician
			shnician: Burke, Amy	
			Igement: 4/9/2018	

Optional Air Source Heat Pump Installation Form

If no internet or mobile device is available or the job cannot be entered online for any reason, this form is available to record the data for later entry online. This form is aligned with the online data entry screen.

The forms can be downloaded from the "Heat Pump" section of the PTCS website at any time: www.bpa.gov/goto/reshvac.

			Refrigera	nt Charge	Check			Run unit for i	t least 1	i mini	stes in compressor-only mode before taking reading
			Outside Air 1	lamp		og	Mode u	sit tested in: 🗌 He	rting (if s	65°)) Cooling (if > 65°F)
COMFORT S	YSTEMS"					L	ist Upda	ted April 2018	55°F)		Alternative Test Method
42											Specify method used
	PTCS® Air	Sourc	e Heat Purr	p Form	(optio	inal)					Target
L) Enter all data on a	mobile device or co	mputer	at <u>ptcs.bpa.gov</u> u	ising the cert	tified teo	chnician's	account	. This optional			Test result
Customers of 8	ut for later entry or onneville Power Adm	inistratio	ues entering data n (8PA) utilities: en	r Submit this nail <u>ResHVAC</u>	Storm to Sbpa.go	g, fax to 1.	177,848.	1074, or call			Meets specification?
Customers of P	GE or Pacific Power a	mail Resi	identialforms@ene	revtorst ore o	roll18	66 365 35	16				
2) Submit the Registry Installation Report (found online) and additional required documents to the customer utility. Unless requested by the utility, submission of this form is not required.								Auxiliary (strip) heat lockout has been set to:			
Site Information	Tech		Install		Flectric						
Tech # Nam			Date		Utility						and an
Installation Site Address			Site			Site		Site	et no	high-	rr than 85 °F or, mate at termeratures above 35 °F, or
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rome opper		eraction an			coores [
Natural Gas Furnace (Gr Back up Heat: None	is Company:	Dectric 2	ional 🗌 Natural Ga	Non-Electric Sp Furnace	Non-Elect	ing:	ating		L		
Auto +	SEER	•	HSPI*		Out	Ideor HP		jor requirements.			
Heat Pump	Outdoor HP				Cap	Non Variab	e Speed	1P Compressor			
Make	Model #				0	Variable Sp	eed HP C	empressor			
	Indeer HP Model #				Bab Pro	ance Point vide BP do	umentaci	on to utility.			
Did yo	a perform all of your	tests in 1	Test Only/Check C	harge mode?	Yes	No No	N/A				
External Static Pres	ssure Test		0	eck unit operati	ing et full i	capecity un	ess condi	ions do not permit.			
1. Measure return static pr	essure	1. Return	n Static Pressure		Unit	ts: Use age	re units fi	e Trueflow test			
 measure supply plenum Calculate external static 	static pressure	2. Sunni	V Static Pressure		-	ra 🛄 ind	ies H2O	-			
in #1 and #2 values; ignore	the minus sign				1						
TrueFlow Test											
1. Measure NSOP (Normal	System Operating Press	re) [A]	1. NSOP [A]	Za. Pist	te Size:	2b. Piste	location				
2. Check TrueFlow plate siz 3. Manuara TESOP (Supply)	reard location	Inter Links	a trisce (R)	14	20 ection Fac	Ter ICI fro	n table	Return Grille			
4. Calculate Correction Fac	tor [C]		a. 17907 (0)	er calco	state VIIA	(/1e1)					
5. Measure plate pressure			5. Plate Pressure	6. Raw	Flow CFM		_		11		
6. Enter Raw Flow CFM fro	m tables (0)			from ta	ibles [D]						
7. Calculate Corrected Flow 8. Calculate CFM/ton			7. Corrected Flow CFM = [C] x [D]			8. CFM/	on				
		_	Page 1 of 2								

Program Requirements for Performance Tested Comfort Systems[®] and Prescriptive Duct Sealing

Introduction

This document sets forth the minimum program requirements for trainers and trainings, technicians and installations, and quality assurance (QA) delivered in connection with the Performance Tested Comfort Systems[®] (PTCS) Program and the Prescriptive Duct Sealing measures. For Bonneville Power Administration (BPA) utilities, the program requirements outlined here replace the PTCS Provider Standards issued by the Regional Technical Forum.

- 1. Trainer Requirements
- 2. Technician Requirements
- 3. Quality Assurance Requirements

1. Trainer Requirements

- **1.1. Minimum Trainer Qualifications** Trainers shall meet all requirements for technician certification and meet the following minimum standards:
 - **1.1.1. PTCS Heat Pump Commissioning Trainers** shall have a minimum two (2) years verifiable full time experience installing or inspecting the following: testing heat pump auxiliary heat controls, indoor coil airflow, sizing and refrigerant charge. Applicants' projects will be reviewed and possibly inspected for accuracy and pass rate.
 - **1.1.2. PTCS Duct Sealing Trainers** shall have a minimum two (2) years verifiable full time experience installing or inspecting the following: duct system testing, diagnostics, repair, and sealing in site built and manufactured homes. Applicant's projects will be reviewed and possibly inspected for accuracy and pass rate.
 - **1.1.3.** Maintain an acceptable history of delivered training quality, at the discretion of the BPA program manager.
 - **1.1.4.** Trainers shall have training and/or teaching experience that is supported with a reference who can attest to teaching effectiveness. This must be for teaching activities that have happened in the last two years. If current trainers or applicants do not have this experience, they may conduct two trainings that may be observed, evaluated, or coached to monitor for teaching effectiveness.
 - **1.1.5.** The program will have a yearly renewal requirement (I.e. attend the annual Train-the-Trainer training session provided by BPA) that will allow for new program information to be passed from the program to trainers.
 - **1.1.6.** Heat Pump trainers are not required, but are encouraged to have industry certifications such as NATE or BPI.
 - **1.1.7.** Trainers will be asked to provide information about their background of working with energy efficiency.
 - **1.1.8.** Provisional approval is granted upon application submittal that meets these requirements. Full approval is granted following provisional approval and upon a BPA-approved PTCS certified trainer observing a training.
- **1.2. Training Requirements** Trainers may certify a technician in PTCS or Prescriptive Duct Sealing only if the trainee has scored not less than 80% on a BPA-provided written test and meets all other requirements for the specific training, as listed in the following sub-sections. The trainee will be able to operate necessary equipment, complete program installation form(s) and understand program QA requirements.
 - **1.2.1. PTCS Heat Pump and Duct Sealing Trainings** Trainers must conduct at least two trainings per year. Trainings must utilize PTCS program provided presentations and collateral. Trainers must offer a PTCS program provided evaluation to trainees at the conclusion of the training and will submit evaluations to the PTCS program.



- **1.2.2. PTCS Heat Pump Trainings** shall prepare the trainee to demonstrate understanding of auxiliary heat control requirements, airflow testing using approved methods, sizing, and refrigerant charge methods. The training must include hands-on experience, and all trainees must demonstrate their skills to pass the class.
- **1.2.3. PTCS Duct Sealing Trainings** shall prepare the trainee to demonstrate competency in duct system testing, diagnostics, repair, and sealing in site built and manufactured homes; capture and record required CFM duct leakage measurements; conduct a total duct leakage test; and conduct a duct leakage to outside test.
- **1.2.4.** Trainers shall provide student with dated proof of training completion after the students have demonstrated mastery of the subject.
- **1.2.5.** Trainers will confirm an individual's training completion status to BPA and/or BPA utilities upon request.

2. Technician Requirements

- **2.1.** Technician shall submit dated proof of training completion for the measures they install. In addition to PTCS or Prescriptive Certifications from BPA-approved trainers, additional acceptable trainings are listed below.
 - 2.1.1. PTCS Heat Pump alternatives: BPI®AC and Heat Pump Professional, NATE® Heat Pump Service Certification, CheckMe!, a two year vocational degree in Air Source Heat Pump installations, or a verifiable apprenticeship with a BPA-approved technician lasting a minimum of 2 years. To receive alternative certification a technician must complete the following steps:
 - o receive alternative certification a technician must complete the following steps:
 - 1) Watch the flow plate instruction and heat pump sizing videos on the BPA YouTube Channel page:
 - <u>https://www.youtube.com/watch?v=iKOakSgQPm8&t=4s</u>
 - https://www.youtube.com/watch?v=yrmN3ZuAv90
 - https://www.youtube.com/watch?v=yc4H9vnbHhs&t=3s
 - https://www.youtube.com/watch?v=vVoCDs3rkC0
 - 2) Complete the PTCS Heat Pump Admin/Sales class on the PTCS Learning Management Site:
 - https://clearesult.moodle.school/login/index.php
 - 3) Quick call with a PTCS Trainer to go over any other details (ESP probe locations, TrueFlow[®] Air handler Flow Meter, etc.). Regardless of certification type, technician shall be trained to use a TrueFlow[®] Air Handler Flow Meter.
 - 2.1.2. PTCS Ground Source Heat Pumps require a heat pump credential identified in 2.3.1, and an International Ground Source Heat Pump Association (IGSHPA) certification. Ground Source Heat Pumps may be installed by both a PTCS Heat Pump technician and an IGSHPA certified technician or one technician certified in both.
 - 2.1.3. PTCS and Prescriptive Duct Sealing training alternatives: <u>Please see the Prescriptive Duct Sealing Program</u> <u>Requirements</u>. A certified PTCS Trainer can approve a technician for PTCS Duct Sealing certification if the technician demonstrates adequate experience and knowledge required to certify duct sealing to meet Prescriptive and PTCS standards. Technicians seeking to PTCS certify duct sealing shall have been trained to test duct leakage according to PTCS standards.
- 2.2. Technicians who attend a PTCS Duct Sealing training will also be certified for Prescriptive Duct Sealing. Technicians can complete the online <u>Prescriptive Duct Seal Certification Training</u> to be certified for only Prescriptive Duct Sealing.
- **2.3.** Technicians must create an account on the PTCS Online Registry at <u>https://ptcs.bpa.gov</u>, and enter projects there. Projects must be approved in Registry before incentives can be paid.
- **2.4.** Technicians must complete, sign, and submit the Certified Technician Application to BPA and be approved prior to installing heat pump or duct sealing measures. Technicians will be ineligible to do work or access the online



- **2.5.** registry until the application has been approved.
- **2.6.** Technicians are responsible for maintaining current knowledge of technical standards and program requirements. BPA offers technicians annual continuing education classes for this purpose, and technicians are strongly encouraged to attend.
- **2.7.** New PTCS Heat Pump technicians shall inform the PTCS program of the first three projects to be input into the registry for quality assurance inspections of installations through video or photo review. Technicians with high quality assurance inspection failure rates will be subject to increased quality assurance inspections.
- **2.8.** Technicians shall respond promptly and correctly to data input issues and QA inspections. Technicians are required to correct errors identified during the QA inspection within 10 business days of notification. Failure to do so may result in disqualification from BPA programs.

