Davis Field Inspector's Guide

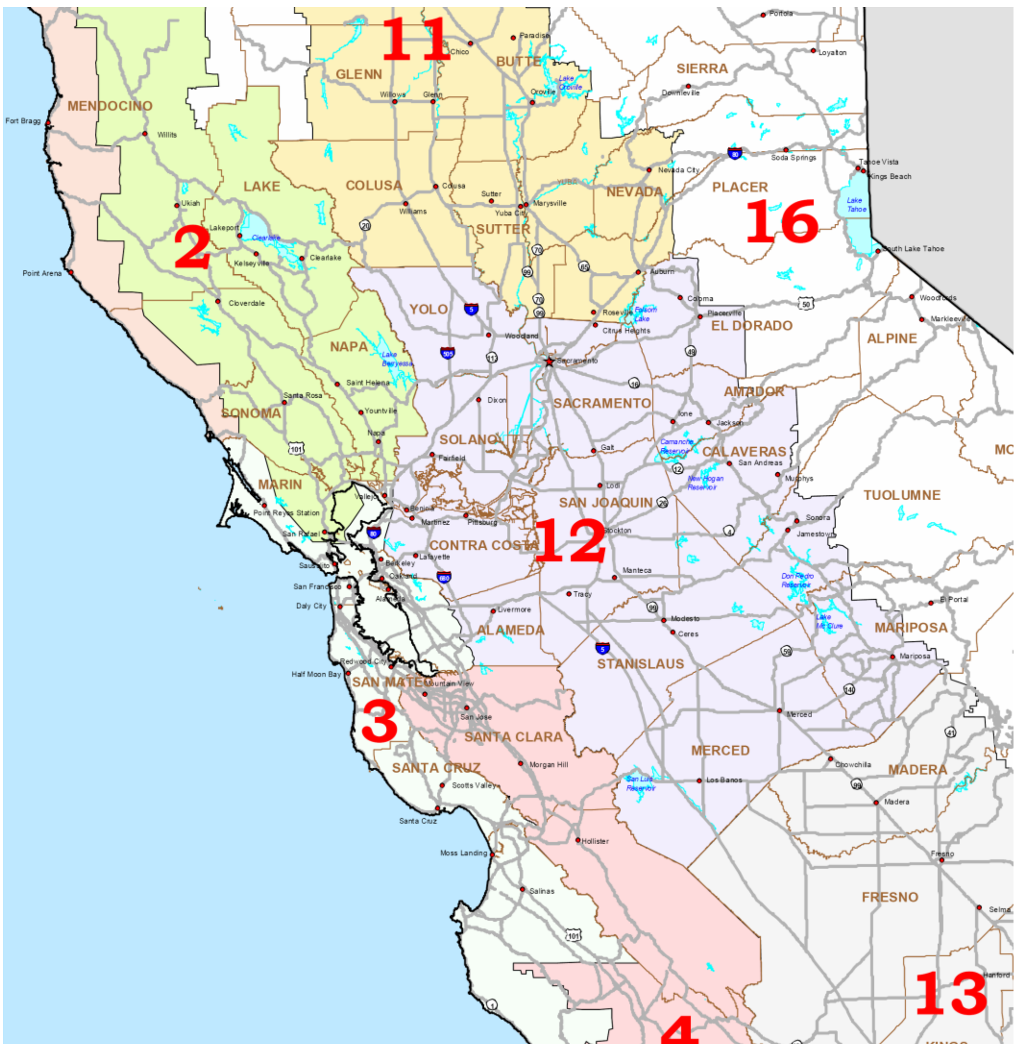
TO THE

2008 Energy Code

FOR PRESCRIPTIVE COMPLIANCE OF

Refrigerant Charge & Airflow

FOR RESIDENTIAL ALTERATIONS



Davis Field Guide #3

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Preface

The ***Davis Field Guide*** to the 2008 Energy Code for prescriptive compliance for Refrigerant Charge & Airflow for residential alterations is a guide for those who need to understand in laymen's language the new code that went into effect for permits issued on or after January 1st, 2010. This guide assumes you have a basic knowledge of the Title 24 code and with this knowledge we attempt to simplify the prescriptive requirements. The information in this guide was taken from publications from the California Energy Commission and are deemed accurate at time of this publication. References from these publications will be noted when applicable. Since this is time sensitive material, if you have any questions about the code or any changes, call the energy hotline at the California Energy Commission (CEC) for any changes or clarifications at:

1-800-772-3300.

We hope you enjoy and use this guide to simplify your life!

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Refrigerant Charge and Airflow:

This information is found in the Residential Compliance Manual, chapter 8 section 8.4.2 "Prescriptive Requirements". We will also make reference to the 2008 Building Energy Efficiency Standards or "Standards".

In climate zones 2, 8-15, when a new or replacement or altered split system is installed (air conditioning or heat pump), there must be a refrigerant charge measurement completed and verified by a HERS rater. Besides a refrigerant charge measurement, new for 2008, Standard 151(f)7A states:

"When refrigerant charge measurement or charge indicator display is shown as required by TABLE 151-B, TABLE 151-C or TABLE 151-D, ducted split system central air conditioners and ducted split system heat pumps shall:

i. Have temperature measurement access holes (TMAH) saturation temperature measurement sensors (STMS), and proper refrigerant charge confirmed through field verification and diagnostic testing in accordance with procedures set forth in the Reference Residential Appendix RA3.2"

Before you get too worried, let's break it down.

Alterations:

What is an altered system? The Standard 152(b)1Fii states:

"When a space-conditioning system is "altered" by the installation or replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, cooling or heating coil, or the furnace heat exchanger, the following requirements shall be met:

ii. Meet the refrigerant charge and airflow requirements of Reference Residential Appendix RA3."

To clarify, even if there is a changeout of a furnace only and there is an existing split system air conditioner; you must meet the above requirement.

There are two different refrigerant charge procedures. We will focus on the Standard charge measurement procedure and comment on the Alternate charge measurement (Weigh-in method) later.

- The Standard procedure shall be completed when the outdoor temperature is 55°F or higher.
- If the outdoor temperature is between 55°F and 65°F the return dry bulb temperature shall be maintained 70°F or above during the test.

There are two Standard Charge Measurement procedures:

- **Superheat Method**
  - ✓ For fixed orifice systems
  - ✓ Determined by calculating the difference between evaporator saturation temperature and suction line temperature.

