ONICON
Flow and Energy Measurement

The Benefits of Using an ONICON BTU Meter to Measure Energy Use Versus Calculating the Values Using a Building Automation System

THE ISSUE

Traditional flow, temperature and instantaneous energy calculations have long been used in the control and performance optimization of plants that make chilled water, condenser water, hot water, etc. With the onset of cost allocation based on totalized energy data, it became clear that traditional methods used for calculating instantaneous energy rates were not adequate for this new purpose. Error ranges that were perfectly reasonable when used to compare relative performance were wholly inadequate when accumulated in custody transfer and cost allocation applications, which require the highest possible accuracy based on well-documented calibration against an absolute standard.

ONICON System-10 BTU Meter Installed in a Chiller Plant

THE OLD SOLUTION

The old method of measuring energy involved the use of a flow meter and a pair of temperature sensors connected to analog inputs of a Building Automation System (BAS). The raw signals from the flow and temperature sensors were processed by the BAS and that data was used to calculate an energy rate and total. While it is possible to calculate energy using this method, it is not possible to objectively state and certify the overall accuracy of energy measurements made in this way. This is particularly true for hydronic systems that, at times, operate with low flow rates or low temperature differentials. Under these conditions, even small errors in measurement and signal processing can lead to significant errors in the reported results. Measurement errors using the traditional method are highly variable and sometimes difficult to quantify. Some of these errors are introduced due to the generalized nature of BAS hardware designs and compounded by the accumulation of error components in the measurement process. Possible sources of error are listed below.

Potential Sources of Error with Traditional Energy Measurement

- Flow Meter Measurement Accuracy
- Flow Signal D/A Conversion
- Flow Signal Input Offset
- Temperature Sensor Measurement Accuracy
- Temperature Transmitter Accuracy
- Temperature Sensor Matching
- Temperature Signal Transmission Error
- Temperature Signal Input Offset
- Resolution of Inputs
- Resolution of Calculation
- Specific Heat Corrections
- Density Corrections

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THE ONICON SOLUTION

ONICON BTU meters are specifically designed for measuring energy in hydronic HVAC systems. The specialized nature of these products and application specific calibration using NIST* traceable standards allow ONICON BTU meters to address the two major concerns associated with traditional energy measurement. With a purpose-built design, data conversion errors and data resolution errors are dramatically reduced or eliminated altogether. Input offset errors and computational errors are well defined and minimized due to the system level final calibration. Most importantly, the flow meter and temperature sensors are designed, built and calibrated to the high degree of accuracy required for this application. Every flow meter is wet calibrated in a flow laboratory using a NIST traceable volumetric prover. Every pair of temperature sensors are wet calibrated in a bath against a NIST traceable reference to minimize both absolute and differential errors over the entire range of operating temperatures. In addition, all sensor input signals to the BTU meter are either digital or current based; reducing or eliminating input offset errors and signal transmission errors. When combined with the associated flow meter and temperature sensors, the ONICON BTU meter is a highly accurate, verifiable thermal energy measurement system that outperforms old and outdated methods of measurement.

ENERGY CALCULATION ACCURACY COMPARISON

The following example is presented to illustrate the effects of error on typical chilled water HVAC systems using a BAS to calculate energy versus an ONICON BTU meter.

Assumptions:

- Chilled Water
- 2" Schedule 40 Pipe
- 40 GPM
- 10°F ΔT

Energy Calculation Error Using a BAS

To simplify the example, this calculation only takes into account potential errors due to the temperature sensors, 4-20mA transmitters, flow meter, and BAS (all other potential sources of error are ignored). The device errors are listed on the table below.

	Accuracy	Device	Error
PT 1000 RTD Error	Class A	T1	0.32°F
		T2	0.32°F
4-20 mA Converter Error	0.2% of Span	T1	0.24°F
		T2	0.24°F
Flow Meter Error	1% of Rate	FM10	0.4 GPM
BAS Input Error	12-Bit Input Accuracy	FM10	0.02 GPM
		T1	0.03°F
		T2	0.03°F

**National Institute of Standards and Technology*

Energy Calculation Error Using a BAS, continued

Maximum Error

Temperature error (°F) = 0.32 + 0.32 + 0.24 + 0.24 + 0.03 + 0.03 = 1.19°F

Temperature error (%) = {(1.19 + 10) / 10} – 1 = 11.9%

Flow error (GPM) = 0.40 + 0.02 = 0.42 GPM

Flow error (%) = {(40 + 0.42) / 40} – 1 = 1.05%

Maximum Energy Error (%) = 11.9% + 1.05% = 12.93%

Average Error (Determined Using the Sum of the Squares Method)

Temperature error (°F) = $\sqrt{(0.32)^2 + (0.32)^2 + (0.24)^2 + (0.24)^2 + (0.03)^2 + (0.03)^2}$ = 0.57°F

Temperature error (%) = {(0.57 + 10) /10} – 1 = 5.7%

Flow error (GPM) = $\sqrt{(0.4)^2 + (0.02)^2}$ = 0.40 GPM

Flow error (%) = {(40 + 0.40) / 40} – 1 = 1.00%

Average Energy Error (%) = $\sqrt{(5.7\%)^2 + (1.00\%)^2}$ = 5.77%

Energy Calculation Error Using an ONICON BTU Meter

Includes all possible sources of error.

Differential temperature error (°F) = ±0.15°F

Differential temperature error (%) = {(0.15 + 10) /10} – 1 = 1.5%

Flow error (GPM) = 0.4 GPM

Flow error (%) = 1.0%

Computational error (%) = 0.05%

Maximum Energy Error (%) = 1.5% + 1.0% + 0.05% = 2.55%

Average Energy Error (%) = $\sqrt{(1.5\%)^2 + (1.0\%)^2 + (0.05)^2}$ = 1.80%

The calibrated ONICON BTU meter drastically decreases the effect of error on your HVAC system.

SUMMARY

Without equipment specifically designed to measure hydronic energy, it is very difficult to derive energy measurements with the verifiable level of accuracy that is demanded in today's high performance buildings. Old methods of calculating energy consumption using a BAS produces a compounding accumulation of errors that substantially reduces accuracy. ONICON's system approach provides sole-source responsibility for the accuracy of the data used for custody transfer and cost allocation.

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