3. Quality Assurance (QA) Requirements

- **3.1.** Heat Pump QA Inspectors shall have documented experience commissioning and/or co-commissioning a minimumof 10 certified systems, and possess current PTCS certification (or other approved certification). Utility employees may request an opportunity to demonstrate testing skills to BPA as a substitute. Heat Pump QA Inspectors shall participate in BPA's annual PTCS continuing education or PTCS refresher webinars to stay on top of program specs and issues. BPA reserves the right to consider other performance issues, in addition to QA performance.
- **3.2.** Duct System QA Inspectors shall have documented experience testing and/or co-testing a minimum of 10 systems and possess current certification (or other approved alternative). Utility employees may request an opportunity to demonstrate testing skills to BPA as a subsitute. Duct system QA Inspectors shall participate in BPA's annual PTCS continuing education or PTCS refresher webinars to stay on top of program specs and issues. BPA reserves the right to consider other performance issues, in addition to QA performance.
- **3.3.** New QA inspectors must <u>submit an application</u> and be approved by the program prior to performing inspections.
- **3.4.** Certified inspectors may not conduct QA inspections in a territory where they install PTCS or prescriptive duct sealing measures.
- **3.5.** Utilities may request reimbursement from BPA for inspections they conduct by submitting a Letter of Interest. The Letter of Interest and submittal instructions are available by request to the BPA program manager.
- **3.6.** Only QA inspections performed by a BPA-approved QA inspector shall be entered in the online registry. BPA will coordinate efforts to achieve a QA rate of approximately 10% of all projects per program year.
- **3.7.** Inspectors shall use BPA Quality Assurance Inspection Forms to collect inspection data and determine whether a site has passed or failed inspection. Inspectors shall record these results in the PTCS online registry.
- **3.8.** The QA inspector has the responsibility to: (1) fail any system that he/she finds does not meet installation specifications adopted by BPA at the time of installation; (2) report that failure to the BPA program manager, utility and technician; (3) identify corrective actions required to bring substandard systems up to measure specifications; (4) support BPA audits of prior QA inspections as requested.
- **3.9.** *Timeliness:* For QA to be most effective, an inspection should be done within 90 days or, in new homes, before owner occupies the home.
- **3.10.** Repeated failures will lead to additional training requirements or other measures to improve technician performance. Failure to improve performance may lead to technician removal from the program.



3.11. Duct Sealing Inspections shall be designated as passing according to these requirements:

- **3.11.1.** A visual inspection shows that high pressure areas have been sealed (air handler, supply, plenum, and take-offs). Physical items to check: UL-181 Mastic is applied according to manufacturer's specifications, straps are used if needed, no ducts are disconnected, no tape is used on the system except UL 181 tape on the access coveronly, and a CO detector is installed in homes with combustion air zones.
- **3.11.2.** In addition to the visual inspection, PTCS duct sealing jobs shall not have duct leakage (CFM) exceeding 120% of the program requirements,
- **3.11.3.** "Fail" if it does not meet any of the applicable inspection criteria. The technician must return to the jobsite and perform the required corrections.
- **3.11.4.** Duct Accessibility: The following guidelines can be used to determine if a portion of a duct system is accessible or not. Accessible ducts do not require drywall patching, are within reasonable reach by an average person, and do not require destruction of duct insulation. Technicians may consider pressure boundary manipulation (bringing ducts within pressure boundaries of the house) as an alternative to sealing difficult to reach ducts.
- **3.12.** Heat Pump Inspections shall be designated as passing according to these requirements:

3.12.1. Equipment – meets program-required 9.0 HSPF and 14 SEER or 7.6 HSPF2 and 13.4 SEER2 requirements for PTCS measures and federal minimum standard for commissioning, controls, & sizing measures

- **3.12.2.** External Static Pressure measurement at or below 0.8 inches of water (200 Pa). See spec for a different requirement pertaining to a VSHP.
- **3.12.3.** Airflow measurement at or above 325 CFM/ton (this allows for testing equipment error rate). The CFM/ton may be lower if recommended by the heat pump manufacturer.
 - 1) For projects with an airflow value submitted using the ESP-CFM Manufacturer Table methodology, the inspector will note the airflow value using observable fan settings and available ESP-CFM tables.
 - If fan settings are not observable, airflow will be tested using a TrueFlow[®] Air Handler Flow Meter for reference purposes only.
 - 2) Airflow measurement is not required for variable speed systems, but airflow should be confirmed if performing an inspection at the time of installation.
- **3.12.4.** Auxiliary heat settings are set to only come on at or below 35°F in normal (no defrost) operation.
- **3.12.5.** Refrigerant charge: use the minimum expected temperature split method and/or verification of compliance with manufacturer requirements for line set length and ounces of refrigerant added. Minimum temperature split testing is not required for variable speed systems.
- **3.12.6.** Ensure correct heat loss calculations and proper equipment sizing.
- **3.12.7.** "Fail" if it does not meet any of the inspection criteria. Except for sizing, the technician must return to the jobsite and perform corrections to bring the system into compliance. Incorrect sizing automatically triggers a corrective action plan or review of the contractor's sizing calculations for accuracy and appropriate inputs, if approved by BPA.





Frequently Asked Questions

This document is intended to provide program specific information for utilities, PTCS certified technicians and companies about the BPA PTCS (heat pump and duct sealing) and Prescriptive duct sealing program. *Utility programs determine their own reimbursement criteria, which may include additional requirements above and beyond what BPA requires. Contractors should be aware of their customers' utility requirements before starting work.* Answers provided below may be revised if the program, BPA Implementation Manual, or PTCS specifications change.

How to Participate

How can I become a certified PTCS technician?

1. Get Trained

- PTCS Technician (heat pump and duct sealing): Attend and pass a training with a BPA-approved trainer, or show proof of completing an approved alternative training (See Program Requirements, Section 2).
- Prescriptive Duct Sealing Technician: Complete the Prescriptive Duct Sealing training, a link can be found in the Prescriptive Duct Sealing Program Requirements.

2. Create an online account on the PTCS Online Site Registry if you have not previously done so. Click on "Register" in the top right-hand corner to get started.

3. Submit completed Certified Technician Application along with dated proof of training by email to ResHVAC@bpa.gov, or fax to 1-877-848-4074.

How can I get a PTCS Technician ID?

After the technician creates an online account, the PTCS team has received the complete application, and approved the training; the team will activate the account. The PTCS Technician ID will be sent to the email on file with the account.



I have an industry certification. Can I get a certification without additional training?

We accept several industry certifications. A list of all approved alternative certifications in the PTCS Duct Sealing and Heat Pump Program Participation Requirements is available.

What if I change companies?

Submit a new Certified Technician Application with your new company information and an explanation of what was updated to ResHVAC@bpa.gov. Do not enter jobs completed with your new company before your account has been updated.

How do I update my account if I get an additional certification?

Submit a new Certified Technician Application to ResHVAC@bpa.gov and include your new certification and relevant training information.

Do I need a new online account for each new certification I obtain?

No. We will update your existing account with the additional certifications listed on your application.

If I get locked out of my account or forget my password, should I create a new account?

No. Please don't create another account since it will generate a duplicate account. Contact the customer service team by email at ResHVAC@bpa.gov or by phone at 1-800-941-3867 and we can help you get the information you need.

How do I become a trainer and/or inspector?

Start by reviewing the Program Participation Requirements, Trainer Participation Application, and Quality Assurance Inspector Application. Contact the PTCS Program if you have any questions.

PTCS Online Registry User Guide

The website can be found here: https://ptcs.bpa.gov/

The PTCS website is an online tracking tool where:

- All completed jobs are required to be entered into the online registry. Upon entry, all jobs are automatically reviewed for compliance with the specification. A status is assigned reflecting that review (status definitions are later in this section).
- > New technicians must create an account to be certified and receive their PTCS technician ID
- Utilities can view and track entered jobs in their territory
- Quality Assurance inspections are entered and tracked
- Optimized for use on mobile devices

What mobile devices can be used with the mobile PTCS site? Smartphones (Apple, Android, etc.), tablets, and other mobile devices with internet access.

Can the Mobile Site be used if some data is unavailable? Yes. Enter as much data as you can then "Save Progress" to access and complete it later.

What to do after entry? Submit the required paperwork to the customer's utility.

Technicians and office staff can search for and view reports for jobs entered into this system. Technician can enter projects they worked on. Contact the PTCS team at ResHVAC@bpa.gov or call (800) 941-3867 to request additional access to view all work entered for a company or with any questions about functionality or access.

Log In to the System/Create an Account

If you <u>have not previously created</u> an account on this website previously, click on "Register" in the top right-hand corner. If you <u>have</u> <u>previously created</u> an account on this website, click on "Login" in the top right-hand corner. If you need a login information reminder, click on "Forgot your Password?" or "Forgot your User Name?" on the Login screen.

		Login Register
	About the Program	Contact Us!
Login		
Userx		
Password:		
Keep Me Logged In		
Log In > Create a New Account		
Forget your Password? Forget your User Name?		

/

Entering an Air Source Heat Pump Online

- Log in to installing technician's account at https://ptcs.bpa.gov/
- Click on "Enter a Project" button or click on "Contractors" then "Enter a Job" from menu button.



3) Enter site address and click "Next"
Address not validating? Send form to BPA by fax to (877) 848-4074 or email to ResHVAC@bpa.gov.

- Click on the correct address. If option is not available, click "Previous" to edit accordingly or contact program staff.
- 5) Enter site details
- 6) "Existing Heat System Type":
 - New construction home: Select newly installed heating system
 - Existing home: Select heating system being replaced
- 7) Select installation type
 - Option link not available? Account certification types might not be updated. Contact the BPA PTCS team.
 - Already one entered? Search for previously entered jobs for this site and/or contact the BPA PTCS team.







8) Enter installation and commissioning information.

	Certificate Information							
	Completed Date	01/01/2017						
	Site	Data						
	NEW HEAT PUMP DATA							
	AHRI Number	6750234						
AHRI number will auto-	SEER	18.0000						
populate this information.	HSPF	10.0000						
Manually enter AHRI data	EER	13.0000						
If not recognized and	UNIT INFORMATION							
contact program staff for	Make	TRANE						
approval of pending status.	Model	4TWV8036A1						
	Capacity (Tons)	3						
	INDOOR UNIT							
	Model	*AM8C0C36V31						
	VALIDATE SYSTEM							
	Heat Pump Stage(s)	Variable Speed 🗸						
	Balance Point	25						
	Is this system correct?	Yes 🗸						

	Airflow Test					
Measurement unit type will	External Static Pressure	100				
apply to ESP and TrueFlow	Test measured in	Pa V				
Test	TRUEFLOW TEST					
	NSOP	26				
	Plate Size	20 🗸				
CFM/Ton calculated here;	TFSOP	26				
range of 325 to 500 CFM/Ton	Plate Pressure	51				
accepted.	Calculated CFM per Ton	366.59				
If CFIVI/Ton is lower than 325,	Refrigerant Charge Check					
please contact the Program for	Outside Air Temp (F)	32				
support.	Mode Tested	Heating 🗸				
••	Supply Temp	97				
	Return Temp	79				
Temperature Split and	Calculated Temperature Split	18.0				
Subcooling calculated from	Controls Setup					
R-410A tables	Is the compressor low ambient locked out control set to 5 degrees or less?	Not Installed/Disabled 💙				
	Auxiliary (strip) heat lockout has been set to:	35F 🗸				
	Indoor Thermostat Make	Honeywell				
	Indoor Thermostat Model	8000				

9) Check the Required Acknowledgment box, depending on who is entering this job.

