G.A.S.

Heat Allocation Meters

Supplemental Guide

Updated January 13, 2011

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EMS²
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FURNACE HEATING SYSTEMS

Heat output from a **forced hot air furnace (FHA)** is provided when the main gas valve is opened allowing gas flow to the main furnace. The FHA is a constant BTUH output device. This means that the amount of heat delivered per hour (while the main burner operates) is constant as measured in BTUH. The amount of heat delivered appears as the BTUH output rating on the furnace model number name plate and is typically in the range of 40,000 to 100,000 BTUH.

GAS_T METERING SYSTEM

The **GAS_T** wireless metering module is designed to accurately meter FHA systems with 24VAC gas valves. The 24VAC control wires to the main gas valve are connected to the 24VAC input on the GAS_T module which measures the length of time (better than 1 second resolution) that the gas valve is open and the main burner is operating.

This operating time is converted to counts of 1 per 36 seconds (.01 hour) of FHA operation and output to the Inovonics 5201-Ext transmitter for transmission through the Tapwatch Hardware/software system.

Error detection circuitry is incorporated in the design of the GAS_T module in order to detect disconnected wires from the GAS_T module to the gas valve wires. Error codes from this circuitry to the Inovonics 5201-Ext transmitter allow the meter reading/billing provider to precisely determine if service is required to reconnect wires to the gas valve or if residents have simply not used their furnaces to heat their apartment.

HYDRONIC BASEBOARD & SINGLE SPEED FAN COIL

Heat output from a **baseboard** 24VAC zone valve or a **single speed fan coil** system depends on:

1. The amount of **time** the heat is "on"
2. The **temperature** of the boiler water delivered to the apartment.

The longer the time of operation and the higher the temperature, the higher the heat delivered in BTUH.

Most hydronic heating systems employ controls to conserve energy use. Typically, the main heater circulating pump is shut off by an outside temperature control which disables the pump if outside air temperature exceeds a preset value (usually 60^{O} F to 65^{O} F). Residents are not able to heat their apartment when this occurs even though their thermostat calls for heat and their zone valve is open.

In addition, boiler water temperature is usually controlled by a thermostat set-back control device which modulates boiler water temperature as outside air temperature changes. As the outside air temperature drops, the boiler water temperature rises to provide more heat to match the increased demand for heat. Typically, boiler water might be set at 140^{O} for 50^{O} F outside air and increase to 190^{O} as outside air temperature drops to 0^{O} F.

The amount of heat delivered by a baseboard 24VAC system also depends upon the **total length of finned radiation** in each apartment. Heat output requires convective air flow across the finned radiation which requires free air flow (i.e. open louvers and nothing blocking the movement of air through the baseboard).

The amount of heat delivered by a single speed fan coil type system also depends upon the **size and efficiency of the fan coil unit**. Manufacturers' ratings are typically used to obtain the BTUH rating.

Old and/or poorly maintained fan coils (build up of dust and debris on finned surfaces) can deliver significantly less BTUH than manufacturers' specifications and the condition of the fan coil must be considered for accurate metering and billing.

- Baseboard systems are **heat only**.
- Fan coil systems may be **heat only**, or **heating and cooling** if connected to a boiler/chiller system. The cooling output of a fan coil varies similarly to the heating output but is typically 1/3 to 1/4 of the maximum heating output.

GAS_{TT} METERING SYSTEM

The **GAS_{TT}** wireless metering module is designed to accurately meter 24VAC **baseboard** and **single speed fan coil heating/cooling systems** where boiler or chilled water temperature varies with set back controls. Both time and temperature are measured:

- Time is obtained by a 24VAC connection to the zone valve wiring
- Temperature is obtained from a temperature sensor attached to the baseboard radiation or fan coil input water supply.

At a maximum temperature of 200^{O} F, using the Tapwatch hardware/software system, the GAS_{TT} outputs 1 count per 36 seconds (.01 hour) to the Inovonics 5201 Ext transmitter for transmission. As the boiler temperature drops to a minimum of 90^{O} F, the output count is reduced linearly to 1 count per 360 seconds to directly correspond to a linear reduction in BTUH per foot of radiation.

Heat output for single speed fan coils is measured the same way for boiler systems. Chilled water in the range of 38^{O} F to 58^{O} F is also metered but at a reduced count factor that corresponds to a value of 0.3 times the maximum heat output at 38^{O} F cooling versus 1.0 times at 200^{O} F heating. No data is taken in boiler off/chiller off range from 58^{O} F to 90^{O} F.

Error detection circuitry is incorporated in the design of the GAS_{TT} module in order to detect all forms of tampering or malfunction which can result in loss of data transmission. These error codes include:

- Detection of cut wires to the zone valve or temperature sensor
- Sensor removed from piping
- Zone valve malfunction (stuck open or closed)
- Manual override of zone valve.

These error codes allow the meter reading/billing provider to precisely determine if service is required to correct loss of data or if residents have simply not used heating or cooling from their heating/cooling system.

BTUH billing requires:

- **Radiation length** for baseboard systems
- **Fan coil scale factors** (multiplier based on fan coil size provided from manufacturer's specifications).

PNEUMATIC BASEBOARD HEATING SYSTEMS

Heat output from a **pneumatic baseboard system** depends upon:

- The amount of **time** the heat is "on"
- The **temperature** of the boiler water delivered to the apartment
- The **water flow rate** through the radiation piping.

Pneumatic zone valves are not "on/off" as are 24VAC zone valves. Rather, they operate proportionally to the temperature difference between the thermostat setting and the room air temperature.

Turning the thermostat up 5^{O} F to 10^{O} F will open the zone valve completely and will result in maximum water flow of 1 to 3 gallons per minute. Normal operation of the thermostat is only 1^{O} F to 2^{O} F which results in water flow of 0.1 to 0.5 gallons per minute.

