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Find Gallons Per Minute Using System Temperatures

When flow measurement stations (like balancing valves) aren't built into a system, you can still calculate gpm through a hydronic system using a few simple measurements.

By Rob 'Doc' Falke

This is a follow-up to Doc's last Hotmail article, Unbalanceable Hydronic System Solutions. Readers asked, "How do I find Gallons Per Minute (gpm) when a hydronic system doesn't have flow measurement stations?"

When flow measurement stations (like balancing valves) aren't built into a system, you can still calculate gpm through a hydronic system using a few simple measurements. Let's take a look at which water temperature measurements you can take, and the math needed for this simple gpm diagnostic test.

To avoid overwhelming you, I'll use a very basic example of a small hot water HVAC system with a boiler and air handler.

Physics

While many of us had little interest in physics when we were in school, most of us use it every day. Physics deals with the nature and properties of matter and energy. It harnesses how they work together. You use the principles of physics to improve HVAC system performance.

Formulas are of little value unless you can use the knowledge from them to accomplish something. Notice how the formulas that follow are turned into step-by-step instructions to help you find the information you need. Once you find the answer, it becomes clear what you must do to improve system performance.

Water Heat Transfer Formula - Btu

Hydronic systems built to be balanced are equipped so you can directly measure system and equipment gpm. This primary water heat transfer formula is used to calculate system delivered Btu when gpm is known. This is not the formula to calculate gpm, but understanding it is a bridge to easily flow calculations.

The formula is Btu/hr. = GPM x Δt x 500. Reviewing this formula will make it much easier to use the GPM variation coming up next.

In this example, our diagnostic test and calculation steps will follow the order of the formula:

Step One: GPM

- Connect the hydro-manometer to the balancing valve serving the air handler or coil. Measure water pressure and interpret and record system gpm. For our example, assume the gpm is 8.8.

Step Two: Δt

- Measure the water temperature entering and exiting the coil with a clamp-on type temperature probe. Read and record the two temperatures.
- Subtract the two temperatures to find the water temperature change (Δt) over the coil. For this example, assume the Δt is 26.2 degrees F.

Step Three: 500

- Multiply the two numbers found in the previous steps times 500 to find water-delivered Btu through the coil.
- Example: GPM x Delta t degrees x 500 = Water side Btu/hour. The measured gpm through the balancing valve was 8.8 gpm. The measured water temperature change (Δt) through the coil is 26.2 degrees. Apply these numbers to the formula and you get 8.8 gpm x 26.2 degrees Δt x 500 = 115,280 Btu/hour.

If the air handler's rated heating capacity is 120,000 Btu/hr., you're doing well. If the air handler's rated heating capacity is 250,000 Btu/hr., Houston, we have a problem.

Water Heat Transfer Formula: GPM
The secondary water heat transfer formula will help you find GPM moving through equipment. The GPM formula is GPM = Air side Btu ÷ (measured water Δt x 500).

We'll walk through this version of the formula in a little greater detail. Since the portion of the formula in parenthesis is to be completed first, we'll organize the steps you'll take in the field accordingly.

Step One: Δt

- Measure the Δt entering and exiting the coil of the air handler using a clamp-on type dry bulb temperature probe. Read and record the two temperatures.
- Subtract the two temperatures to find the water side Δt across the coil.

Example: Water temperature entering the hot water coil is 168.4°. As the air through the coil removes heat from the water, the temperature of the water decreases to 136.3 degrees. Subtract 168.4 degrees - 136.3 degrees to find water side Δt across the coil of 31.1 degrees.

Step Two: 500

Multiply temperature change times 500 to find the formula divisor. Example: Coil water temperature change of 31.1 degrees x 500 = 15,550.

- This is the divisor in the formula to calculate air handler gpm.

Step Three - Air Btu

- The next step is to find Btu/hr. delivered from the air side of the air handler.
- This number can come from two sources: First, you can use the hot water coil rated Btu/hr. in the air handler. Assume this air handler's rated heating Btu is 50,000.
- Second, you can measure the Air Btu delivery through the air hander. This test method is the most accurate, but it requires more effort. Technicians who measure equipment performance know installed equipment rarely performs as rated because of installation defects. *Contact Doc for a test procedure to measured Airside Btu Delivery.*

Step Four – Work the calculation

- With the test data and information in hand, you're prepared to calculate the gpm moving through the air handler.
- Apply the calculation GPM = Air Btu ÷ (Δt x 500). Remember to complete the calculation in parenthesis first.
- Divide the Airside Delivered Btu of 50,000 by 15,550 to find 3.2 gpm through the coil.

To summarize, you can increase your hydronic systems diagnostic ability by measuring a couple temperatures, subtracting and dividing to find gpm when test ports and valves aren't available. Hopefully your future will be filled with hydronic systems including balancing valves. If not, perhaps this test and calculation method will help you out of a tight spot.

Rob "Doc" Falke serves the industry as president of National Comfort Institute, Inc., an HVAC-based training company and membership organization. If you're an HVAC contractor or technician interested in a free test procedure describing how to measure delivered Btu through an air system, contact Doc at robf@ncihvac.com or call him at 800-633-7058. Go to NCI's website at nationalcomfortinstitute.com for free information, articles, and downloads.