☑ Quality Assurance (QA) inspections are conducted on PTCS jobs submitted. By checking this box you are indicating that you are aware of this requirement and that some of your jobs may be selected for inspection. You also agree to make, within a reasonable time frame, any necessary corrections to the jobs that fail to meet PTCS specifications upon inspection. *

Finish

10) Click "Finish" to complete or "Save Progress" to complete later

- Final screen: Measure ID/Job ID numbers and status listed (includes save progress feature for later measure completion)
- "Pending" jobs are reviewed weekly; contact program staff for immediate review
- Contact program staff if job needs to be rejected, corrected, or re-entered

Registry Statuses Explained: PTCS Duct Sealing

Each time a completed job is entered into the registry, it is assigned a status based on the input validation.

BPA Approved: These measures meet all of the program installation and Implementation Manual requirements and can be claimed for payment by BPA utilities.

In Progress: Incomplete saved job that is assigned a measure number for later completion

PTCS Certified Only: These measures are tested for CFM leakage and meet minimum tightness and quality installation requirements of PTCS, but did not meet the pre-test requirements for additional sealing, testing, or payment.

BPA Pending: This occurs when something in the job requires further review. The PTCS team reviews these on a weekly basis. Please contact us if you require more immediate review.

Rejected: These measures did not meet the requirements of the program.

How to Find an Entered Job

Select "Completed	elect "Completed	• Contractors	• About the Program	My Account	Conta
Jobs" from the Contractors drop down menu or by clicking "Search for Project" on the	Company Measures				
	Enter a Job	riptive Online Site Registry Id Source Heat Pumps, and Prescriptive Duct Sealing			
homepage.		Completed Jobs	Search	for Project	1
			-		

Search for	Contractor Measures My Current Job Statistics Please click on an item below to vie	ew details, or <u>cl</u>	i <u>ck here</u> to start a	a new job.		
 completed jobs using any type of criteria and click "Search". Data can also be exported into a .csv file. TIP! Search using very little. E.g. only the house number ("123" from 123 Main St.). 	Measure Installed: Measure Entered: Measure ID: Status: (Ctrl+click to select or deselect items) Address: Address Line 2:	between between Accepted Audit BPA Approved BPA Pending test	*To word type	and and broaden results, omit is (i.e. NW, Southwest s (i.e. Rd, Street)	directional) or street	
	City: Tech ID: Company Name: Measure Type: Utility: (Ctrl+click to select or deselect items)	portland (Search All) Better Air NW (Search All) Albion, City of Alder Mutual Li APS (Arizona P Ashland, City c Asotin County	(Vancouver, WA) Ight Company ower Supply) of PUD No. 1		>>> < >	Export Results
Clicking on the measure ID will result in a report you can print and provide to the customer utility.	Measure IDMeasu650871 - 1234Test test Pot1768531Prescriptive I	re Type rtland, OR ≠ Duct Seal	Entered 2/25/2016 9: AM	I Status :48 <u>Record Only</u>	Installed 2/1/2016	Notes Ø /

Some Frequently Asked Questions about Using the Registry

I need something edited. Help!

The PTCS team can edit submitted information for you without updating the measure ID. Contact them by email at ResHVAC@bpa.gov or call 1.800.941.3867.

When I submit a job online, do I have to notify the utility that it is completed or does BPA do that for me? Yes, the responsibility is on the technician and/or their company to notify the utility that a job is complete and entered into the site registry. Please contact the utility to find out what paperwork they require and how to submit information.

What if there is more than one heat pump job at the home? Call the PTCS team at (800)-941-3867 or email at ResHVAC@bpa.gov.

How do I enter a job with a lot number? On the initial "Site Address" screen, please enter the site's lot number in the "Street Address 2" field.

When I submit a job online, do I have to notify the utility that it is completed or does BPA do that for me? Yes, the responsibility is on the technician and/or their company to notify the utility that a job is complete and entered into the site registry. Please contact the utility to find out what paperwork they require and how to submit information.

What if there is more than one heat pump job at the home? Call the PTCS team at (800)-941-3867 or email at ResHVAC@bpa.gov.

How do I enter a job with a lot number? On the initial "Site Address" screen, please enter the site's lot number in the "Street Address 2" field.

What do I do if the address cannot be verified upon entry? Please verify the address is correct and submit the form(s) by email to ResHVAC@bpa.gov or by fax to (877) 848-4074.

What do I do if a job I enter has a status of "Pending"?

Two Options:

- Jobs in BPA territory: This team reviews jobs in a "Pending" status on a bi-weekly basis. Please call (800)-941-3867 or email ResHVAC@bpa.gov.
- Jobs in ETO territory (Pacific Power or Portland General Electric): The ETO team regularly reviews jobs in a "Pending" status. Please call 1-866-365-3526 or email residentialforms@energytrust.org if you require more immediate review or if you have any questions.

How to complete a saved job? Log into the registry using the installing technician's account. Search for the saved job by measure ID or address and click "Continue Progress" in the search results.

What is the difference between a job ID and a measure ID? No difference. These terms are referring to the same number, which is currently a seven digit number.

What do I do if I have to re-enter a job or have to fix something that was already entered and approved?

- Jobs in BPA territory: Please call (800)-941-3867 or email ResHVAC@bpa.gov if you require more immediate review or if you have any questions.
- Jobs in ETO territory (Pacific Power or Portland General Electric): Please call 1-866-365-3526 or email residentialforms@energytrust.org.

Quality Assurance

All PTCS certified technicians agree to have a percentage of their jobs reviewed by third party inspectors. PTCS Service Providers, such as CLEAResult and utility inspectors, conduct these site inspections and provide feedback to technicians and utilities in order to continue to improve the quality of the installations.

Quality assurance site visits include a visual inspection of equipment and airflow tests to ensure that the equipment is saving as much energy as possible. There is no additional charge to the customer for these visits.

Technicians will be contacted following the inspection with regarding any required remediation action.

New PTCS Heat Pump technicians shall inform the PTCS program of the first three projects to be input into the registry for quality assurance inspections of installations through video or photo review. Technicians with high quality assurance inspection failure rates will be subject to increased quality assurance inspections.

Air Source Heat Pump installations will be inspected and graded on:

- ✓ Equipment Type
- ✓ Airflow
- ✓ Refrigerant Charge
- ✓ Control Set Up
 - Auxiliary (Strip) Heat Lockout
- ✓ Sizing

Technician Support Plan

If you have an inspection that failed, you will be contacted about the status and what can be corrected. The image below is included at the end of this manual and depicts the process for remediating jobs.



If any corrective action is required, the homeowner must be contacted within 10 business days of notification. Action must be taken within 10 business days of contact or as soon as the homeowner is available.

Marketing Materials to Grow Your Business: Free and Customizable

The PTCS Program has developed several marketing materials available for use. They are free to customize and use. Go to our marketing material portal to find all of these materials: https://www.bpa.gov/EE/Utility/marketing/Pages/BPA-Marketing-Portal.aspx

Contact the ResHVAC team at reshvac@bpa.gov with any questions on customizing.

What's available:

- ✓ PTCS General Marketing: Updated logo, new tagline, and program poster
- ✓ Air Source Heat Pumps: Ad, bill stuffer, brochure, postcard, and several orientations of web banners



Stay Informed

Questions? Contact your PTCS Trainer or the PTCS Program Team at ResHVAC@bpa.gov or (800) 941-3867).

Stay informed by signing up for our newsletter. How to sign up:

- On https://ptcs.bpa.gov/, click on "Stay Informed!" link at the bottom
- Email ResHVAC@bpa.gov

PTCS Heat Pump Class Summary

The classroom portion of the training module consists of a Power Point presentation, demonstrations with the equipment, and practice activities on paper as well as with props and testing equipment. It also includes a quiz that reinforces the training objectives.

Course Content

Section 1: Introduction Section 2: Sizing Section 3: Airflow Section 4: Refrigerant Charge Section 5: Controls Section 6: Participation Rules & Paperwork Section 7: Resources Field Training: Commissioning a heat pump Certification Exam!

The field portion of the training is a crucial piece for successfully teaching the concepts. The class will go to a site and perform heat pump commissioning. In the field, students will conduct airflow testing using a flow plate and manometer, measure temperature split, refrigeration charge, and practice controls setup.

Training Presentation

The following section includes all of the slides used in this training. If the trainer has added slides on his or her own, these will likely not be included. You are encouraged to take notes in the spaces provided during the class presentation.





*As of March 2021







 Section 1: Introduction

 Pergy Efficiency Performance Tested Comfort System

 • Why Quality Installation Matters

 • Why Quality Installation Matters

 • Cop and Requirements

 • Cop and HSPF

 • Quality Installation: The Big Four

ection 1: Introduction

- Why Quality Installation Matters
- Primary goal: System performs at its rated capacity per AHRI
- HSPF/SEER assumes system is properly sized with "perfect" airflow and proper refrigerant charge.
- Customers get a higher efficient heat pump that is commissioned that qualifies for a third-party quality assurance inspection, has longer equipment life, and a lower electric bill when compared to a typical system.
- Regional Power Utilities keep electric rates low, which helps avoid the cost of building new electric power generation.

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Section 1: Introduction

Equipment Maintenance

Manometers

- Should be recalibrated every two years
- A field calibration check should be completed annually or whenever a gauge has been dropped or damage suspected. This procedure can be found at the link below.

Flow Plates

- Modified and damaged flow plates will give you incorrect readings
- Energy Conservatory can provide gasket replacements

Blower Door and Duct Blaster Fans

- These maintain their calibration unless physical damage occurs to the fan or flow sensing system. A fan field check procedure can be found at the link below.
- Visit: <u>https://energyconservatory.com/calibration-repair/</u> for more info.

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Balance Point Using AHRI Data 3 Ton H 47°F Single Speed 21,600 34,200 40 35 30 BTUs (×I 000) 25 -HP 20 —нь 15 10 0 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 Outside Air Temperature (OAT) 20







 Home with higher heat loss could use 3-ton VSHP instead of 3.5 ton or higher single-speed heat pump




















			Requirement Only - Air Flow: M	
7	75	SHP	System Airflow	

SPEC >	VSHP Requirement Only - <u>Air Flow</u> : Must be as specified in the
	heat pump manufacturer's documentation. Does not need to be
	measured using TrueFlow plate, External Static Pressure - CFM
	manufacturer lookup table, or Duct Blaster pressurization fan
	matching.

VSHP Requirement Only – <u>External Static Pressure</u>: Must be as specified in the heat pump manufacturer's documentation.

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Section 3: Airflow

Low Flow Culprits

- Restrictive registers
- Open all registers; replace restrictive registers
- Restrictive air filters
- Use less restrictive air filters
- Poor duct design
- Straighten ductwork
- Install turning vanes and/or more ductwork



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Section 3: Airflow System should be tested by PTCS Duct Sealing Technician Recommended, some utilities require PTCS Duct Sealing with Heat Pump installation Use of mastic is required in the PTCS Duct Sealing specification





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Section 3: Airflow	
Create a Report	
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Andream March March Part Na Jack Part (March Mar	parta atalanan yananan yana parta parta parta. E C
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Section 3: Airflow

Increasing Measurement Accuracy

- Limit obstructions within 6 inches upstream or 2 inches downstream of the flow plate
- If installing spacers, install spacer directly in front of any obstructions
- If flow plate is directly downstream of a 90 degree bend in the duct system, install a spacer on the inside of inside corner

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Steps to Measure Airflow Using External Static Pressure Measurements

 Measure return static pressure (downstream from the filter, 0.28 inches of water column in this example).

- Measure supply plenum static pressure (0.34 inches of water column in this example).
- Calculate external static pressure (return static pressure + supply static pressure; 0.28 + 0.34 = 0.62 inches of water column in this example).