- **Subcool Method**
  - ✓ For systems with a TXV (expansion valve).
  - ✓ Determined by calculating the difference between condenser saturation temperature and liquid line temperature.
  - ✓ Superheat is verified to confirm the TXV is working properly

The proper procedure for either standard charge measurement can be found in the Residential Appendix RA3.2.2.5 which states:

The following procedure shall be used to obtain measurements necessary to adjust required refrigerant charge as described in the following sections:

1.If the condenser air entering temperature is less than 65ºF, establish a return air dry bulb temperature sufficiently high that the return air dry bulb temperature will be not less than 70ºF prior to the measurements **at the end of the 15-minute period** in step 2.

2. Connect the refrigerant gauges to the service ports, taking normal precautions to not introduce air into the system.

3. Turn the cooling system on and let it run for ***15 minutes*** to stabilize temperatures and pressures **before taking any measurements.** While the system is stabilizing, proceed with setting up the temperature sensors.

4. Attach one pipe temperature sensor to the suction line near the suction line service valve and attach one pipe temperature sensor to the liquid line near the liquid line service valve.

5. Attach a temperature sensor to measure the condenser entering air dry-bulb temperature. The sensor shall be placed so that it records the average condenser air entering temperature and is shaded from direct sun.

6. Be sure that all cabinet panels that affect airflow are in place before making measurements. The temperature sensors shall remain attached to the system until the final charge is determined.

7. Place wet-bulb temperature sensor (cotton wick) in water to ensure it is saturated when needed. **Do not get the dry-bulb temperature sensors wet.**

8. Insert the dry-bulb temperature sensor in the supply plenum at the "Title 24 – Supply Temperature Access" detailed in Section RA3.2.2.2.2.

9. At 12 minutes, insert a dry-bulb temperature sensor and a wet-bulb temperature sensor into the return plenum at the "Title 24 – Return Temperature Access" detailed in Section RA3.2.2.2.2.

10. At 15 minutes when the return plenum wet-bulb temperature has stabilized, using the temperature sensors already in place, measure and record the return (evaporator entering) air dry-bulb temperature (Treturn, db) and the return (evaporator entering) air wet-bulb temperature (Treturn, wb).

11. Using the dry-bulb temperature sensor already in place, measure and record the supply (evaporator leaving) air drybulb temperature (Tsupply, db).

12. Using the refrigerant gauge or saturation temperature measurement sensor already attached, measure and record the evaporator saturation temperature (Tevaporator, sat) from the low side gauge.

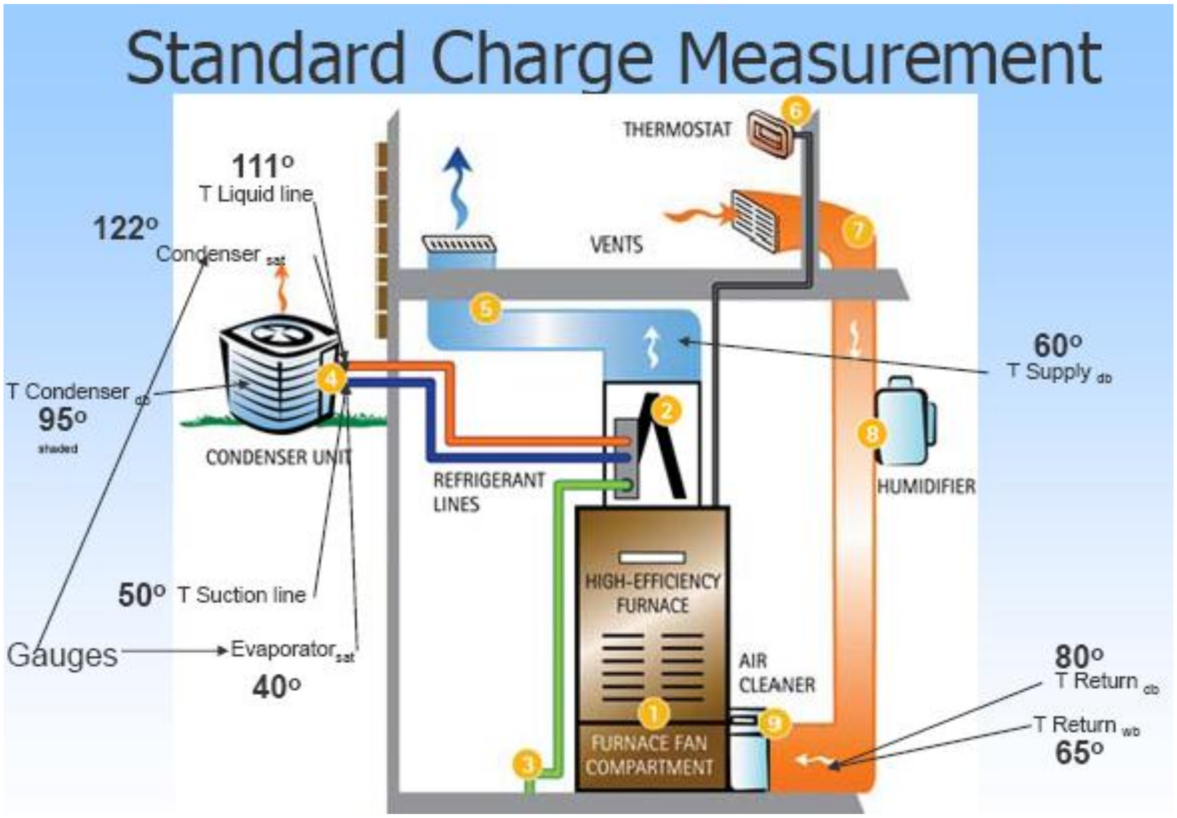
13. Using the refrigerant gauge or saturation temperature measurement sensor already attached, measure and record the condenser saturation temperature (Tcondenser, sat) from the high side gauge.

14. Using the pipe temperature sensor already in place, measure and record the suction line temperature (Tsuction,).

15. Using the pipe temperature sensor already in place, measure and record the liquid line temperature (Tliquid).

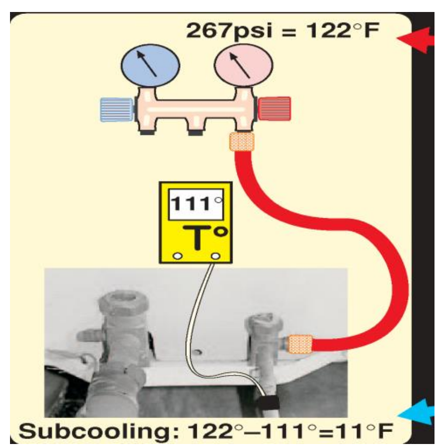
16. Using the dry-bulb temperature sensor already in place, measure and record the condenser (entering) air dry-bulb temperature (Tcondenser, db).

