UPG
Technical Services

APPLICATION ENGINEERING BULLETIN Number # AE-001-05

TOPIC: Airflow Measurement Using Electric Heat (Single Phase)[1]

SCOPE & PURPOSE:

- The purpose of this bulletin is to show how airflow in cubic feet per minute can be measured when electric heat is installed. Examples of systems using electric heat include air handlers with electric heat, heat pumps with auxiliary electric heat elements and remote VAV boxes using electric reheat.

- Correct airflow is essential to the proper operation of heating and cooling systems. The following method may be used to determine the airflow while using the electric heat, then that measured airflow will still be correct for other modes of operation as long as the fan speed remains unchanged. Airflow in CFM (Cubic Feet per Minute) does not change with changes in temperature.[2] Therefore, as long as this method of measuring airflow is used with the supply air fan operating at the speed (RPM) for which you want to know the CFM, the measured airflow will remain the same no matter what the air temperature and as long as the selected fan speed remains unchanged.

CONTENT:

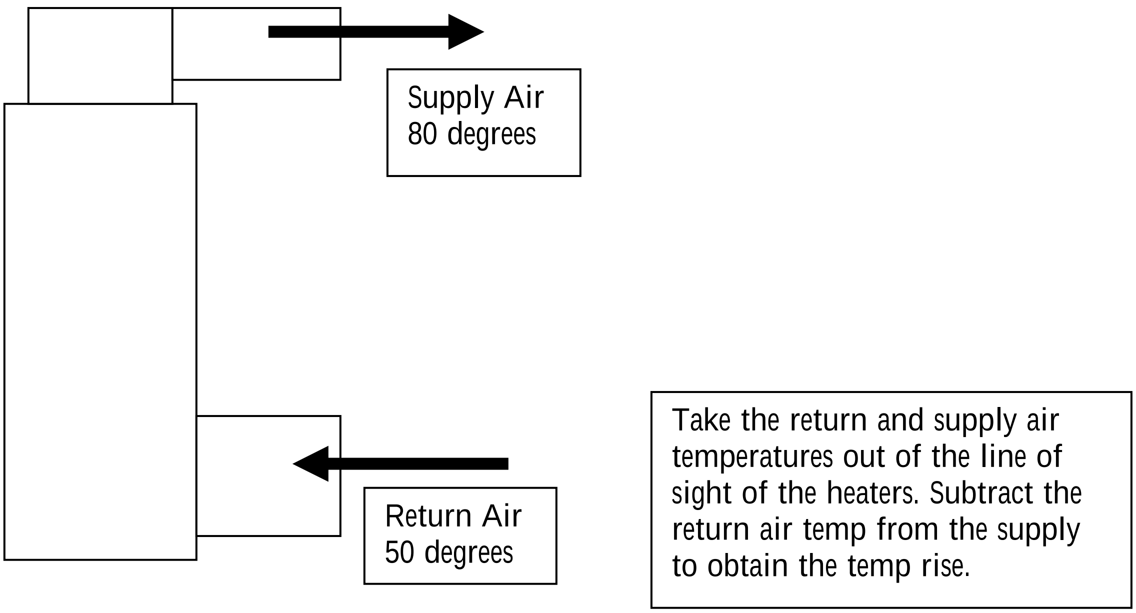
Measuring airflow has always been one of the more difficult and time consuming tasks a service person does. Most service technicians check the airflow by measuring the temperature drop across the cooling coil or the temperature rise across a heating system. If the air temperature drop or rise falls within an expected range, the assumption is the airflow is acceptable. The following method of measuring the airflow through a system also uses temperature differential but results in an actual CFM value. This

[1] Another Application Bulletin is available for heaters connected to three-phase.
[2] Changes in the temperature of air, changes the density of the air (lbs per cubic foot) but the airflow rate in CFM remains constant. Therefore, the measured CFM remains accurate for any particular motor speed even if the air temperature changes such as between the heating and cooling modes.