Blower Motor	External Static Pressure (Inches of Water Column)						
Setting	0.10	0.20	0.30	0.40	0.50	0.60	0.70
High	1606	1566	1524	1480	1450	1412	1376
Medium-high	1511	1467	1430	1387	1353	1309	1274
Medium	1300	1250	1210	1175	1134	1078	1009
Medium-low	1104	1060	1029	987	912	841	784
Low	913	886	832	765	694	569	530















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Section 4: Refrigerant Charge Methods
Refrigerant Charge Methods
Heating
Measure sensible temperature split & compare to chart
Subcooling
Subcooling
Alternative Methods
Superheat
Manufacturer's method
In communicating systems, set unit into charge/test mode.







Section 4: Refrigerant Charge Charging Methods



- Verify charge requirements with manufacturer
- Measure and compare to tables
 - Outdoor temp
 - Liquid/suction operating pressures

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Section 4: Refrigerant Charge

Supply Side Ventilation

- If the house has a supply side ventilation system, make sure it is closed for the temperature rise test. If it is open, the temperature test will be incorrect.
- If you see this running to the outside, make sure it's closed.



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Section 5: Controls

Dual Fuel Systems

- Dual fuel or Hybrid systems are typically allowed depending on utility
- The heat pump is the primary source of heat and switches over to gas backup
- Switchover point should be set at 35°F
- Most of the time the systems are not wired to allow the gas furnace to engage during defrost
- Keep in mind that gas heat is a lot hotter than strip heat and can put stress on the compressor if not setup correctly

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- If available, use "test mode", but understand what it actually does
- Use thermostat support sheets as a reference



- Also called equipment test, charge check, test compressor heat/cool, etc.
- Variable-speed systems often will not heat to highest capacity at mild outdoor conditions, therefore running system in a "test" mode if often required

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Section 6: Participation Rules & Paperwork
Next Steps to Certification
Online Account
Technician Application
Entering a Job into the Mobile Registry
Quality Assurance Inspections

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► 111





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Section 6: Participation Rules & Paperwork

Mobile Registry Updates

- Online registry optimized for use on any mobile device
 Not an app you download
- Save progress function to complete entered data later
- > Enter job data before, during, and after installation by saving your progress
- Times out after 4 hours of inactivity
- Informational bubbles explaining some program components
- Some limitations
 - No offline entry mode. Can't use without internet access.
 - Optional forms available to record data for later entry, but not required to submit.
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Section 6: Participation Rules & Paperw

Exercise: Optional Mobile Entry Practice

- Information at the back of your trainee manual
- Go to test site on a mobile device: https://ptcs.test.bpa.gov
- Only a test environment. Nothing will publish live on this site.
- ▶ Sign in:
 - Username: TestContractor
 - Password: Ptcs1234
- Click "Enter a Job" button
- Use an active physical address
- AHRI number: 7565113
- Use any data for the rest of the entry. Some suggestions:
- External Static (0.70 H2O), TrueFlow (NSOP 0.45, Plate 20, TFSOP 0.40, Plate Pressure 0.26, 3.5 ton), Refrigerant Charge (Heating mode, Outdoor Temp 57, Supply 98, Return 68)

▶ 120





Section 6: Participation Rules & Paperwork

Optional Air Source Heat Pump Installation Form

If no internet or mobile device is available or the job cannot be entered online for any reason, this form is available to record the data for later entry.

Can be found on <u>ptcs.bpa.gov</u> and at the end of your manual.

Note: Some participating utilities require installation form, please check with utility prior to job submission





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Section 6: Participation Rules & Paperwork

Notifying Utility of the Completed Job

- Technician or company required to notify the utility of the completed job.
- Contact customer's utility for information on required paperwork.
- Utilities have access to the online registry and are able to review completed job details.





Remote QA Inspections

- Remote QA inspections can now be performed virtually with an inspector by using a video sharing application on a smart phone. Photo QA option is available.
- After completion the PTCS staff enters the project into the PTCS registry for you!
- Report to PTCS when you are commissioning your first 3 projects so we can perform a remote QA.
- Contact us at <u>resHVAC@bpa.gov</u> to schedule your first 3 projects.

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Section 7: Resources NATE Continuing Education Hours Fmail us at ResHVAC@bpa.gov Give us your: Name Date of class NATE ID# 134







Certified Technician Application

Performance Tested Comfort Systems and Prescriptive Duct Sealing

All sections of this form are required for technicians interested in participating as a program provider of PTCS[®] Heat Pumps, PTCS Duct Sealing, and/or Prescriptive Duct Sealing for Bonneville Power Administration (BPA). **Sole-proprietors** shall complete both Technician and Company signatures.

- 1) Create an account in the online registry at <u>ptcs.bpa.gov</u> if not done so already.
- 2) Submit this form by email to <u>ResHVAC@bpa.gov</u> or by fax to 1-877-848-4074 (if applicable, include proof alternative certification).
- 3) If approved, the PTCS team will activate technician's online account and list technician information on <u>bpa.gov/goto/reshvac</u>.

Contact Information

Company	Company Rep		
Name	company kep		
Company	Company City/S	tate/Zip'	k
Address*			
Technician Name		Contra	ctor license #
Technician Email			Phone
General Company Email			
*Mailing address if different:			

PTCS or Prescriptive Training Completed

Certification Type	PTCS or Prescriptive Training: Company, Instructor, or Online Module	*Alternative Certification Name & Number (<i>if applicable</i>)	Date Trained
PTCS Duct Sealing			
Prescriptive Duct Sealing			
PTCS Air Source Heat Pump			
**Ground Source Heat Pump	**IGSHPA # (If also certified):		

*Some alternative certifications are accepted (see list of accepted alternatives in Program Requirements document on <u>bpa.gov/goto/reshvac</u>). Submit documented and dated proof of training completion with this application.

****Ground Source Heat Pump** installs require one PTCS Air Source Heat Pump Tech and one IGSHPA Certified Tech <u>OR</u> one tech certified in both PTCS and IGSHPA. If this technician is IGSHPA Certified as well as PTCS HP Certified, please provide their IGSHPA number in this field.

Certified Technician Requirements Applicant Must Ag	gree to: (P	articipation Requirements listed on bpa.gov/goto/reshvac)

- 1. Maintain all state and locally required licenses and insurance coverage.
- 2. Comply with all appropriate specifications: Prescriptive Duct Sealing, PTCS Duct Sealing and/or PTCS Heat Pump Commissioning technical specifications.
- 3. Comply with all program requirements as specified in BPA Program Requirements posted on <u>bpa.gov/goto/reshvac</u>.
- 4. Conduct business in an ethical and professional manner.
- 5. Accurately and completely record all jobs using the program forms and online registry.
- 6. Report all required job information to the customer utility in accordance with its requirements.
- If required, contact homeowner to schedule corrective action within 10 days of receiving notice from the utility and/or Quality Assurance Inspector. Complete corrective action within 10 working days of contacting homeowner, or as soon as the homeowner is available.
- 8. Provide and maintain current Technician contact information with BPA.

Requirements the Certified Technician's Company (or Certified Technician, if a Sole-Proprietor) Must Agree to:

- 1. Maintain all state and locally required licenses and insurance coverage (i.e. Construction Contractors Board (CCB), State license if required by law or regulations, worker's compensation, general liability (commercial coverage), and automobile liability). Comply with all applicable employment laws.
- 2. Conduct all business in an ethical and professional manner.
- 3. Ensure technician complies with all program requirements as specified in BPA Program Requirements posted on <u>bpa.gov/goto/reshvac</u>.
- 4. Ensure technician completes all work in accordance with the:
 - a. Applicable ordinances, codes and accepted industry standards including PTCS and Bonneville Power Administration's (BPA) standards.
 - b. Current program specifications listed on <u>bpa.gov/goto/reshvac</u> using program-required methods and testing equipment where indicated.
- 5. Ensure technician accurately and completely records all jobs using program forms and the PTCS Online Registry and submits required project paperwork to the utility program in accordance to its requirements.
- 6. If required, ensure technician schedules corrective action on job within 10 days of receiving notice from the utility and/or Quality Assurance Inspector and corrective action is completed within 10 working days of contacting the homeowner, or as soon as the homeowner is available.

Signatures

By signing below, the Applicant agrees to comply with the Certified Technician Requirements and certifies that all information provided in this application is true and correct to the best of their knowledge.

Technician Signature Date			
(Required)			
By signing below, the Company Representative further certifies that they are authorized to sign on behalf of the Company,			
agrees to comply with Technician's Company Requirements, and certifies that all information provided in this application is true			
and correct to the best of their knowledge. This signature is required even if applicant is a sole proprietor.			
	Data		

Company Representative	Date
Signature (Required)	

Frequently Asked Questions about the PTCS and Prescriptive Certification

(More found on the "How to Participate" Page on bpa.gov/goto/reshvac):

- When do I get a PTCS Technician ID for the first time? After your application has been reviewed and approved, the PTCS team will activate your online account and you will receive your PTCS Tech ID number by email.
- What do I do if I change companies? Submit this form with your updated company information listing all areas of certification.
- What if I get an additional certification? Submit this form with your updated training/certification information including all other areas of certification.
- Who do I contact with questions? Contact your trainer or the PTCS team by calling 1-800-941-3867 or emailing ResHVAC@bpa.gov.



PTCS[®] Air Source Heat Pump Optional Data Collection Tool

- 1) Enter all data into the registry on a mobile device or computer at ptcs.bpa.gov using the certified technician's account. This optional form can be filled out for later entry online. Issues entering data? Submit this form for entry:
 - Customers of Bonneville Power Administration (BPA) utilities: email <u>ResHVAC@bpa.gov</u>, fax to 1.877.848.4074, or call 1.800.941.3867
 - Customers of PGE or Pacific Power: email <u>Residentialforms@energytrust.org</u> or call 1.866.365.3526
- 2) Submit the Registry Installation Report (found online) and additional required documents to the customer utility. Unless requested by the utility, submission of this form is not required.

Site Information

PTCS PTCS Tech Install Electric						
Tech #	Tech # Name Date Utility					
Installation Site Site Site					Site	
Site Address City State Zip						
Home Type: Existing Site Built New Construction Site Built Manufactured: # of Sections 1 2 3						
Heated Area: Sq Ft Foundation Type (Site Built): Crawlspace Full Basement Half Basement Slab						
Existing Heating System Being Replaced (If new home, indicate heating system installed):						
🗌 Electric Forced Air w/out AC 🔲 Electric Forced Air w/ AC 📄 Electric Zonal 📄 Air Source Heat Pump 📄 Ground Source Heat Pump						
🗌 Natural Gas Furnace (Gas Company:) 🔲 Other Non-Electric Space Heating:						
Back up Heat: 🗌 None 📄 Electric Forced Air 📄 Electric Zonal 📄 Natural Gas Furnace 📄 Non-Electric Space Heating						

New Heat Pump Equipment Data

*If less than 9.0 HSPF or 14 SEER, check with utility for requirements.

Heat Pump Make Outdoor HP Image: Non Variable Speed HP Compression Indoor HP Image: Non Variable Speed HP Compression Indoor HP Balance Point?	AHRI #		SEER*	HSPF*	Outdoor HP Capacity (tons)
Indoor HP Balance Point?	Heat Pump Make	Outdoor HP Model #			Non Variable Speed HP Compressor
Model # Provide BP documentation to uti		Indoor HP Model #			Balance Point? Provide BP documentation to utility.