Essentially, we are taking eight (8) measurements across the system.
5 of the temperatures are taken at the condensing unit and 3 are taken at the inside unit at the plenums.



Since most newly installed split systems have an expansion valve (TXV or EXV), we will start with the ***Subcool method***.

- Actual Subcool = $T_{condenser,\ sat} - T_{liquid,\ db}$
- Subcool Verification Standard = Actual Subcool °F – Target Subcool °F
- For the **Installer**, If the difference is between **minus 3°F and plus 3°F**, then the system **passes** this part of the required refrigerant charge criterion.



In the example graphic to the right, we convert the high side gauge from PSI to the corresponding temperature for the particular refrigerant being used. This is typically found right on the gauge itself or you can use a conversion chart.

The liquid line temperature is taken with a dual channel capable digital thermometer.

In our example the temperature of the refrigerant is 122 degrees. Our liquid line temperature is 111 degrees. From the formula above, that would be 122 – 111 for an actual subcool of 11 degrees.

We use the manufacturer's target subcool (typically found on the nameplate or inside the access panel on the condenser). There is no rule of thumb and we cannot assume just any number. Target subcool varies from each manufacturer and different efficiencies and we must use a real number from the manufacturer.

If the target subcool from the manufacturer is 9 degrees, the installer's actual subcool would need to be *between* 6 – 12 degrees (+/- 3 degrees) to pass the subcool requirement. In our example, 11 degrees would be a pass.

Note: If the charge is adjusted, <u>you must wait 15 minutes for the system to stabilize before taking a final measurement.</u>

Metering device calculation is also required to confirm the expansion valve is working properly. This is essentially a superheat calculation. Since the expansion valve regulates the superheat in the refrigeration system, it is important it is working properly.

Calculate Actual Superheat as the suction line temperature minus the evaporator saturation temperature. These temperatures are taken off the low side gauge and suction line temperature.

Actual Superheat = Tsuction, – Tevaporator, sat.

In our prior graphic, our suction line temperature was 50°F and our low side gauge was 40°F. 50°F - 40°F = 10°F superheat.

If possible, determine the Superheat Range specified by the manufacturer.

For the Installer, if the superheat is within the manufacturer's superheat range, then the system **passes** the metering device criterion. If the manufacturer's specification is not available and the superheat is *between* 4°F and 25°F, then the system **passes** the metering device criterion.

We still need to pass the airflow test which we will discuss shortly. Next, let's discuss fixed metering devices (no expansion valve).

Fixed Metering Device Calculations

The **Superheat Charging Method** is used only for systems equipped with **fixed metering devices**. These include capillary tubes and piston-type metering devices.

1. Calculate Actual Superheat as the suction line temperature minus the evaporator saturation temperature.

2. Determine the Target Superheat using Table RA3.2-2 using the return air wet-bulb temperature (Treturn, wb) and condenser air dry-bulb temperature (Tcondenser, db).

3. If a dash mark is read from Table RA3.2-2, the target superheat is less than 5°F. Note that **a valid refrigerant charge verification test cannot be performed under these conditions**. The usual reason for a target superheat determination of less than 5°F is that outdoor conditions are too hot and dry. One of the following is needed so a target superheat value can be obtained from Table RA3.2-2 either

> a) turn on the space heating system and/or open the windows to warm up indoor temperature; or
> b) retest at another time when conditions are different. Repeat the measurement procedure as necessary to establish the target superheat. Allow system to stabilize for 15 minutes before the final measurements are taken.

4. Calculate the difference between actual superheat and target superheat (Actual Superheat – Target Superheat).

5. For the Installer, if the difference is between minus 5°F and plus 5°F, then the system **passes** the required refrigerant charge criterion.

6. For the Installer, if the difference is greater than plus 5°F, then the system **does not pass** the required refrigerant charge criterion and the Installer shall add refrigerant. Adjust refrigerant charge and check the measurements as many times as necessary to pass the test. After the final adjustment has been made, **allow the system to run 15 minutes before completing the final measurement procedure**.

7. For the Installer, if the difference is between minus 5°F and minus100°F, then the system **does not pass** the required refrigerant charge criterion, the Installer shall remove refrigerant. Adjust refrigerant charge and check the measurements as many times as necessary to pass the test. After the final adjustment has been made, **allow the system to run 15 minutes before completing the final measurement procedure.**

Airflow:

In order to have a valid charge test, the airflow shall be verified by passing the temperature split test. Alternatively, one of the three measurements in RA3.3 (flow hood, flow grid or plenum pressure matching) may be used with a measured airflow in excess of 300 cfm/ton. This is handy if you cannot pass using the temperature split method. The duct blaster can be used for the plenum pressure matching option. Plenum pressure matching instructions can be found at the end of this section, Appendix A. If a system fails, then remedial actions must be taken.

If the airflow is changed and the refrigerant charge has previously been tested, then the refrigerant charge shall be re-tested. Be sure to run the air conditioner for 15 minutes after the final adjustments before taking any measurements.

Both the airflow and charge must be re-tested until they simultaneously pass.

1. Calculate the Actual Temperature Split as the return air dry-bulb temperature minus the supply air drybulb temperature. Actual Temperature Split = Treturn, db - Tsupply, db

2. Determine the Target Temperature Split from Table RA3.2-3 using the return air wet-bulb temperature (Treturn, wb) and return air dry-bulb temperature (Treturn, db).

3. If a dash mark is read from Table RA3.2-3 then there probably was an error in the measurements because the conditions in this part of the table would be extremely unusual. If this happens, re-measure the temperatures. If re-measurement results in a dash mark, complete one of the alternate airflow measurements in Section RA3.3.

4. Calculate the difference between target and actual temperature split (Actual Temperature Split-Target Temperature Split).

5. For the Installer,

   a) If the difference is between plus 3°F and minus 3°F, then the system **passes** the adequate airflow criterion.