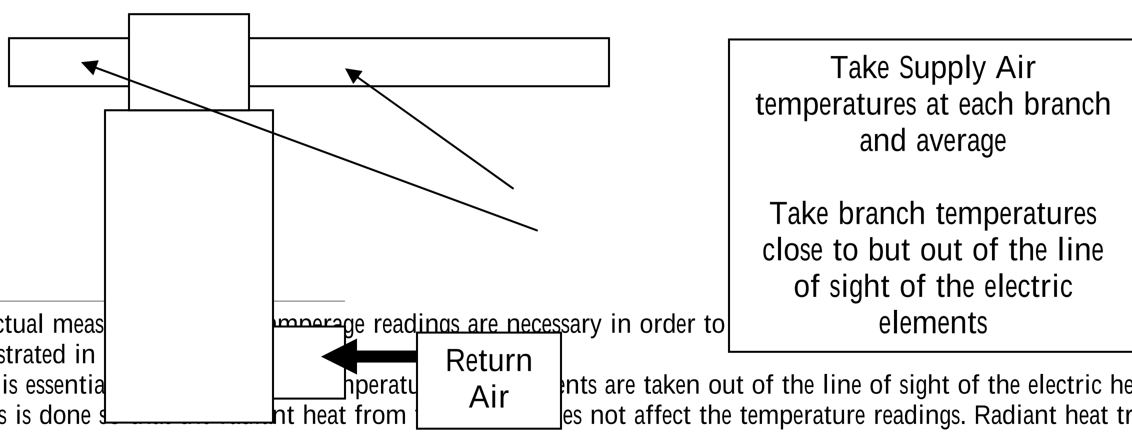
method applies wherever electric heat is found. Electric heaters are often utilized for reheat as well as for emergency heat on heat pumps.

Operate the system with the heat enabled and on. Allow the system to run long enough to reach stabilized conditions before measuring any values. Measure the voltage at the heater and the amperage thru the heater. Use actual measured values. Do not use the name plate or rated voltage and amperage.[3]

Assume an electric reheat coil draws 25 amps at 240 volts. Take the temperature rise of the air as it passes through the electric heater and find that the air is heated from 50 degrees to 80 degrees. That is a 30-degree rise in air temperature.



When applying this airflow measurement method to a residential system where two or more trunks tie directly into the furnace plenum, it will be necessary to take air temperatures in each plenum and then average each reading. See illustration below.[4]



[3] Actual meas[illegible]mperage readings are necessary in order to [illegible]quation illustrated in [illegible]

[4] It is essentia[illegible]nperatu[illegible]nts are taken out of the line of sight of the electric heat elements. This is done s[illegible]nt heat from [illegible]es not affect the temperature readings. Radiant heat travels in straight lines therefore, moving the thermometer out of the line of sight of the heaters solves the problem.

Use the following equation to determine the BTUH of the heater. Use measured voltage, amperage and temperature rise. Do not use the name plate wattage, voltage or amperage in the equation.

BTUH[5] = Voltage X Amperage X 3.42[6]

Now multiply the 25 amps by the 240 volts to find that the wattage output of the heater is 6000 watts. Since there are 3.42 Btu per watt, multiply the 6000 watts by 3.42 to find that the electric heater is adding 20,520 btuh to the air. This amount of heat is increasing the air temperature by 30 degrees.

Now multiply the 30 degrees by the constant 1.08[7] to get a number, which can be divided, into the 20,520 Btu to find the airflow in CFM.

Multiplying the 1.08 by 30 degrees of rise gives the number of 32.4. Divide the 20,520 by this factor of 32.4 and you find that the CFM of air is 633 CFM.

$$\text{CFM} = \frac{\text{BTUH}}{1.08 \text{ times Temp Rise}}$$

$$\text{CFM} = \frac{20{,}520 \text{ btuh}}{1.08 \text{ times } 30}$$

$$\text{CFM} = \frac{20{,}520 \text{ btuh}}{32.4}$$

[5] Do not use the unit rated capacity in BTUH in this equation when calculating for airflow in CFM. For accurate airflow actual operating heating capacity must be used. This is most easily accomplished when working with a system utilizing an electric heating element such as used on most heat pumps or electric reheat in VAV boxes.