Did you perform all of your tests in Test Only/Check Charge mode? See No N/A

External Static Pressure Test

Check unit operating at full capacity unless conditions do not permit.

1. Measure return static pressure	1. Return Static	2. Supply Static	3. External Static
2. Measure supply plenum static pressure	Pressure	Pressure	Pressure
 3. Calculate external static pressure (ESP): add values in #1 and #2 values; ignore the minus sign 	Variable speed system's ESP meets manufacturer's specifications	Maximum ESP allowed by manufacturer	Units: <u>Use same units for TrueFlow</u>

TrueFlow Test Not required for variable speed systems or if you complete External Static Pressure - CFM Manufacturer Lookup Table below.

Original True Flow Test	1. NSOP [A]	2a. Plate Size: 2b. Plate location:	
1. Measure NSOP (Normal System Operating Pressure) [A]		14 20 Air Handler Return Gr	
2. Check True Flow plate size and location	3. TFSOP [B] 4. Correction Factor [C] fr		or [C] from table
3. Measure TFSOP (Supply Pressure with True Flow Plate) [B]		or calculate $\sqrt{([A]/[B])}$	
4. Calculate Correction Factor [C]	5. Plate 6. Raw Flow CFM from table		from tables [D]
5. Measure plate pressure	Pressure		
6. Enter Raw Flow CFM from tables [D]	7. Corrected Flow		8. CFM/ton
7. Calculate Corrected Flow 8. Calculate CFM/ton	CFM = [C] x [D]		

Digital/Bluetooth True Flow Test	1. Plate Location		2. Total Airflow	3. CFM/ton
Air Handler Return Grille				
External Static Pressure - CFI	M Manufacture	Not required for variable speed	systems or if you completed	

	IrueFlow Test table above	
 Use manufacturer lookup table to determine total airflow. Calculate CFM/ton 	1. Total Airflow	2. CFM/ton

Variable speed system's airflow meets manufacturer's specifications? Yes No N/A

Refrigerant Charge Check Run unit for at least 15 minutes in compressor-only mode before taking readings. Not required for variable speed systems.

Outside Air Temp $^{\circ}F$ Mode unit tested in: Heating (if $\leq 65^{\circ}F$)Cooling (if $> 65^{\circ}F$)	Variable speed system's refrigerant charge meets manufacturer's specifications.
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Heating Mode (65 ⁰ F or lower)	Cooling Mode (higher than 65 ⁰ F)	Alternative Test Method
Supply Air (SA) Temp	Liquid Line Pressure	Specify method used
Return Air (RA) Temp	Liquid Saturation Temp [A]	Target
Temp Split (SA – RA)	Liquid Line Temp [B]	Test result
Expected Temp Split from table:	Sub cooling [A] – [B]	Meets specification? Y

Controls

Г

Auxiliary (strip) heat locked out to not engage at outdoor	temperatures above 35°F:	Auxiliary (strip) heat not installed:
HP Thermostat Make	HP Thermostat Model	

Notes





NOSTIC TOOLS TO MEASURE BUILDING PERFORMANCE

Performance Tested Comfort Systems (PTCS) Equipment Discount List

In partnership with CLEAResult, The Energy Conservatory is pleased to extend the following discounts to contractors participating in the Performance Tested Comfort Systems (PTCS) program.

Please forward completed order forms to Kyle Chase: Email: kyle.chase@clearesult.com

Company Billing Address	Shipping Address (if different than Billing Address)
Contact Name:	Contact Name:
Company Name:	Company Name:
Street Address:	Street Address:
City, State, Zip:	City/State/Zip:
Phone:	Email:

All orders require payment via credit card prior to order processing. Please complete payment information below to avoid delays in processing your order request.

Credit Card Information: _ Visa _ Master Card _ Discover _ AMEX

Credit Card #: ___

Name on card: ____

_____ Exp. Date: _____ CVV# _____

Credit Card Address (if different from billing address above)

Less Unit Total Equipment Model Numbers Qty 12.5% Total Price Per Unit Discount Model 3 110V System Minneapolis Blower Door™ \$3.755.00 (\$469.38) \$3.285.62 with DG-1000 Digital Gauge Series B110V Minneapolis Duct Blaster® \$2,965.00 (\$370.63) \$2,594.37 with DG-1000 Digital Gauge Series B110V Minneapolis Duct Blaster® without Gauge \$1.705.00 (\$213.13) \$1.491.87 without DG-1000 DG-1000 Pressure and Flow DG-1000 Digital Gauge (stand alone) \$1,620.00 (\$202.50) \$1,417.50 Gauge DG-8 Pressure Gauge DG-8 Digital Gauge Pressure Gauge \$549.00 (\$68.63) \$480.37 Digital TrueFlow® Grid Kit without Gauge Digital TrueFlow® Meter No Gauge \$1071.00 (\$133.88) \$937.12 (Additional Options Available) **Total Amount**

<u>Unit Prices **do not** include shipping charges or sales tax where applicable to TEC.</u> Equipment will be shipped Ground UPS, unless notified otherwise, with shipping charges added to the invoice. Additional items are available from TEC and eligible for program discount.

For product and order questions:

The Energy Conservatory

2801 21st Ave. South, Ste. 160 Minneapolis, MN 55407 Phone: (612) 827-1117 phone

For CLEAResult Questions

CLEAResult 100 SW Main, Ste 1500 Portland, OR 97204 Phone: 503.467.2140 Email: kyle.chase@clearesult.com

Revised 05/2021

PTCS Technician Support Plan





Having trouble passing your inspection?



The program may ask you to fix an issue(s) found during an inspection.



outlining the issue(s) and timeframes to fix things. You will receive a letter



If it passes reinspection you are back on your PTCS way!

Let us help you!



participate in a mandatory reinspection or you have If a project does not pass you will be contacted to multiple failing projects, Improvement Plan.



providing you the resources designing an individualized Improvement Plan and you need to get back Let us help you by on track.

remain successful with the We will take a look at your projects to make sure you have what you need to next round of PTCS PTCS program.



to complete your Improvement Plan the program may need to If you are unable or unwilling stop partnering with you.

PTCS program after six months under the opportunity to reapply to the If partership stops, you may have certain conditions.

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PTCS Job Entry Practice on your Mobile Device

No need to download an app. Practice using a valid address. This practice is on a Test site and will not publish to the main live site. Please type in the URL exactly as it appears with "test".

- 1) Go to test site on a mobile device: <u>https://ptcs.test.bpa.gov</u>
- 2) Sign in:
 - Username: TestContractor
 - Password: Ptcs1234
- 3) Enter a Job:
 - Either click "Enter a Job" button on the homepage, or
 - Click three-lined menu button and select "Enter a Job" under Contractors

	Welcome Amy
Welcome to the PTCS® and Prescriptive Online Site Registry Login to enter and search for PTCS Duct Sealing, Air Source and Ground Source Heat Pumps, and Prescriptive Duct Sealing projects.	Log Out Contractors - Company Measures
Enter a Project	Enter a Job Completed Jobs
Search for Project	Enter A Job QA QA Inspection Search

- Begin by entering any active physical address and select "Enter an Air Source Heat Pump form". Enter any data as this won't affect real projects. Some suggestions:
 - AHRI number: 7565113
 - External Static Pressure (.70 H2O)
 - True Flow Test
 - NSOP (.45 H2O)
 - ▶ TFSOP (0.40 H2O)
 - Plate #20
 - Plate Pressure (0.26 H2O)
 - Size: 3.5 ton
 - Refrigerant Charge (Heating Mode, Outdoor Temp 57, Supply 98, Return 68)
- 5) **Click on the measure ID** to get the Registry Installation Report.
- 6) If you have extra time, search for the job.
 - Click on the logo and click "Search for Project"
 - Search for the work you just entered (*hint: search by as little information as possible*) and click on the measure ID in the results for the report.

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Reference Materials

Support sheets for setting up the program's most widely used thermostat models to ensure the back-up heat is locked out above 35F are located on our program website. Included in this section is one example and there are support sheets available for most thermostat models used in the program.

The tables in this section can be used to verify measurements for the TrueFlow test section of the commissioning procedure and to verify what the minimum expected temp split or subcooling should be based on the CFM/ton and outside ambient temperature.

These and more reference materials can be downloaded from the "Heat Pump" section of the PTCS website at any time: www.bpa.gov/goto/reshvac.

PTCS Heat Pump Thermostat Support Sheet

Manufacturer: Honeywell

Thermostat Models: Wi-Fi and RedLINK VisionPRO 8000 (Models: TH8321WF, TH8321R,

TH8320R, TH8110R)

Caution, entering installer set-up mode may result in altering settings. Select "DO NOT SAVE CHANGES" when exiting installer set-up

Is a Password Required? <u>YES</u>

Password is 4-digit date code Password can be found in two ways:

- a. 1. Press "Menu"
 - 2. Select "Dealer Information"
 - 3. Scroll Down to "Date Code"
 - 1. Remove Thermostat from wall



2. Password (date code) is 4 digits listed to the right of the model number *It is recommended that the thermostat not be removed from the wall, if possible. If the installer did not configure dealer information during the initial installation, a password can only be obtained by removing the unit from the wall.*

1. How to enter installer set-up

a. Press Menu

b.

- b. Scroll to bottom and Select "Installer Options"
- c. Enter 4-digit password (instructions above) and press "DONE"
- d. Scroll to "Installer Setup" and press "select"

2. Determine system characteristics through T-Stat

- **a.** Scroll through "Installer Setup" options by pressing "Next". Note: refrain from pressing the up and down arrows as this will change the settings
- **b.** Code 200 is for Conventional Forced Air
- c. Code 201 is for Air-to-Air Heat Pump
- d. Code 202 (1-3) and Code 207 (1-4) are for Heat Stages/Backup heat stages, and compressor stages

3. Check Outdoor Temperature Sensing Capabilities

- **a.** From "Installer Setup", scroll through settings to ensure outdoor air temperature is being collected by either Wi-Fi, wired outdoor sensor, or wireless outdoor sensor (on RedLINK enabled models only)
- **b.** For Wi-Fi connection with no wired outdoor sensor: Press "MENU" and select "Wi-Fi SETUP" to determine if Wi-Fi is activated. Ensure Code 106 "Outdoor Sensor" is set to "Yes"
- c. For a wired outdoor sensor: Ensure Code 106 "Outdoor Sensor" is set to "Yes", Code 500a "Wired Sensor on S Terminals" is set to "Yes", and Code 500b "Wired Outdoor Sensor" is set to "Yes"
- d. For RedLINK models with wireless outdoor sensor: Ensure Code 106 "Outdoor Sensor" is set to "Yes"

PTCS Heat Pump Thermostat Support Sheet

Manufacturer: Honeywell

Thermostat Models: Wi-Fi and RedLINK VisionPRO 8000 (Models: TH8321WF, TH8321R,

TH8320R, TH8110R)

4. Check Strip Heat settings

- a. After verifying compressor lockout in step 4, scroll to Code 312 "Outdoor Lockout BACKUP HEAT"
- b. Verify temperature is set to 35 degrees or less to meet spec

5. Access Test Mode for testing system at full capacity

- a. Press Menu
- b. Scroll to bottom and Select "Installer Options"
- c. Enter 4-digit password and press "DONE"
- d. Scroll and select "Installer Setup"
- e. Scroll and select "Installer Test" below "Installer Setup" to enter Test Mode
- f. Scroll and select desired system to test:
 - A. <u>Heating mode:</u> scroll down to "Heat Stages" and press "Select". Cycle to the highest heat stage available by pressing the up-arrow button on the top right to test in the highest compressor heating setting. Timer will begin to count as test proceeds. If unit is a single stage system, when testing in "HEAT STAGES" do not scroll to heat stage 2. This will cause strip heat to come on.
 - **B.** <u>Cooling mode:</u> scroll down to "Cool Stages" and press "Select". Cycle to highest cooling stage available by pressing the up-arrow button on the top right to test in the highest compressor cooling setting. Timer will begin to count as test proceeds.
 - **C.** Wait at least 10 minutes before taking static pressure readings and inserting flow plate for TrueFlow plate test. Listen to ensure fan has staged up completely.
 - D. Wait at least 20 to 25 minutes before doing temperature split readings for refrigerant test. The longer the system is allowed to run, the more likely it will reach a steady state. System test automatically times out after 30 minutes of inactivity.