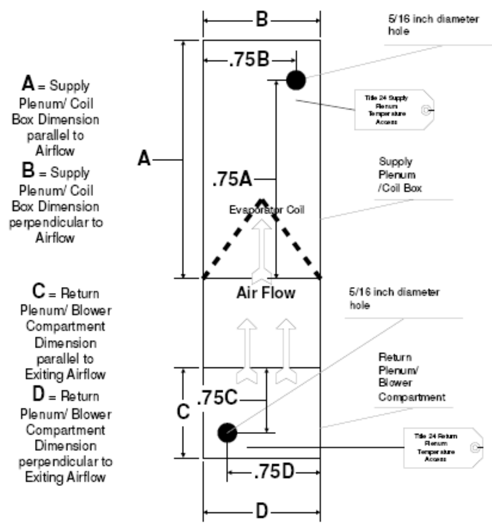
   b) If the difference is greater than plus 3°F, then the system **does not pass** the adequate airflow criteria and the airflow shall be increased by the installer. Increasing airflow can be accomplished by eliminating restrictions in the duct system, increasing blower speed, cleaning filters, or opening registers.

If these actions do not result in adequate airflow, additional repairs may be necessary to correct the airflow (i.e. cleaning the blower, cleaning the indoor coil, modifying the duct system; measures that would decrease static pressure).

After corrective measures are taken, repeat the measurement procedure as often as necessary to establish adequate airflow. **After the final adjustment, allow the system to stabilize for 15 minutes before taking the final measurements.**

If the difference is greater than minus 3°F, re-measure to confirm the average temperature of the airflow. If upon re-measurement it is still greater than minus 3°F, it is a pass. Airflow that is greater than minus 3°F is typically higher than average.

Along with the refrigerant charge measurement, new for 2008, Temperature Measurement Access Holes (TMAH) must be installed---with labels--- by the contractor and HERS verified. This is to allow the HERS rater a non-intrusive method to verify the airflow using the temperature split method.



New or replacement space-conditioning system:

(All new equipment, all new ductwork. May include existing boots and plenums, if accessible for sealing)

If the new or replacement space conditioning system (in an existing residential building) is located in climate zones 2, 8, or 9, the HERS required "RCA" measure is the same as those for an alteration. You can stop reading---you're done!

If the new or replacement space conditioning system (in an existing residential building) is located in climate zones 10-15, HERS required measures are the same as those for an alteration PLUS two additional HERS required measures along with the requirement for the contractor providing static pressure probe access and installing saturation temperature measurement sensors.

Additional measure 1:

Cooling Coil Airflow:

The airflow must be at least 350 cfm per nominal ton and be measured (temperature split method is not allowed) and verified by a HERS rater. This measurement can be done with plenum pressure matching, a flow grid device or a flow capture hood. Refer to Residential Appendix RA3.

For example, a 5 ton system must have a minimum measured airflow of 1,750 cfm (5 times 350 equals 1,750).

Additional measure 2:

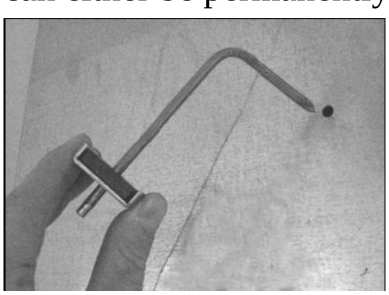
Fan Watt Draw:

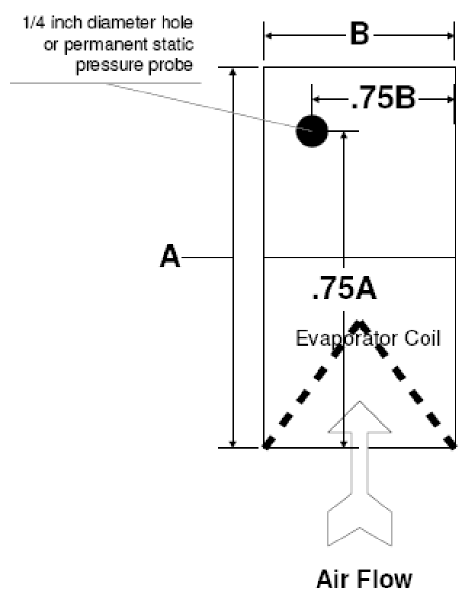
The actual measured (cfm) is multiplied by a factor of 0.58. That is the maximum fan watt draw that is allowed and must be HERS verified. Refer to Residential Appendix RA3.

Example:
A 5 ton system has an actual measured airflow of 1825 cfm. Multiply 1,825 times 0.58. That is 1,058.5. If your measurement is equal to or below that, it is a pass.

Static Pressure Probe (Access):

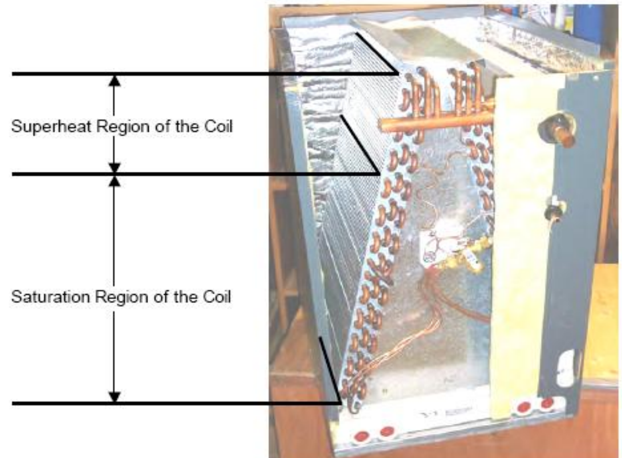
Since cooling coil airflow must be measured, plenum pressure matching and flow grid methods require reading the static pressure off the supply plenum. The static pressure probe can either be permanently installed or the contractor can drill an access hole for one—label it--- so the HERS rater can use a non-intrusive method to read the static pressure.