[6] The value 3.42 is the number of BTU produced by each watt of electric heat. This value has been established thru careful lab testing.

[7] The 1.08 multiplier is not some mysterious magic number. This number includes the specific heat of air (.24 btu per pound per degree F). It takes .24 Btu of heat to change the temperature of one pound of air by one degree Fahrenheit. The 1.08 also contains the specific density of air (.075 pounds per cubic foot). The air is measured in CFM yet the specific heat is per pound of air. The weight per cubic foot of air (.075 lbs) is needed to convert between the air volume and weight. Also contained in the 1.08 factor is the number of minutes in an hour (60 minutes per hour). This is required to convert between Btu per *hour* and cubic feet per *minute*. The factor of 1.08 is the product of the specific heat (.24 btu) times the density (.075 lbs cubic foot) times the number of minutes per hour (60 min\hour).

$$CFM = \frac{20{,}520 \text{ btuh}}{32.4}$$

$$CFM = 633.3$$

The factor 1.08 assumes standard air at 70 degrees F at sea level.[8] For practical purposes on most air conditioning and heating systems, the specific heat of .24 will remain a good useable constant. Since there will always be 60 minutes in each hour, this too is a fixed constant. Should we find ourselves at an altitude other than sea level however, the density of the air may change enough to affect the accuracy of our formula. The following list of factors for different altitudes gives the adjusted factor due to the change in the air density for that altitude.

Sea level	1.08	5000 feet	.90
1000 feet	1.04	6000 feet	.86
2000 feet	1.00	7000 feet	.83
3000 feet	.96	8000 feet	.80
4000 feet	.93	9000 feet	.77[9]

Be careful when taking the temperature readings so as not to allow the thermometers to be in the line of sight of the heaters. If the thermometers are placed in sight of the heaters, radiant heat from the heaters will increase the temperature readings and give a false airflow rate. It is the temperature rise of the air that we are looking for, not the temperature of the heaters.

The formula used here for determining CFM comes from the sensible heat formula:

BTUH = 1.08 X CFM X Temperature Change.[10]

[8] Although temperature can also affect these values, the values listed for each altitude are accurate as long as the air temperatures fall within those reasonable for normal heating and cooling applications. Any supply or return air temperatures outside of the normally expected heating & cooling range would also fall outside of the operational range of the equipment thus the equipment should not be used for such an application anyway.

[9] Above 9,000 feet these values decrease more rapidly and are not linear decreases. Fifty percent of the Earth's atmosphere lies within the first 3.5 miles. Ninety percent of the Earth's atmosphere lies within 16 miles of the Earth's surface. Atmospheric air density decreases rapidly with altitude, especially at altitudes over 9,000 feet.

SUMMARY/CONCLUSION:

- This method of determining the airflow through a heat pump can be used to determine the CFM with the heaters turned on and the CFM will be the same when the heat pump is in the heating or cooling cycle. Whether the air is being heated or cooled, the airflow rate in CFM is the same. The air density in pounds per cubic foot changes but the CFM does not.
- The accuracy of this method of measuring airflow depends upon the locations of and accuracy of the temperature measurements, the accuracy of the voltage and current readings and following the stated procedure.
- Do not attempt to apply the information in this bulletin to a gas or any other fossil fuel heating system. A variation of this method is available for use on fossil fuel heating systems.

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KEY WORDS (For searches)

- Airflow
- Temperature Rise
- Temperature Differential
- Electric Heat
- CFM Measurement
- Altitude Adjustment
- Altitude Correction

This is one bulletin in a series which are being made available in an effort to answer commonly asked regarding the application, installation, operation, service and troubleshooting of York, Luxaire and Coleman heating and cooling equipment.

[10] The terms "temperature change", "temperature rise" and "delta T" all mean the same thing. Each refers to the change in temperature of the air as it is heated by any of several heating devices such as an electric heater, gas furnace, hot water or steam coil.