6. Exit Test Mode

- **a.** System test automatically times out after 30 minutes of inactivity. Test mode runs for 30 minutes by default.
- **b.** Press "Home" to exit test mode, or "back" to select a different stage or mode to test

7. Exit Set-Up Mode

- a. Select "DONE"
- b. Next screen prompt says, "Do you want to exit installer setup?"; select "YES"
- c. Next screen prompt says, "Do you want to save changes"; select "NO"
- **d.** If left alone system set-up automatically times out after 30 minutes of inactivity and returns to original settings

Caution, entering installer set-up mode may result in altering settings. Select "DO NOT SAVE CHANGES" when exiting installer set-up

Resources: Honeywell Technical Support: 1-800-468-1502 **Source:** <u>https://forwardthinking.honeywellhome.com/products/thermostats/</u>

Flow Conversion Table for TrueFlow Metering Plates (Pascals)

Plate	Plate	Plate
Pressure	#14	#20
(Pascals)	(CFM)	(CFM)
10	201	105
10	364	487
11	381	511
12	390	555
13	415	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

Flow conversion table for TrueFlow Metering Plates (using In. H_2O)

(In. H ₂ O) (CFM) (CFM) 0.04 362 485 0.045 384 515 0.05 405 543 0.055 425 569 0.06 444 594 0.065 462 619 0.07 479 642 0.075 496 665 0.08 513 686 0.085 528 708 0.09 544 728 0.095 558 748 0.105 587 786 0.11 601 805 0.12 628 841 0.125 641 858 0.13 653 875 0.13 653 875 0.14 678 908 0.145 690 924 0.155 713 956 0.16 725 971 0.165 736 986 0.17	Plate Pressure	Plate #14	Plate #20
0.04 362 485 0.045 384 515 0.05 405 543 0.055 425 569 0.06 444 594 0.065 462 619 0.07 479 642 0.075 496 665 0.08 513 686 0.085 528 708 0.095 558 748 0.105 587 767 0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.13 653 875 0.14 678 908 0.145 690 924 0.155 713 956 0.16 725 971 0.165 736 986 0.17	(In. H₂O)	(CFM)	(CFM)
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0.065 462 619 0.07 479 642 0.075 496 665 0.08 513 686 0.085 528 708 0.09 544 728 0.095 558 748 0.1 573 767 0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185	0.06	444	594
0.07 479 642 0.075 496 665 0.08 513 686 0.085 528 708 0.09 544 728 0.095 558 748 0.1 573 767 0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.13 653 875 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185	0.065	462	619
0.075 496 665 0.08 513 686 0.095 558 708 0.095 558 748 0.1 573 767 0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.13 666 892 0.14 678 908 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.23	0.07	479	642
0.08 513 686 0.085 528 708 0.09 544 728 0.095 558 748 0.1 573 767 0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.13 653 875 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.205 820 1099 0.21	0.075	496	665
0.085 528 708 0.09 544 728 0.095 558 748 0.1 573 767 0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.15 702 940 0.15 702 940 0.15 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.185 779 1044 0.19 790 1058 0.205 820 1099 0.21	0.08	513	686
0.09 544 728 0.095 558 748 0.1 573 767 0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21	0.085	528	708
0.095 558 748 0.1 573 767 0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.15 702 940 0.15 702 940 0.15 702 940 0.15 702 940 0.15 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.205	0.09	544	728
0.1 573 767 0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.23	0.095	558	748
0.105 587 786 0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.13 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1085 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.23 878 1177 0.24	0.1	573	767
0.11 601 805 0.115 614 823 0.12 628 841 0.125 641 858 0.13 653 875 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.225 860 1151 0.23 869 1164 0.23 878 1177 0.24	0.105	587	786
0.115 614 823 0.12 628 841 0.125 641 858 0.135 666 892 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.265 924 1228 0.265 924 1228	0.11	601	805
	0.115	614	823
0.125 641 858 0.13 653 875 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.23 87 1177 0.24 888 1189 0.245 897 1201 0.25 <td>0.12</td> <td>628</td> <td>841</td>	0.12	628	841
0.13 653 875 0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.225 860 1151 0.23 859 1164 0.23 859 1164 0.235 878 1177 0.24 888 189 0.245 897 1201 0.25 </td <td>0.125</td> <td>641</td> <td>858</td>	0.125	641	858
0.135 666 892 0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.2	0.13	653	875
0.14 678 908 0.145 690 924 0.15 702 940 0.155 713 956 0.165 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.23 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.2	0.135	666	892
0.145 690 924 0.15 702 940 0.155 713 956 0.165 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238	0.14	678	908
0.15 702 940 0.155 713 956 0.165 736 986 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 933 1249	0.145	690	924
0.155 713 956 0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.25 915 1226 0.26 924 1238	0.15	702	940
0.16 725 971 0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 933 1249	0.155	713	956
0.165 736 986 0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 933 1249	0.16	725	971
0.17 747 1001 0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 933 1249	0.165	736	986
0.175 758 1015 0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.25 906 1214 0.25 915 1226 0.26 924 1238 0.265 913 1249	0.17	747	1001
0.18 769 1030 0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 933 1249	0.175	758	1015
0.185 779 1044 0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 933 1249	0.18	769	1030
0.19 790 1058 0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 933 1249	0.185	779	1044
0.195 800 1072 0.2 810 1085 0.205 820 1099 0.21 830 1112 0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 933 1249	0.19	790	1058
0.2 810 1085 0.205 820 1099 0.21 830 1112 0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 189 0.255 906 1214 0.255 915 1226 0.26 924 1238 0.265 913 1249	0.195	800	1072
0.205 820 1099 0.21 830 1112 0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.265 924 1238 <td>0.2</td> <td>810</td> <td>1085</td>	0.2	810	1085
0.21 830 1112 0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 913 1249	0.205	820	1099
0.215 840 1125 0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 913 1249	0.21	830	1112
0.22 850 1138 0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.255 906 1214 0.255 915 1226 0.26 924 1238 0.265 913 1249	0.215	840	1125
0.225 860 1151 0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 915 1226 0.26 924 1238 0.265 913 1249	0.22	850	1138
0.23 869 1164 0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 913 1249	0.225	860	1151
0.235 878 1177 0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 913 1249	0.23	869	1164
0.24 888 1189 0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 913 1249	0.235	878	1177
0.245 897 1201 0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 913 1249	0.24	888	1189
0.25 906 1214 0.255 915 1226 0.26 924 1238 0.265 933 1249	0.245	897	1201
0.255 915 1226 0.26 924 1238 0.265 933 1249	0.25	906	1214
0.26 924 1238	0.255	915	1226
0.265 933 1249	0.26	924	1238
5.55 1245	0.265	933	1249
0.27 942 1261	0.27	942	1261
0.275 950 1273	0.275	950	1273

Plate Pressure	Plate #14	Plate 20
(In. H₂O)	(CFM)	(CFM)
0.28	959	1284
0.285	967	1296
0.29	976	1307
0.295	984	1318
0.3	992	1329
0.305	1001	1340
0.31	1009	1351
0.315	1017	1362
0.32	1025	1373
0.325	1033	1384
0.33	1041	1394
0.335	1049	1405
0.34	1057	1415
0.345	1064	1426
0.35	1072	1436
0.355	1080	1446
0.36	1087	1456
0.365	1095	1466
0.37	1102	1476
0.375	1110	1486
0.38	1117	1496
0.385	1124	1506
0.39	1132	1516
0.395	1139	1525
0.4	1146	1535
0.405	1153	1545
0.41	1160	1554
0.415	1167	1563
0.42	1174	1573
0.425	1181	1582
0.43	1188	1591
0.435	1195	1601
0.44	1202	1610
0.445	1209	1619
0.45	1216	1628
0.455	1222	1637
0.46	1229	1646
0.465	1236	1655
0.47	1242	1664
0.475	1249	1673
0.48	1255	1681
0.485	1262	1690
0.40	1268	1699
0.495	1275	1708
0.455	1281	1716
0.505	1281	1725
0.505	1200	1723
0.51	1200	1740
0.313	1 1000	1 1/4/

Plate Pressure	Plate #14	Plate 20
(In. H ₂ O)	(CFM)	(CFM)
0.58	1380	1848
0.585	1386	1856
0.59	1392	1864
0.595	1398	1872
0.6	1404	1880
0.605	1409	1888
0.61	1415	1896
0.615	1421	1903
0.62	1427	1911
0.625	1433	1919
0.63	1438	1926
0.635	1444	1934
0.64	1450	1942
0.645	1455	1949
0.65	1461	1957
0.655	1466	1964
0.66	1472	1972
0.665	1478	1979
0.67	1483	1987
0.675	1489	1994
0.68	1494	2001
0.685	1500	2009
0.69	1505	2016
0.695	1511	2023
0.7	1516	2031
0.705	1521	2038
0.71	1527	2045
0.715	1532	2052
0.72	1538	2059
0.725	1543	2067
0.73	1548	2074
0.735	1553	2081
0.74	1559	2088
0.745	1564	2095
0.75	1569	2102

Appendix B Flow Resistance Correction Factors

Table B.1: Flow Resistance Correction Factors (using Pascals)

Normal System Operating Pressure in Pascals (NSOP)

		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
TrueFlow	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
System	24	0.05	0.68	0.70	0.02	0.07	0.91	0.90	0.06	1.04	1.00	1.12	1.10	1.19	1.22	1.20	1.29	1.32	1.30	1.30	1.41	1.44
Operating	20	0.02	0.00	0.73	0.76	0.00	0.85	0.92	0.90	0.96	1.04	1.07	1.11	1 10	1.10	1 16	1.24	1.27	1.30	1.00	1.30	1.33
Pressure	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
in	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
Pascals.	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
(TF SOP)	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	0.00	0.03	0.00	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 in Pascals (NSOP)