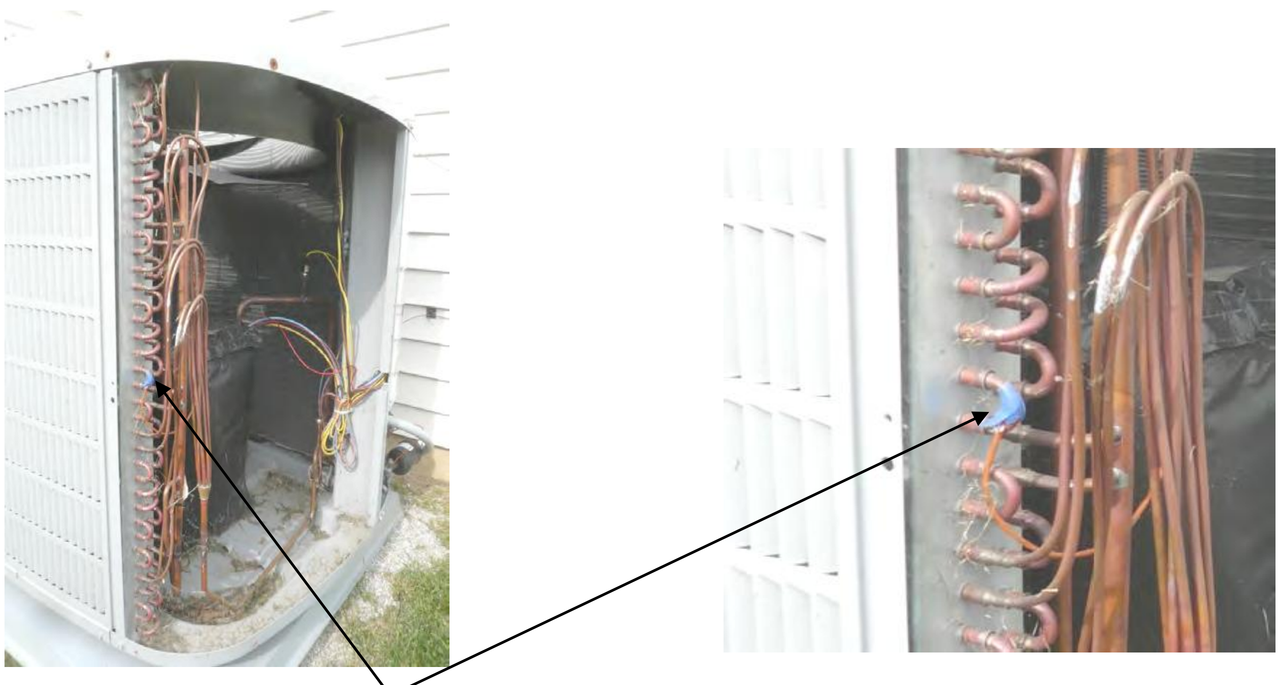


Saturation Temperature Measurement Sensors (STMS):

This is another non-intrusive method for the HERS rater to complete a refrigerant charge measurement. STMS are installed at the saturation region of the condenser and evaporative coil. With a K type thermocouple, the HERS rater can "plug in" the STMS and read the temperature on a meter instead of attaching refrigerant gauges to the refrigerant lines thus potentially allowing refrigerant to escape and skewing the measurement results.



Evaporative Coil
(interior view)



Condenser Coil with STMS attached

Final Note on Refrigerant Charge Measurement:

A valid refrigerant charge measurement by a HERS rater can only be done when the outside (ambient dry bulb at the condenser) is 55^0 or higher (standard charge measurement method). An installer is allowed to perform a "weigh-in" method for compliance but a HERS rater must use the standard charge measurement method. The enforcement agency (building department) may accept the installer's Certificate of Installation (CF-6R-Mech-26-HERS) weigh-in method to close out or "final" the permit with the certification from the installer that when a HERS verification is completed, if such verification demonstrates the refrigerant charge measurement does not pass, the installer, at no charge to the homeowner, will return and correct the charge (Residential Appendix RA2.4.4). If an installer uses the weigh-in method, it cannot be part of a sample group and must be HERS verified using the standard charge measurement method.

We also recommend when wanting to use the temperature split method for airflow compliance, Table RA3.2-3 temperature range is 70 – 84 degrees, regardless of the outdoor temperature (condenser, db) you must maintain the indoor (return, db) temperature within this range to use the chart.

You may have noticed that we reference "split systems", that is because package units are exempt from the refrigerant charge measurement requirement.

Unlike the duct sealing and testing requirement, the refrigerant charge requirement does not have a 40' duct length in unconditioned space rule. This HERS required measure must be performed regardless on the length of the duct system, in unconditioned space or not. The installation of a charge indicator display (CID), if verified by a HERS rater, may be used as an alternative to the prescriptive requirement for HERS diagnostic testing of the refrigerant charge in split system air conditioners and heat pumps. In other words, if a CID is installed, no refrigerant charge measurement is required---that is because the CID is a refrigerant charge measurement device! As of this publication, there is currently no CID on the market.

Target Superheat (no expansion valve):

Table RA3.2-2 Target Superheat (Suction Line Temperature - Evaporator Saturation Temperature)

