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Common hydronic terms…

I was recently called in to help size a heat exchanger for a Jacuzzi application. It seems the customer wanted to maintain the tub at 75°F when it was not in use and then hit a button and raise the setpoint to 105°F. They were looking for help in calculating the load and what size heat exchanger was needed to do the job.

The first thing we had to do was establish the load and how quickly the customer wanted the Jacuzzi to come up to the 105°F setting. To do this, we needed to know the volume of water we had, the temperature rise and the time table. Here is what we had for information: the Jacuzzi held 600 gallons of water and was maintaining temperature at 75°F. The customer wanted to raise the tub to 105°F in a one-hour time frame.

The first step was to convert the gallons of water into pounds of water. Why? We will get into that later, but it has to do British Thermal Units (BTUs). Six hundred gallons multiplied by 8.33 (the weight of one gallon of water at 60°F which is an acceptable number throughout most heating applications) = 4,998. Next, we multiply this by the temperature rise needed: 4,998 multiplied by 30°F = 149,940 BTUs. And since the customer said that a one hour time frame was acceptable, these 149,940 BTUs is the amount of energy required to raise 600 gallons (or 4998lbs.) of water 30°F in one hour. If two hours was an acceptable time frame, then the load would be 149,940/2 = 74,970 BTU/H. If they wanted the Jacuzzi heated in only 30 minutes the load would be 149,940 x 2 = 299,880 BTU/H. If they wanted it heated to 105°F in ten minutes, the load would be 149,940 x 6 = 899,640 BTU/H. We base everything on BTU/H because all of our heat sources are rated in BTUs per hour. Once we calculate the load, then we include the time factor.

What is a BTU? It is an expression of energy. An English man named Thomas Tredgold wrote a heating book back in the early 1800's called *Warming and Ventilating of Buildings*. In this book, he used the term "British Thermal Unit". He took a pound of water and heated it from 62°F to 63°F. He decided that one British Thermal Unit (BTU) was the amount of energy (heat) required to raise one pound of water one degree Fahrenheit. So this term that we use dozens of times a day in the heating business was made up 200 years ago! We almost think of BTUs as the Holy Grail of heating and, in reality, it is just an energy term made up by a heating engineer who was trying to quantify what happens when one pound of water is heated up one degree Fahrenheit. That is why we had to convert the gallons of water in the Jacuzzi to pounds of water in order to calculate the required BTU load.

If we were going to provide a circulator to pump boiler water through one side of the plate & frame heat exchanger to heat the Jacuzzi, we would have to calculate the necessary flow rate. To establish the proper flow, which is expressed as gallons per minute (GPM), we would start with the load. GPM = BTU/H / 500 x delta T; BTU/H is the load, 500 is the weight of a gallon of water (8.33) multiplied by sixty minutes in an hour (to convert BTUs per hour into gallons per minute) and the delta T is the design temperature drop that the system water will experience as it delivers the design load, which is usually selected at 20°F. So, when establishing flow rate, it is necessary to convert gallons to pounds and introduce a time factor (60 minutes equals one hour). If we were to use the above Jacuzzi example to calculate the required GPM, it would look like this; 149,940 BTU/H divided by 10,000 = 14.9 GPM. (10,000 is 500 multiplied by the design temperature drop of 20°F).

If you have had the chance to work on a steam system, you probably have come across the expression "*A Square Foot of Steam*". This came from the early days of steam heating and was used to describe the capacity of a radiator. The very first radiators looked like the one seen in **Figure 1**. The capacity of the radiator was derived from the square foot surface area of the radiator. The manufacturer said that one square foot of surface was equal to one square foot of radiation. Which means *what*? Back to our friend Thomas Tredgold. He not only gave us the expression *British Thermal Units*, he also came up with the term *Square Feet of Radiation*. A square foot of steam is equal to 240 BTU/H when the steam

Figure 1

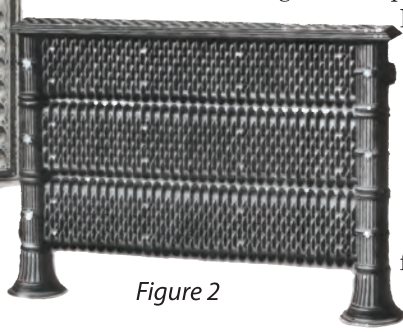

Figure 2

inside the radiator is 215°F (which, by the way, is about 1psi of steam pressure) and the room air is 70°F. This was Tredgold's definition of a square foot.

You might have also heard the term EDR or Equivalent Direct Radiation. This evolved from the term *"A Square Foot of Radiation."* Radiator manufacturers were responding to increasing demands from the public to change the style and size of radiators. They didn't want them to be as large and take up so much space. To achieve this while still providing adequate capacities, the manufacturers had to provide more surface area to a device that was taking up less space in the room (see **Figure 2** p.33). This change also required a new term to describe the capacity of these new style radiators and thus EDR became the term to describe a square foot of steam. The Equivalent amount of Direct Radiation meant *if* this new style of radiator looked liked the older flat style and had *this* amount of square foot surface area, which equates to *this* amount of Square Feet of Radiation.

An interesting side note that Dan Holohan has always talked about was the issue of actually *measuring* the capacity of these new fancier style radiators. As Dan tells the story, the manufacturers came up with an ingenious way of calculating the radiator's actual square foot surface area. They took a large vat and filled it with paint and then weighed it. They would then take a radiator, with all its holes plugged, hang it from a chain and lower it into the vat, letting it sit inside there for a while. Then they would raise the radiator up, let it drip dry over the vat and then re-weigh the vat. The difference was the amount of paint clinging to *all* of the outside surfaces of the radiator.The last step was to put that amount of paint into a can and then proceed to paint the floor with the paint. Whatever number of square feet of floor was covered became the square foot EDR rating for that radiator! Years later, after more exact methods came into play to establish radiator capacities, they went back and compared the modern methods to the Paint Method and found that the results were very close.

Consider this information the next time you are asked to set a pressure-trol: all of the radiators installed in the house are capable of keeping the house at 70°F with 215°F steam (1psi) even on the coldest day of the year. When the steam piping was selected and installed, it was chosen from a pressure drop column of 1oz per 100 feet of pipe. You don't need pressure to drive steam out into the system, you need good air venting to remove *any* air found in the piping and radiation.

If you have any questions or comments, email gcarey@fianic.com, call (800) 423-7187 or follow me on Twitter at @Ask_GCarey.