50 70 75 80 85 90 95 100 105 55 60 65 110 115 120 125 130 135 140 145 150 1.00 1.05 1.14 1.18 1.22 1.26 1.30 1.34 1.38 1.73 50 1.10 1.41 1.45 1.48 1.52 1.55 1.58 1.61 1.64 1.67 1.70 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 1.12 1.15 1.19 1.22 1.26 1.29 1.32 1.35 1.38 1.41 0.91 0.96 1.00 1.04 1.08 1.44 1.47 1.50 1.53 1.55 1.58 1.11 1.14 1.18 1.21 1.24 1.27 1.30 1.33 1.36 1.39 1.41 65 0.88 0.92 0.96 1.00 1.04 1.07 1.44 1.47 1 4 9 1.52 70 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 0.85 0.89 75 0.82 0.86 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 0.89 0.93 0.97 1.00 1.41 1.00 1.03 1.06 1.09 1.12 1.15 1.17 1.20 1.22 1.25 1.27 80 0.79 0.83 0.87 0.90 0.94 0.97 1.30 1.32 1.35 1.37 TrueFlow 0.97 1.00 1.03 1.06 1.08 1.11 1.14 1.16 1.19 85 0.77 0.80 0.84 0.87 0.91 0.94 1.21 1.24 1.26 1.28 1.31 1.33 System 0.94 0.97 1.00 1.03 1.05 1.08 1.22 1.25 1.29 90 0.75 0.78 0.82 0.85 0.88 0.91 1.11 1.13 1.15 1.18 1.20 1.27 Operating 0.79 0.83 0.86 0.92 0.95 0.97 1.00 1.03 1.05 1.08 1.10 1.12 1.15 1.17 1.26 95 0.73 0.76 0.89 1.19 1.21 1.24 Pressure 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 in Pascals. 105 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 1.13 1.15 1.18 1 20 0.69 0.72 1.11 (TF SOP) 110 0.67 071 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 1.13 1 15 1 17 1.11 115 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 1 2 1 1 4 120 0.65 0.68 071 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 1 2 125 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 0.78 0.81 130 0.62 0.65 0.68 0.71 0.73 0.76 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 0.72 0.75 0.77 0.79 0.82 0.84 0.86 0.88 0.90 0.92 0.94 0.96 0.98 0.61 0.64 0.67 0.69 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 $0.62 \quad 0.64 \quad 0.67 \quad 0.69 \quad 0.72 \quad 0.74 \quad 0.77 \quad 0.79 \quad 0.81 \quad 0.83 \quad 0.85 \quad 0.87 \quad 0.89 \quad 0.91 \quad 0.93 \quad 0.95 \quad 0.96$ 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

Flow Resistance Correction Factor =

NSOP / TF SOP



Table B.2: Flow Resistance Correction Factors (using In. H₂O)

Normal System Operating Pressure in In. H₂O (NSOP)

		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
TrueFlow	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
System	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
Operating	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
Pressure	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
in In H 0	0.14	0.53	0.60	0.65	0.71	0.70	0.80	0.85	0.89	0.93	0.96	1.00	1.04	1.07	1.10	1.13	1.10	1.20	1.22	1.25	1.28	1.31
(TE SOD)	0.15	0.52	0.56	0.03	0.00	0.73	0.77	0.02	0.00	0.09	0.93	0.97	0.07	1.03	1.00	1.10	1.13	1.10	1.10	1.21	1.24	1.20
$(\mathbf{IF} \mathbf{SOP})$	0.10	0.30	0.50	0.01	0.00	0.60	0.73	0.79	0.05	0.07	0.90	0.94	0.97	0.07	1.03	1.00	1.09	1.12	1.10	1.17	1.20	1.22
	0.17	0.40	0.54	0.55	0.62	0.00	0.75	0.75	0.00	0.04	0.85	0.88	0.94	0.07	0.97	1.00	1.00	1.00	1.11	1 11	1.10	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 in In. H₂O (NSOP)

		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
TrueFlow	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
System	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
Operating	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
Pressure	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
in In, H ₂ 0	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
(TE SOP)	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
(11 501)	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

Flow Resistance Correction Factor = $\sqrt{NSOP / TF SOP}$



R410A Pressure Temperature Chart

PSIG	۴	PSIG	°F	PSIG	۴F	PSIG	°F	PSIG	۴F	PSIG	۴F
12	-37.7	114	37.8	216	74.3	318	100.2	420	120.7	522	137.6
14	-34.7	116	38.7	218	74.9	320	100.7	422	121	524	137.9
16	-32.0	118	39.5	220	75.5	322	101.1	424	121.4	526	138.3
18	-29.4	120	40.5	222	76.1	324	101.6	426	121.7	528	138.6
20	-36.9	122	41.3	224	76.7	326	102	428	122.1	530	138.9
22	-24.5	124	42.2	226	77.2	328	102.4	430	122.5	532	139.2
24	-22.2	126	43	228	77.8	330	102.9	432	122.8	534	139.5
26	-20.0	128	43.8	230	78.4	332	103.3	434	123.2	536	139.8
28	-17.9	130	44.7	232	78.9	334	103.7	436	123.5	538	140.1
30	-15.8	132	45.5	234	79.5	336	104.2	438	123.9	540	140.4
32	-13.8	134	46.3	236	80	338	104.6	440	124.2	544	141
34	-11.9	136	47.1	238	80.6	340	105.1	442	124.6	548	141.6
36	-10.1	138	47.9	240	81.1	342	105.4	444	124.9	552	142.1
38	-8.3	140	48.7	242	81.6	344	105.8	446	125.3	556	142.7
40	-6.5	142	49.5	244	82.2	346	106.3	448	125.6	560	143.3
42	-4.5	144	50.3	246	82.7	348	106.6	450	126	564	143.9
44	-3.2	146	51.1	248	83.3	350	107.1	452	126.3	568	144.5
46	-1.6	148	51.8	250	83.8	352	107.5	454	126.6	572	145
48	0	150	52.5	252	84.3	354	107.9	456	127	576	145.6
50	1.5	152	53.3	254	84.8	356	108.3	458	127.3	580	146.2
52	3	154	54	256	85.4	358	108.8	460	127.7	584	146.7
54	4.5	156	54.8	258	85.9	360	109.2	462	128	588	147.3
56	5.9	158	55.5	260	86.4	362	109.6	464	128.3	59 2	147.9
58	7.3	160	56.2	262	86.9	364	110	466	128.7	596	148.4
60	8.6	162	57	264	87.4	366	110.4	468	129	600	149
62	10	164	57.7	266	87.9	368	110.8	470	129.3	604	149.5
64	11.3	166	58.4	268	88.4	370	111.2	472	129.7	608	150.1
66	12.6	168	59	270	88.9	372	111.6	474	130	612	150.6
68	13.8	170	59.8	272	89.4	374	112	476	130.3	616	151.2
70	15.1	1/2	60.5	274	89.9	376	112.4	478	130.7	620	151.7
	16.3	1/4	61.1	2/6	90.4	3/8	112.6	480	131	624	152.3
74	17.5	1/6	61.8	2/8	90.9	380	113.1	482	131.3	628	152.8
70	18.7	1/8	62.5	280	91.4	382	113.5	484	131.6	632	153.4
/°	19.8	100	63.1	282	91.9	384	113.9	460	132	640	153.9
00	21	102	64.5	204	92.4	200	114.5	466	132.5	640	154.5
02 94	22.1	196	65.1	200	92.0	300	114.7	490	132.0	644	155 5
86	23.2	188	65.8	200	93.5	390	115 5	492	132.9	652	155.5
88	24.5	100	66.4	290	93.8	392	115.5	494	133.5	656	156.6
90	25.4	192	67	294	94.5	396	116.2	450	133.0	660	157.1
92	20.4	194	67.7	296	95.2	398	116.6	500	134	664	157.7
94	28.5	196	68.3	298	95.7	400	117	502	134.5	668	158.2
96	29.5	198	68.9	300	96.2	402	117.3	504	134.8	672	158.7
98	30.5	200	69.5	302	96.6	404	117.7	506	135.2	676	159.2
100	31.2	202	70.1	304	97.1	406	118.1	508	135.5	680	159.8
102	32.2	204	70.7	306	97.5	408	118.5	510	135.8	684	160.3
104	33.2	206	71.4	308	98	410	118.8	512	136.1	688	160.8
106	34.1	208	72	310	98.4	412	119.2	514	136.4	692	161.3
108	35.1	210	72.6	312	98.9	414	119.6	516	136.7	696	161.8
110	35.5	212	73.2	314	99.3	416	119.9	518	137		
112	36.9	214	73.8	316	99.7	418	120.3	520	137.3		

Outdoor								CFM/T	NO							
Temp.	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450
5	13.0	12.6	12.2	11.8	11.4	11.0	10.8	10.6	10.4	10.2	10.0	9.8	9.6	9.4	9.2	9.0
7	13.8	13.4	13.0	12.6	12.2	11.8	11.6	11.3	11.1	10.8	10.6	10.4	10.1	9.9	9.6	9.4
0	14.6	14.2	13.8	13.4	13.0	12.6	12.3	12.0	11.8	11.5	11.2	10.9	10.6	10.4	10.1	9.8
11	15.4	15.0	14.6	14.2	13.8	13.4	13.1	12.8	12.4	12.1	11.8	11.5	11.2	10.8	10.5	10.2
13	16.2	15.8	15.4	15.0	14.6	14.2	13.8	13.5	13.1	12.8	12.4	12.0	11.7	11.3	11.0	10.6
15	17.0	16.6	16.2	15.8	15.4	15.0	14.6	14.2	13.8	13.4	13.0	12.6	12.2	11.8	11.4	11.0
17	17.6	17.2	16.8	16.4	16.0	15.6	15.2	14.8	14.4	14.0	13.6	13.2	12.8	12.4	12.0	11.6
19	18.2	17.8	17.4	17.0	16.6	16.2	15.8	15.4	15.0	14.6	14.2	13.8	13.4	13.0	12.6	12.2
21	18.8	18.4	18.0	17.6	17.2	16.8	16.4	16.0	15.6	15.2	14.8	14.4	14.0	13.6	13.2	12.8
23	19.4	19.0	18.6	18.2	17.8	17.4	17.0	16.6	16.2	15.8	15.4	15.0	14.6	14.2	13.8	13.4
25	20.0	19.6	19.2	18.8	18.4	18.0	17.6	17.2	16.8	16.4	16.0	15.6	15.2	14.8	14.4	14.0
27	20.6	20.2	19.8	19.4	19.0	18.6	18.2	17.7	17.3	16.8	16.4	16.0	15.6	15.2	14.8	14.4
29	21.2	20.8	20.4	20.0	19.6	19.2	18.7	18.2	17.8	17.3	16.8	16.4	16.0	15.6	15.2	14.8
31	21.8	21.4	21.0	20.6	20.2	19.8	19.3	18.8	18.2	17.7	17.2	16.8	16.4	16.0	15.6	15.2
33	22.4	22.0	21.6	21.2	20.8	20.4	19.8	19.3	18.7	18.2	17.6	17.2	16.8	16.4	16.0	15.6
35	23.0	22.6	22.2	21.8	21.4	21.0	20.4	19.8	19.2	18.6	18.0	17.6	17.2	16.8	16.4	16.0
37	24.0	23.6	23.1	22.7	22.2	21.8	21.2	20.6	20.0	19.4	18.8	18.4	18.0	17.6	17.2	16.8
39	25.0	24.5	24.0	23.6	23.1	22.6	22.0	21.4	20.8	20.2	19.6	19.2	18.8	18.4	18.0	17.6
41	26.0	25.5	25.0	24.4	23.9	23.4	22.8	22.2	21.6	21.0	20.4	20.0	19.6	19.2	18.8	18.4
43	27.0	26.4	25.9	25.3	24.8	24.2	23.6	23.0	22.4	21.8	21.2	20.8	20.4	20.0	19.6	19.2
45	28.0	27.4	26.8	26.2	25.6	25.0	24.4	23.8	23.2	22.6	22.0	21.6	21.2	20.8	20.4	20.0
47	29.2	28.5	27.8	27.2	26.5	25.8	25.2	24.6	24.0	23.4	22.8	22.4	21.9	21.5	21.0	20.6
49	30.4	29.6	28.9	28.1	27.4	26.6	26.0	25.4	24.8	24.2	23.6	23.1	22.6	22.2	21.7	21.2
51	31.6	30.8	29.9	29.1	28.2	27.4	26.8	26.2	25.6	25.0	24.4	23.9	23.4	22.8	22.3	21.8
53	32.8	31.9	31.0	30.0	29.1	28.2	27.6	27.0	26.4	25.8	25.2	24.6	24.1	23.5	23.0	22.4
55	34.0	33.0	32.0	31.0	30.0	29.0	28.4	27.8	27.2	26.6	26.0	25.4	24.8	24.2	23.6	23.0
57	34.8	33.8	32.8	31.8	30.8	29.8	29.2	28.5	27.9	27.2	26.6	26.0	25.4	24.8	24.2	23.6
59	35.6	34.6	33.6	32.6	31.6	30.6	29.9	29.2	28.6	27.9	27.2	26.6	26.0	25.4	24.8	24.2
61	36.4	35.4	34.4	33.4	32.4	31.4	30.7	30.0	29.2	28.5	27.8	27.2	26.6	26.0	25.4	24.8
63	37.2	36.2	35.2	34.2	33.2	32.2	31.4	30.7	29.9	29.2	28.4	27.8	27.2	26.6	26.0	25.4
65	38.0	37.0	36.0	35.0	34.0	33.0	32.2	31.4	30.6	29.8	29.0	28.4	27.8	27.2	26.6	26.0