Condenser Air Dry-Bulb Temperature (°F) ($T_{condenser,db}$)	Return Air Wet-Bulb Temperature (°F) ($T_{return,wb}$)																										
	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
55	8.8	10.1	11.5	12.8	14.2	15.6	17.1	18.5	20.0	21.5	23.1	24.6	26.2	27.8	29.4	31.0	32.4	33.8	35.1	36.4	37.7	39.0	40.2	41.5	42.7	43.9	45.0
56	8.6	9.9	11.2	12.6	14.0	15.4	16.8	18.2	19.7	21.2	22.7	24.2	25.7	27.3	28.9	30.5	31.8	33.2	34.6	35.9	37.2	38.5	39.7	41.0	42.2	43.4	44.6
57	8.3	9.6	11.0	12.3	13.7	15.1	16.5	17.9	19.4	20.8	22.3	23.8	25.3	26.8	28.3	29.9	31.3	32.6	34.0	35.3	36.7	38.0	39.2	40.5	41.7	43.0	44.2
58	7.9	9.3	10.6	12.0	13.4	14.8	16.2	17.6	19.0	20.4	21.9	23.3	24.8	26.3	27.8	29.3	30.7	32.1	33.5	34.8	36.1	37.5	38.7	40.0	41.3	42.5	43.7
59	7.5	8.9	10.2	11.6	13.0	14.4	15.8	17.2	18.6	20.0	21.4	22.9	24.3	25.7	27.2	28.7	30.1	31.5	32.9	34.3	35.6	36.9	38.3	39.5	40.8	42.1	43.3
60	7.0	8.4	9.8	11.2	12.6	14.0	15.4	16.8	18.2	19.6	21.0	22.4	23.8	25.2	26.6	28.1	29.6	31.0	32.4	33.7	35.1	36.4	37.8	39.1	40.4	41.6	42.9
61	6.5	7.9	9.3	10.7	12.1	13.5	14.9	16.3	17.7	19.1	20.5	21.9	23.3	24.7	26.1	27.5	29.0	30.4	31.8	33.2	34.6	35.9	37.3	38.6	39.9	41.2	42.4
62	6.0	7.4	8.8	10.2	11.7	13.1	14.5	15.9	17.3	18.7	20.1	21.4	22.8	24.2	25.5	27.0	28.4	29.9	31.3	32.7	34.1	35.4	36.8	38.1	39.4	40.7	42.0
63	5.3	6.8	8.3	9.7	11.1	12.6	14.0	15.4	16.8	18.2	19.6	20.9	22.3	23.6	25.0	26.4	27.8	29.3	30.7	32.2	33.6	34.9	36.3	37.7	39.0	40.3	41.6
64	-	6.1	7.6	9.1	10.6	12.0	13.5	14.9	16.3	17.7	19.0	20.4	21.7	23.1	24.4	25.8	27.3	28.7	30.2	31.6	33.0	34.4	35.8	37.2	38.5	39.9	41.2
65	-	5.4	7.0	8.5	10.0	11.5	12.9	14.3	15.8	17.1	18.5	19.9	21.2	22.5	23.8	25.2	26.7	28.2	29.7	31.1	32.5	33.9	35.3	36.7	38.1	39.4	40.8
66	-		6.3	7.8	9.3	10.8	12.3	13.8	15.2	16.6	18.0	19.3	20.7	22.0	23.2	24.6	26.1	27.6	29.1	30.6	32.0	33.4	34.9	36.3	37.6	39.0	40.4
67	-	-	5.5	7.1	8.7	10.2	11.7	13.2	14.6	16.0	17.4	18.8	20.1	21.4	22.7	24.1	25.6	27.1	28.6	30.1	31.5	33.0	34.4	35.8	37.2	38.6	39.9
68	-	-	-	6.3	8.0	9.5	11.1	12.6	14.0	15.5	16.8	18.2	19.5	20.8	22.1	23.5	25.0	26.5	28.0	29.5	31.0	32.5	33.9	35.3	36.8	38.1	39.5
69	-	-	-	5.5	7.2	8.8	10.4	11.9	13.4	14.8	16.3	17.6	19.0	20.3	21.5	22.9	24.4	26.0	27.5	29.0	30.5	32.0	33.4	34.9	36.3	37.7	39.1
70	-	-	-	-	6.4	8.1	9.7	11.2	12.7	14.2	15.7	17.0	18.4	19.7	20.9	22.3	23.9	25.4	27.0	28.5	30.0	31.5	33.0	34.4	35.9	37.3	38.7
71	-	-	-	-	5.6	7.3	8.9	10.5	12.1	13.6	15.0	16.4	17.8	19.1	20.3	21.7	23.3	24.9	26.4	28.0	29.5	31.0	32.5	34.0	35.4	36.9	38.3
72	-	-	-	-	-	6.4	8.1	9.8	11.4	12.9	14.4	15.8	17.2	18.5	19.7	21.2	22.8	24.3	25.9	27.4	29.0	30.5	32.0	33.5	35.0	36.5	37.9
73	-	-	-	-	-	5.6	7.3	9.0	10.7	12.2	13.7	15.2	16.6	17.9	19.2	20.6	22.2	23.8	25.4	26.9	28.5	30.0	31.5	33.1	34.6	36.0	37.5
74	-	-	-	-	-	-	6.5	8.2	9.9	11.5	13.1	14.5	15.9	17.3	18.6	20.0	21.6	23.2	24.8	26.4	28.0	29.5	31.1	32.6	34.1	35.6	37.1
75	-	-	-	-	-	-	5.6	7.4	9.2	10.8	12.4	13.9	15.3	16.7	18.0	19.4	21.1	22.7	24.3	25.9	27.5	29.1	30.6	32.2	33.7	35.2	36.7
76	-	-	-	-	-	-	-	6.6	8.4	10.1	11.7	13.2	14.7	16.1	17.4	18.9	20.5	22.1	23.8	25.4	27.0	28.6	30.1	31.7	33.3	34.8	36.3
77	-	-	-	-	-	-	-	5.7	7.5	9.3	11.0	12.5	14.0	15.4	16.8	18.3	20.0	21.6	23.2	24.9	26.5	28.1	29.7	31.3	32.8	34.4	36.0
78	-	-	-	-	-	-	-	-	6.7	8.5	10.2	11.8	13.4	14.8	16.2	17.7	19.4	21.1	22.7	24.4	26.0	27.6	29.2	30.8	32.4	34.0	35.6
79	-	-	-	-	-	-	-	-	5.9	7.7	9.5	11.1	12.7	14.2	15.6	17.1	18.8	20.5	22.2	23.8	25.5	27.1	28.8	30.4	32.0	33.6	35.2
80	-	-	-	-	-	-	-	-	-	6.9	8.7	10.4	12.0	13.5	15.0	16.6	18.3	20.0	21.7	23.3	25.0	26.7	28.3	29.9	31.6	33.2	34.8
81	-	-	-	-	-	-	-	-	-	6.0	7.9	9.7	11.3	12.9	14.3	16.0	17.7	19.4	21.1	22.8	24.5	26.2	27.9	29.5	31.2	32.8	34.4
82	-	-	-	-	-	-	-	-	-	5.2	7.1	8.9	10.6	12.2	13.7	15.4	17.2	18.9	20.6	22.3	24.0	25.7	27.4	29.1	30.7	32.4	34.0
83	-	-	-	-	-	-	-	-	-	-	6.3	8.2	9.9	11.6	13.1	14.9	16.6	18.4	20.1	21.8	23.5	25.2	26.9	28.6	30.3	32.0	33.7
84	-	-	-	-	-	-	-	-	-	-	5.5	7.4	9.2	10.9	12.5	14.3	16.1	17.8	19.6	21.3	23.0	24.8	26.5	28.2	29.9	31.6	33.3
85	-	-	-	-	-	-	-	-	-	-	-	6.6	8.5	10.3	11.9	13.7	15.5	17.3	19.0	20.8	22.6	24.3	26.0	27.8	29.5	31.2	32.9
86	-	-	-	-	-	-	-	-	-	-	-	5.8	7.8	9.6	11.3	13.2	15.0	16.7	18.5	20.3	22.1	23.8	25.6	27.3	29.1	30.8	32.6
87	-	-	-	-	-	-	-	-	-	-	-	5.0	7.0	8.9	10.6	12.6	14.4	16.2	18.0	19.8	21.6	23.4	25.1	26.9	28.7	30.4	32.2
88	-	-	-	-	-	-	-	-	-	-	-	-	6.3	8.2	10.0	12.0	13.9	15.7	17.5	19.3	21.1	22.9	24.7	26.5	28.3	30.1	31.8
89	-	-	-	-	-	-	-	-	-	-	-	-	5.5	7.5	9.4	11.5	13.3	15.1	17.0	18.8	20.6	22.4	24.3	26.1	27.9	29.7	31.5
90	-	-	-	-	-	-	-	-	-	-	-	-	-	6.8	8.8	10.9	12.8	14.6	16.5	18.3	20.1	22.0	23.8	25.6	27.5	29.3	31.1
91	-	-	-	-	-	-	-	-	-	-	-	-	-	6.1	8.1	10.3	12.2	14.1	15.9	17.8	19.7	21.5	23.4	25.2	27.1	28.9	30.8
92	-	-	-	-	-	-	-	-	-	-	-	-	-	5.4	7.5	9.8	11.7	13.5	15.4	17.3	19.2	21.1	22.9	24.8	26.7	28.5	30.4
93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.8	9.2	11.1	13.0	14.9	16.8	18.7	20.6	22.5	24.4	26.3	28.2	30.1
94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2	8.7	10.6	12.5	14.4	16.3	18.2	20.2	22.1	24.0	25.9	27.8	29.7
95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.6	8.1	10.0	12.0	13.9	15.8	17.8	19.7	21.6	23.6	25.5	27.4	29.4
96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.5	9.5	11.4	13.4	15.3	17.3	19.2	21.2	23.2	25.1	27.1	29.0
97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.0	8.9	10.9	12.9	14.9	16.8	18.8	20.8	22.7	24.7	26.7	28.7
98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.4	8.4	10.4	12.4	14.4	16.4	18.3	20.3	22.3	24.3	26.3	28.3
99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.8	7.9	9.9	11.9	13.9	15.9	17.9	19.9	21.9	24.0	26.0	28.0
100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.3	7.3	9.3	11.4	13.4	15.4	17.5	19.5	21.5	23.6	25.6	27.7
101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.8	8.8	10.9	12.9	15.0	17.0	19.1	21.1	23.2	25.3	27.3
102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2	8.3	10.4	12.4	14.5	16.6	18.6	20.7	22.8	24.9	27.0
103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.7	7.8	9.9	11.9	14.0	16.1	18.2	20.3	22.4	24.5	26.7
104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.2	7.2	9.3	11.5	13.6	15.7	17.8	19.9	22.1	24.2	26.3
105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	8.8	11.0	13.1	15.2	17.4	19.5	21.7	23.8	26.0
106	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2	8.3	10.5	12.6	14.8	17.0	19.1	21.3	23.5	25.7
107	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.7	7.9	10.0	12.2	14.4	16.6	18.7	21.0	23.2	25.4
108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.2	7.4	9.5	11.7	13.9	16.1	18.4	20.6	22.8	25.1
109	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	9.1	11.3	13.5	15.7	18.0	20.2	22.5	24.7
110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.4	8.6	10.8	13.1	15.3	17.6	19.9	22.1	24.4
111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.9	8.1	10.4	12.6	14.9	17.2	19.5	21.8	24.1
112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.4	7.6	9.9	12.2	14.5	16.8	19.1	21.5	23.8
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.2	9.5	11.8	14.1	16.4	18.8	21.1	23.5
114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	9.0	11.4	13.7	16.1	18.4	20.8	23.2
115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2	8.6	10.9	13.3	15.7	18.1	20.5	22.9

