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TECHNICAL NOTES

TEMPERATURE COMPENSATION
THEORY AND APPLICATION

GENERAL

Many of the applications which are presently being implemented by mass flowmeters may be implemented at a fraction of the cost and at higher accuracies using a turbine flowmeter based inferential mass measurement technique.

What is Temperature Compensation?

Most fluids change density in a consistent manner with temperature. This property allows density to be inferred from a temperature measurement. Mass flow in an inferential mass measurement system is calculated by multiplying volume flow times the density on a continuous or sampled basis.

What are the Limits of Temperature Compensation?

In Temperature Compensated Systems the temperature is used to infer the density. The accuracy of the temperature compensation is measured by how well the circuitry does this. The range over which this approximation remains accurate is also important and should exceed user requirements. An accuracy of +/-0.25% is easily achieved at Hoffer using patented techniques. The total range of compensation may be for density changes from a reference condition of typically +/-10%.

Many of the early temperature compensation systems were mechanical in nature and had a very slow response time since the expansion of a fluid in a mechanical bellows was used to drive a mechanical linkage of sorts. Hoffer's temperature compensation systems are all electronic in operation. The techniques use fast response RTD Temperature Elements and a fast sampling rate.

It is important that the fluid have documented a known density as a function of temperature characteristics. Pressure effects on liquid density can usually be ignored, but this too should be examined.

Temperature compensation does add cost to the measurement system. This is a result of the added complexity and the added cost of the RTD temperature transducer and signal conditioner or transmitter where required.

Where is Temperature Compensation Used?

Wherever the mass flow or weight of the quantity transferred is important, that is where to consider temperature compensation. Consider the following example:

> *Company A* has an above ground storage tank for gasoline and sells it to *Company B* through a long pipeline metered at the sending end by a volumetric metering system. *Company B* also has a volumetric metering system and is not receiving the same amount of fluid *Company A* sent to them. No leaks have been found.
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> The problem was traced to the differences in density when the fluid entered and exited from the pipeline. The temperature had changed by 30° F, corresponding to a density change of 2.1%. This is a result of the fact that the underground temperature averaged 60°, while the surface temperature followed seasonal variations.
>
> The solution is that both *Company A* and *Company B* should have been using temperature compensated systems, and have been billing is gallons at 60°

What Information is Necessary to Implement a Temperature Compensated System?

The most important information is the specifications of the physical properties of the fluid over the temperature range of interest. Normally, this information is available from the material manufacturer and his supplier. This information may be in the form of an equation. Hoffer's Engineering Group will implement this into the desired function within the electronic portion of the system. Second Order Curve Fits are normally used since straightline approximation may result in considerable error in many fluids.

CONCLUSIONS

In many custody transfer and chemical reactions, the mass flow rates are of more concern than the volumetric flow rates. In these applications there is a cost advantage to using a turbine flowmeter based inferential mass measurement system.