PT Charts for Common Refrigerants, Continued

PSIG	Temper	ature °Fał	nrenheit	PSIG	Temperature °Fahrenheit		nrenheit
"Hg	R-410A	R-22	R-134A	"Hg	R-410A	R-22	R-134A
-5	-66	-48	-22	33	-13	10	38
-4	-64	-47	-21	34	-12	11	39
-3	-63	-45	-19	35	-11	12	40
-2	-62	-44	-18	36	-10	13	41
-1	-61	-43	-16	37	-9	14	42
0	-60	-41	-15	38	-8	15	43
1	-59	-39	-12	39	-7	16	44
2	-58	-37	-10	40	-6	17	45
3	-55	-34	-8	42	-4	19	46
4	-54	-32	-5	44	-3	21	48
5	-52	-30	-3	46	-2	23	50
6	-50	-28	-1	48	0	24	51
7	-48	-26	1	50	1	26	52
8	-46	-24	3	52	3	28	54
9	-44	-22	5	54	4	29	56
10	-42	-20	7	56	6	31	57
11	-40	-19	8	58	7	32	59
12	-39	-17	10	60	8	34	60
13	-38	-15	12	62	10	35	64
14	-36	-14	13	64	11	37	65
15	-34	-12	15	66	13	38	66
16	-33	-11	16	68	14	40	68
17	-32	-9	18	70	15	41	69
18	-30	-8	19	72	16	42	71
19	-29	-7	21	74	17	44	72
20	-28	-5	22	76	19	45	73
21	-27	-4	24	78	20	46	75
22	-26	-3	25	80	21	48	76
23	-25	-1	26	85	24	51	79
24	-24	0	27	90	26	54	82
25	-22	1	29	95	29	56	85
26	-20	2	30	100	32	59	88
27	-19	4	31	105	34	62	90
28	-18	5	32	110	36	64	94
29	-17	6	33	115	39	67	96
30	-16	7	35	120	41	69	98
31	-15	8	36	125	43	72	100
32	-14	9	37	130	45	74	103

PT Charts for Common Refrigerants, Continued

PSIG	Temperature °Fahrenheit			
"Hg	R-410A	R-22	R-134A	
135	47	76	105	
140	49	78	107	
145	51	81	109	
150	53	83	112	
155	55	85	114	
160	57	87	116	
165	58	89	118	
170	60	91	120	
175	62	92	122	
180	64	94	123	
185	66	96	125	
190	67	98	127	
200	70	100	129	
205	72	102	131	
210	73	103	132	
220	76	104	134	
230	79	108	137	
240	82	114	140	
250	84	117	143	
260	87	120	146	
275	90	124	149	
290	93	128	153	
305	97	132	157	
320	99	136	162	
335	104	139	166	
350	107	143	171	
365	109	146	174	
380	114	149	177	
405	118	182	182	
500	134	202	202	
600	149	$>\!$	$>\!$	

The following quiz is a class exercise designed to act as a review before you begin field exercises.

1. What is the correction factor? NSOP 0.45"WC, TFSOP 0.50"WC: ______

2. What is the correction factor? NSOP 0.32"WC TFSOP 0.28"WC: ______

3. What is the raw flow? Plate pressure 0.675"WC, #20 plate: ______

4. What is the raw flow? Plate pressure 0 .275"WC, #14 plate: ______

- 5. What is the corrected flow? NSOP 0.30"WC, TFSOP0.36"WC, #14 plate, Plate Pressure 0.455" WC:
- 6. What is the corrected flow? NSOP 0.24"WC, TFSOP 0.18"WC, # 20 plate, Plate Pressure 0.325" WC:
- 7. On the sketch of the air handler below, indicate which location gives you the correct NSOP measurement location for a heat pump:
 - a. #1
 - b. #3
 - c. #4
- 8. Draw lines from the numbers indicating duct location (picture below) to the manometer showing where the external static pressure measurement should be taken.



1 | Page

9. Draw lines (extend off of the red and green hoses in the picture) to show where the flow plate connects to the manometer.





This brochure is intended to be a quick reference guide to sizing heat pumps in compliance with the PTCS program. The goal is greater comfort, less cycling, fewer customer complaints, and lower auxiliary heat use.

1. Importance of Heat Pump Sizing



2. Heat Loss/Heat Gain Analysis

- Manual J calculates heat loss/heat gain.
- Manual S guides in the selection process.
- Manual D guides duct design.



3. Manual J Heating Load Inputs

Below are the critical inputs to consider when determining heating loads and the seven heat pump sizes to choose from.



1.5 2.0 2.5 3.0 3.5 4.0 5.0 ton ton ton ton ton ton ton

4. Manual J Cooling Load Inputs

Below are the critical inputs to consider when determining cooling loads and the seven heat pump sizes to choose from.



5. Duct Multipliers (Typically 5–20%)

Duct multipliers are often an educated guess. Use the ranges below for estimating duct multipliers.

- 0%: Ducts inside conditioned space.
- 10%: Tight and insulated.
- 20%: Leaky or disconnected ducts outside conditioned space.
- **30%**: Leaky old ducts under rodent barrier in manufactured home.
- 20% or More: Ducts should be fixed.

6. Balance Point

Balance Point: Lowest outdoor temperature for which the output of the heat pump can heat the house by using the compressor only.

- Below this temperature, the strip heat is needed to help heat the house.
- If it's a gas backup heat pump, use economic considerations to determine balance point (usually around 40°F).



7. Heat Pump Savings

Keeping the electric strip heat off is the key to maximizing energy savings from heat pumps.

Savings depend on:

- Correct sizing
- · Controls that minimize use of strip heat
- · A high-efficiency heat pump



8. Strip Heat

To minimize the use of strip heat:

- Size the compressor large enough to provide all the heat needed as long as the outdoor temperature is above 30°F.
- Set strip heat lockout at or below 35°F to prevent unnecessary strip heat use.
- Encourage homeowners to avoid setback temperatures more than 2°F.



9. Cooling Load

Do not forget cooling load calculations. Total Cooling Load = Sensible and Latent

- · Sensible: Involves lowering the temperature.
- Latent: Involves removing water vapor from the air (dehumidification).
- · Cooling will reduce both temperature and moisture.
- The selected unit must take care of both sensible and latent loads to maintain comfort.
- In the Northwest, assume low latent cooling loads and select a low indoor wet bulb design temperature in most cases.

10. Consider the Details

- · Insulation levels (none, some, fair amount, a lot).
- House tightness: Usually between .35 and .8 ACH.
- Windows:
 - » U-value is critical! 0.3–0.4 for vinyl.
 - » If Solar Heat Gain Coefficient (SHGC) is unknown, use same value as U-value.
 - » Consider orientation/direction.
- Duct multiplier: Between 0% and 20%. If it's worse than that, fix it.
- · House size.
- Capacity of heat pump at desired balance point.
- Pick the right weather station.

View Our Training Videos At:

PTCS Online School: clearesult.moodle.school PTCS Registry: ptcs.bpa.gov

YouTube: youtube.com/user/BPATraining/videos

PTCS Heat Pump Sizing Reference Guide





Contact PTCS at ResHVAC@bpa.gov or 1.800.941.3867

PTCS Lockouts and Balance Points: Reference Guide

Importance of Lockouts

- Lockout controls minimize use of strip heat, maximizing energy savings.
- Incorrect lockout settings result in the majority of inspection failures.

Auxiliary (Strip) Heat Lockout

PTCS Spec: Set auxiliary heat lockout to 35°F or lower. Controlled through:

- · Thermostat connected to Wi-Fi weather station.
- · Thermostat paired with outdoor temperature sensor.
- · Outdoor unit control board or mechanical lockout.

Compressor Lockout

While not required by the PTCS Spec, they should be disengaged to let the compressor run at all outdoor temps. Honeywell

Note: Set auxiliary (strip) heat lockout at or below 35°F.

Note: Let the compressor run at all outdoor temperatures.

Balance Point

If system is not sized correctly, you run into comfort issues when strip heat is locked out.

- Balance point can be no greater than 30°F.
- · Heat pump capacity drops at colder temperatures.

Note: Some manufacturers use different terminology for lockouts, such as "high balance point" referring to the strip heat lockout temperature or "low balance point" referring to the compressor lockout temperature.

PTCS Resources

For more information on the PTCS program visit:

PTCS Online School: clearesult.moodle.school

PTCS Registry: ptcs.bpa.gov

YouTube: youtube.com/user/BPATraining/videos





PTCS[®] Training Evaluation

Training Type and Date:					
Trainer Name:					
I am a: Technician Utility Representative Con	tractor Re	presentati	ve	🗌 Otł	ner
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The trainer was prepared and organized.	1	2	3	4	5
The trainer followed the training material.	1	2	3	4	5
The trainer was helpful.	1	2	3	4	5
The trainer was easy to understand.	1	2	3	4	5
The trainer spent enough time answering questions.	1	2	3	4	5
The trainer had knowledge of the PTCS Program.	1	2	3	4	5
I felt the exercises/site visits were useful.	1	2	3	4	5
There was a good balance of hands-on and in-classroom learning.	1	2	3	4	5
I felt comfortable asking questions during the training.	1	2	3	4	5
I feel like I know who to go to if I have any questions.	1	2	3	4	5
The training materials will be good for future reference.	1	2	3	4	5
I know what I need to do to successfully install and PTCS certify jobs in the field now.	1	2	3	4	5
I understand the form requirements and know how to enter jobs into the mobile registry.	1	2	3	4	5

I felt the pace of the training was...

Too Slow	Just Right	🗌 Too Fast	Comments?
----------	------------	------------	-----------

I felt the overall length of the training was...

Too Short Just Right

Too Long Comments?

1

Other comments (positive or negative):

When complete, please hand this to your trainer. Thank you for your feedback! You are helping improve this process for future technicians.



Updated April 2018