Target Temperature Split

Table RA3.2-3 Target Temperature Split (Return Dry-Bulb – Supply Dry-Bulb)

Return Air Dry-Bulb (°F) ($T_{return,db}$)	Return Air Wet-Bulb (°F) ($T_{return,wb}$)																										
	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
70	20.9	20.7	20.6	20.4	20.1	19.9	19.5	19.1	18.7	18.2	17.7	17.2	16.5	15.9	15.2	14.4	13.7	12.8									
71	21.4	21.3	21.1	20.9	20.7	20.4	20.1	19.7	19.3	18.8	18.3	17.7	17.1	16.4	15.7	15.0	14.2	13.4	12.5								
72	21.9	21.8	21.7	21.5	21.2	20.9	20.6	20.2	19.8	19.3	18.8	18.2	17.6	17.0	16.3	15.5	14.7	13.9	13.0	12.1							
73	22.5	22.4	22.2	22.0	21.8	21.5	21.2	20.8	20.3	19.9	19.4	18.8	18.2	17.5	16.8	16.1	15.3	14.4	13.6	12.6	11.7						
74	23.0	22.9	22.8	22.6	22.3	22.0	21.7	21.3	20.9	20.4	19.9	19.3	18.7	18.1	17.4	16.6	15.8	15.0	14.1	13.2	12.2	11.2					
75	23.6	23.5	23.3	23.1	22.9	22.6	22.2	21.9	21.4	21.0	20.4	19.9	19.3	18.6	17.9	17.2	16.4	15.5	14.7	13.7	12.7	11.7	10.7				
76	24.1	24.0	23.9	23.7	23.4	23.1	22.8	22.4	22.0	21.5	21.0	20.4	19.8	19.2	18.5	17.7	16.9	16.1	15.2	14.3	13.3	12.3	11.2	10.1			
77	-	24.6	24.4	24.2	24.0	23.7	23.3	22.9	22.5	22.0	21.5	21.0	20.4	19.7	19.0	18.3	17.5	16.6	15.7	14.8	13.8	12.8	11.7	10.6	9.5		
78	-	-	-	24.7	24.5	24.2	23.9	23.5	23.1	22.6	22.1	21.5	20.9	20.2	19.5	18.8	18.0	17.2	16.3	15.4	14.4	13.4	12.3	11.2	10.0	8.8	
79	-	-	-	-	-	24.8	24.4	24.0	23.6	23.1	22.6	22.1	21.4	20.8	20.1	19.3	18.5	17.7	16.8	15.9	14.9	13.9	12.8	11.7	10.6	9.4	8.1
80	-	-	-	-	-	-	25.0	24.6	24.2	23.7	23.2	22.6	22.0	21.3	20.6	19.9	19.1	18.3	17.4	16.4	15.5	14.4	13.4	12.3	11.1	9.9	8.7
81	-	-	-	-	-	-	-	25.1	24.7	24.2	23.7	23.1	22.5	21.9	21.2	20.4	19.6	18.8	17.9	17.0	16.0	15.0	13.9	12.8	11.7	10.4	9.2
82	-	-	-	-	-	-	-	-	25.2	24.8	24.2	23.7	23.1	22.4	21.7	21.0	20.2	19.3	18.5	17.5	16.6	15.5	14.5	13.4	12.2	11.0	9.7
83	-	-	-	-	-	-	-	-	-	25.3	24.8	24.2	23.6	23.0	22.3	21.5	20.7	19.9	19.0	18.1	17.1	16.1	15.0	13.9	12.7	11.5	10.3
84	-	-	-	-	-	-	-	-	-	25.9	25.3	24.8	24.2	23.5	22.8	22.1	21.3	20.4	19.5	18.6	17.6	16.6	15.6	14.4	13.3	12.1	10.8