Low water flow rates result in large temperature drops from input to output within an apartment's radiation piping. Heat output varies with temperature so the input section will usually provide considerably more heat than the output section. Input sections are typically in living areas (where higher temperatures are desired) while output sections are typically in bedrooms (where lower temperatures are desired).

Total heat in BTUH is therefore not uniform over the entire length of radiation in the apartment. (In contrast, a 24VAC zone valve design is typically uniform within ± 5^{O} F to ± 7^{O} F from input to output.)

GAS_{TTP} METERING SYSTEM

The **GAS_{TTP}** wireless metering module is designed to accurately meter **pneumatic baseboard** type heating systems where water temperature and water flow rates vary widely. Two temperature sensors are used:

- Sensor #1 is mounted ¼ of the distance from the inlet
- Sensor #2 is mounted ½ of the distance from the inlet.

From the temperature readings the meter determines a calculated average. This average helps quantify separate BTUH amounts for inlet and outlet sections of apartment radiation. These inlet and outlet section BTUH values are combined to determine total BTUH output for each apartment.

At **high water flow rates**, the two measurements result in a simple average of the radiation temperature converted to a scale factor of 1 count per 36 seconds (.01 hour) at 200 ^{O} F. The count is applied to the Inovonics 5201 Ext transmitter for transmission using the Tapwatch hardware/software system. As the simple average temperature drops to a minimum 90 ^{O} F, the scale factor drops to 1 count per 360 seconds. No data is taken below 90 ^{O} F.

At **low water flow rates**, a formula incorporated in the GAS_{TTP} module is used to calculate the equivalent averages for inlet (first ½) and outlet (last ½) of the apartment radiation which are then combined to give a weighted average BTUH/foot for the radiation.

Error detection circuitry is incorporated in the design of the GAS_{TTP} module in order to detect all forms of tampering which can result in loss of data transmission. These error codes allow the meter reading/billing provider to precisely determine if service is required to correct loss of data or if residents have simply not used heating from their system. BTUH billing requires radiation length of baseboard.

BOILER-CHILLER THREE SPEED FAN COIL SYSTEMS

Heat output of a **three speed fan coil** system depends upon:

- The boiler water (or chilled water) temperature
- Fan speed of the fan coil
- The return air temperature to the fan coil.

The **higher the boiler water temperature** and the **lower the return air** (room air) **temperature**, the higher the heat output (in BTUH) per hour of fan coil operation for a given fan speed.

The **higher the fan speed** at a given water and air temperature, the higher the heat BTUH output.

For cooling, the reverse applies, i.e. the **lower the chilled water temperature** and the **higher the return air temperature**, the higher the cooling BTUH output for a given fan speed. The higher the fan speed, the higher the cooling BTUH output.

Typical fan coil operation requires:

- Boiler water temperature - 110^{O} - 190^{O} F
- Chilled water - 42^{O} - 50^{O} F (for normal operation)
- Return air temperature - 60^{O} - 80^{O} F range.
- Nominal low fan speed - typically 60-70% of high speed rating.

Taking water temperature, return air temperature and fan speed variation all into consideration, the BTUH output per hour of a typical three speed fan coil will vary from nominal maximum output on high speed to -50% to -60% of nominal on low speed at lower boiler temperature. Cooling output varies in a similar fashion but is typically 1/3 to 1/4 of the maximum heating output.

GAS_{TT3} METERING SYSTEM

The **GAS_{TT3}** wireless metering module is designed to accurately meter **three speed fan coils** where water temperature, return air temperature and fan speed vary over the nominal operating range as described above.

Two temperature sensors are used:

- Sensor #1 - measures **return air temperature**
- Sensor #2 - measures **outlet water temperature** (if accessible) or outlet air temperature otherwise.

Temperature difference ($\triangle T = T_{IN} - T_{OUT}$)from these two sensors is calculated and accumulated over time to measure BTUH for heating or for cooling. Maximum $\triangle T$ of 120^{O} F scales to a maximum of 1 count per 30 seconds.

Maximum BTUH measured is **scaled by both fan speed and temperature**. A drop in boiler water temperature (from 200^{O} F maximum) results in a direct reduction in $\triangle T$ and a scale of less than 1 count per 30 seconds decreasing linearly with $\triangle T$. Data accumulation occurs only when fan coil operation is measured by the associated fan speed interface module.

Fan speed is measured by a separate 3-speed fan interface module connected to the high-medium-low speed fan motor wires. This module compares the voltage on each of the 3 fan motor wires with the reference voltage (120 VAC or 208 VAC) to determine the fan motor speed.

The output of this 3 speed fan module provides a third input (in addition to the two temperature inputs) to the GAS_{TT3} module and provides a scaling factor for fan speed.

- The **maximum fan** speed factor is equal to 1
- Medium and low speed factors are determined from manufacturers' fan coil performance specifications.
- Typically, **medium speed** factor is approximately **.85**
- Typically, **low speed** factor is approximately **.70**.

The lower the fan speed, the lower the scale factor which results in a count correspondently less than 1 per 30 seconds.

The GAS_{TT3} outputs 1 count per 30 seconds or less to the Inovonics 5201 EXT transmitter for data transmission using the Inovonics Tapwatch hardware/software system.

Error detection circuitry is incorporated in the design of the GAS_{TT3} module in order to detect all forms of tampering or malfunctions which can result in loss of data transmission. These error codes allows the meter reading/billing provider to precisely determine if service is required to correct loss of data or if residents have simply not used heating or cooling from their fan coil system.

BTUH billing requires both metered data (counts provided by Tapwatch) and the fan coil scale factor (multipliers based on fan coil size provided from the manufacturer's specifications).