Sensors for heat metering and the renewable heat premium payment (RHPP)

Heat metering is a megatrend for two reasons: Firstly, higher energy efficiency of a heating or cooling system and secondly, a change of behavior in terms of awareness about actual consumption of energy. In a heat pump, flow control/heat metering enables optimal control during periods of low heating load and/or production of domestic hot water. Furthermore, to facilitate a reduction in the actual consumption of heating or cooling, the actual and seasonal consumption/performance must be shown. By advocating heat metering (like the German Heizkostenverordnung making heat metering on the heating side as well as the domestic hot water side mandatory by 2014) an equal playing field for various heating and cooling technologies has been created for consumer assessment and potential Renewable subsidies.

As a hydronics expert, Grundfos supplies variable speed pumps and smart sensors for the latter and has already enabled superior energy savings for global heat pump manufacturers. Furthermore, a flow controlled system can be used for heat metering, which is the focus for the following article.

Klaus Frederiksen
Technical Key Account Manager,
GRUNDFOS Direct Sensors™.
kfrederiksen@grundfos.com

OEM Direct Sensors™ Product Family

Accuracy

In the first part of this article, the accuracies of the Grundfos Flow Sensor are listed and compared with those requested in the Energy Saving Trust (see in details www.energysavingtrust.org.uk/) RHPP, where a total maximum error on the SPF value of 10% (on a yearly basis) is allowed.

Calculating the SPF value, 4 sub-assemblies are required: a calculator (or display system), a temperature sensor pair, a flow sensor and an electrical meter.

The total error is calculated as the arithmetic sum of the maximum permissible errors of each sub-assembly:

$$SPFError = Ec + Et + Ef + Ee < 10\%$$

E_c = Maximum permissible error (MPE) calculator
E_t = MPE temperature sensor pair
E_f = MPE flow sensor
E_e = MPE electrical meter

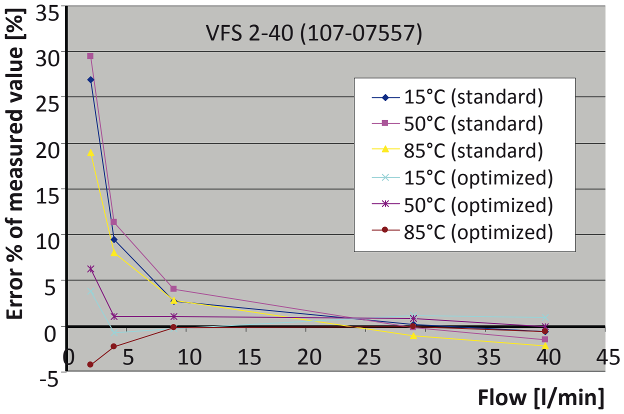
Flow

A Grundfos Flow Sensor is delivered with a maximum error of 1.5% of the full scale value as a standard for heat pump applications. As the error is a percentage of the full scale value it is necessary to consider closely which sensor range to utilize. Thus, it is clear that a 2–40 l/min range will perform better at lower flows, compared to a 5–100 l/min range.

Grundfos Direct Sensors™ has been directly involved in a project with the Danish transmission system operator (Energinet.dk) which included heat metering in 300 residential housing for a period of 1–2 years. The application scope of the project indicated that either the VFS (Vortex Flow sensor Standard) 5–100 l/min or VFS 2–40 l/min sensor would be the preferred range. The 5–100 l/min benefits from a lower pressure drop, while the 2–40 benefits from a higher accuracy - when no flow rates above 40 l/min are likely.

Experience gained by Grundfos from the first 75 installations, indicated that no flows higher than 33 l/min in the heating systems were detected. Due to the better accuracy provided, it was decided in this project to use the VFS 2–40 l/min for the remaining 225 installations.

Please see the following diagram showing accuracy of a standard VFS 2–40 l/min sensor at an independent third party institute (Danish Technological Institute) of 5 flows at 3 different temperatures (15, 50 and 85°C).



(The results presented as "standard" are obtained at a third party institute. The results presented as "optimized" are obtained in the Grundfos laboratory.)

Based on these results, an optimized VFS 2–40 l/min has been developed and tested in the Grundfos lab. These results are also shown on the chart.

It can be seen that the standard VFS 2–40 l/min sensor has an error in percentage of reading below 4% down to typically 8 l/min. To improve this according to the standard, we have optimized the VFS 2–40 l/min performance in order to perform better.

Temperature

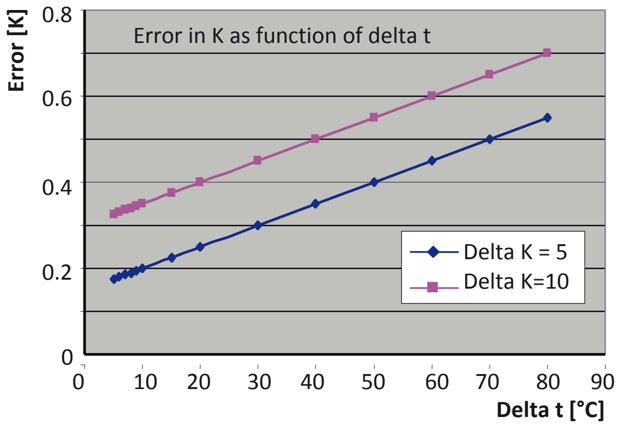
The temperature signal from the sensor has a maximum error of ±1 K in the range from 25–80°C. Looking at this, it will most likely not be enough given that a maximum error of a pair of ±2 K with a temperature difference of 5 K will account for an error of 40% of measured value.

Grundfos Direct Sensors™ have, with success, recommended that customers carry out an alignment of the temperature measurement of the 2 sensors. The recommendation is based on the fact that if the sensor pair offset is adjusted around a single point the error margin in terms of the delta measurement around this point will be considerably reduced.

In practice, this has been carried out by allowing the circulation pump to run while the heat pump is not running (or is in by-pass). Eventually, temperatures at both inlet and outlet of the heat pump will be almost the same.

Using this procedure a maximum delta T value of below 1°K is achievable.

Looking into other solutions for temperature measurements the following demands should be met acc. to EN 1434:



Calculating this in percentage of measured value a maximum error of 3.5% occurs. To meet this demand completely, a pair of Temperature sensors of accuracy <0.2°K must be utilized. There are many suitable devices such as resistance temperature detectors (RTD's), thermocouples and negative temperature coefficient thermistors (NTC's) that can meet this accuracy requirement.

Example on the calculation of the total error:

The data from above have been used to calculate the total error for 2 examples to give a more clear idea of the sensors performance in terms of the total error. In the example, the system has a flow of 30 l/min and an inlet temperature to the heating system of 65°C and 75°C respectively. The error contribution from the temperature sensor pair and flow sensor is accounted for and the total error has been calculated using the arithmetic sum of the errors.

Example 1: (30 l/min, inlet temperature 65°C, return temperature 55°C)

$$E_t + E_f = (1K/10K) * 100\% + 1\% = 11\%$$

Example 2: (30 l/min, inlet temperature 75°C, return temperature 55°C)

$$E_t + E_f = (1K/20K) * 100\% + 0\% = 5\%$$

Summary

It is important to understand that these solutions have been on the market for more than two years with substantial energy savings reaped by some of the world's largest heat pump manufacturers of air-water and ground source heat pumps. We call it Future Now, as we will continue to update our products to obtain even better accuracy of our products for present and future partner's to enable an even more efficient control of and heat metering integrated into their heat pump.