Appendix A

Plenum Pressure Matching:

Test Procedure For Measuring Air Handler Flow (When indoor dry bulb [Treturn, db] is below 70 degrees or above 84 degrees, or cannot pass temperature split method)

Step 1: Measuring the NSOP

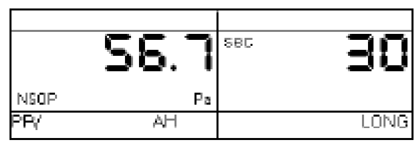
- Open a window or door between the building and outside to prevent pressure changes in the building during the test. If the air handler fan is installed in an unconditioned zone (e.g. crawlspace, attic), open any vents or access doors connecting that zone to the outside (or to the building) to prevent pressure changes in the zone during the test.
- Make sure all supply and return registers are open and untapped. **Filters must be in place**. Turn on the air handler.

- Insert a static pressure probe into the supply plenum, or in a main supply trunk line a few feet away from the supply plenum. Make sure the static pressure probe is pointing into the air flow created by the air handler fan.

- Connect a piece of tubing to the static pressure probe. Connect the other end of the tubing to the **Channel A Input** tap on the DG-700.

- Turn on the gauge and put it the **PR/ AH** mode by pressing the **MODE** button. The icon "NSOP" will begin to flash in the **Channel A** display, indicating that the **PR/ AH** measurement feature has been initiated. At this point, the gauge is monitoring the real-time **Channel A NSOP** pressure, but is not recording the reading. The **Channel B** display is not active at this time.

- Press the **START** button to begin the **NSOP** measurement procedure on **Channel A**. Once the **START** button is pressed, the icon "NSOP" stops flashing and the gauge begins recording a ***long term average*** **NSOP** pressure reading on **Channel A**. During the measurement procedure, the **Channel B** display is used as a timer to let the user know how long (in seconds) the NSOP measurement has been active. The longer the measurement time, generally the more stable the reading typically becomes. In the screen to the right, the measured NSOP pressure is 56.7 Pascals (measured over the past 30 seconds).



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

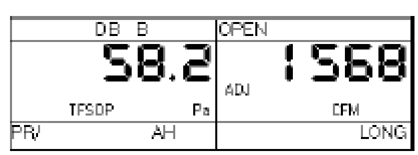
Step 2: Measuring the TFSOP and Adjusted Air Handler Flow

- Once the **NSOP** measurement is made and entered into the gauge (**Step 1**), the gauge is set up to simultaneously measure the Test Flow System Operating Pressure (**TFSOP**) on **Channel A**, and to display the estimated air handler flow rate on **Channel B**.

The Duct Blaster fan is typically installed at the air handler cabinet. However, if this test is being performed on a single return duct system, and the return ductwork is substantially airtight, the Duct Blaster fan may be installed at the single return. Multiple return systems must use the air handler cabinet; seal off the return opening in the cabinet from the air handler fan using tape and cardboard. Connect Duct Blaster Fan to **Channel B**.

- Select the installed test device (DB B) and device configuration (OPEN) on the DG-700 using the **DEVICE** and **CONFIG** buttons.

Turn on the air handler. Now turn on and adjust the Duct Blaster fan (along with the air handler fan) so that the **TFSOP** reading on **Channel A** is close to the **NSOP** reading entered into the gauge in **Step 1**. There is no need to exactly match the **NSOP** and **TFSOP** pressures, because the gauge is making an adjustment to the measured Duct Blaster fan flow using a flow resistance correction factor calculated from the **NSOP** and **TFSOP** pressure readings. If the readings are fluctuating, change the time averaging setting to ***5 second***, ***10 second***, *or* ***long-term average*** using the **TIME AVG** button.



Notes:

Make sure to check the calibration of gauges and temperature sensors at least monthly.

Be sure to tape the temperature sensors securely to the liquid and suction lines and use insulating tape to be sure to get an accurate reading. If you don't like one of the readings---check the temperature at a different location on the refrigerant line to see if you received a bad reading or to confirm you were right.

If you get a bad temperature split (too high) double check the placement of the supply temperature hole. Are you too close to the coil and getting a false reading from a cold spot? Double check at a couple of registers to confirm your supply readings. If so, drill another hole and recheck.

About the Author:

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Greg is the lead CBPCA HERS trainer and has been a Certified HERS Rater for many years. He has been a strong advocate for building performance and the Home Energy Rating System (HERS). Greg has used his diverse experience to help facilitate in the writing of the 2008 Building Standards and developed the CBPCA HERS classroom and training materials. He has first-hand experience implementing the Title 24 Energy Efficiency Standards and understands the challenges building departments face in ensuring code compliance.

About the Publisher:

The ***California Building Performance Contractors Association*** (CBPCA) is a non-profit organization that was formed in 2001 as an answer to our state's increasingly scarce and expensive energy supply. CBPCA was formed to encourage a revolution in home improvement by introducing "building performance contracting" to California's 13 million-plus homes.

CBPCA is the only organization in California that delivers integrated training in energy efficiency, indoor comfort, healthier indoor air, and a safer, more durable building. Our Home Performance with Energy Star training curriculum includes HVAC systems, attic and wall insulation, air infiltration, duct sealing and moisture control, just to name a few.

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