Flow Computer Tutorial

What is a flow computer? A special purpose device which computes a corrected flow based on information derived from raw input signals and stored sensor and fluid properties information

What are the typical applications requiring a flow computer? Computation of Heat Flow, Mass Flow, Corrected Volume Flow typically require a flow computer. In addition, many flow sensors require linearization to improve accuracy. The flow computer is also used for data logging, communication, remote metering, alarming and control functions. In many cases a flow computer may replace some of the functionality of a small PLC in your application.

What are typical uses of flow computers? The figures and equations below illustrate a number of the common applications for flow computers.

Where do the equations come from which are solved by the flow computer? All flow measurement sensors have basic mathematical expressions which describe how they relate the measured input signal to a flow measurement. Often there are a number of such expressions for each flowmeter type which range from the simple to those which include additional second order effects. In addition, there are basic equations from thermodynamics and industry standard equations which are utilized in liquid, gas, steam, and heat.

How can you enhance the accuracy of flow meters? A flow computer often offers a variety of performance enhancement functions. These range from simple square root functions, to more elaborate linearization tables applicable to that flowmeter type. In addition, the flow computer can correct for changes in physical dimensions of the flowmeter with temperature and for the effects of changes in fluid properties of the material being measured in some cases.

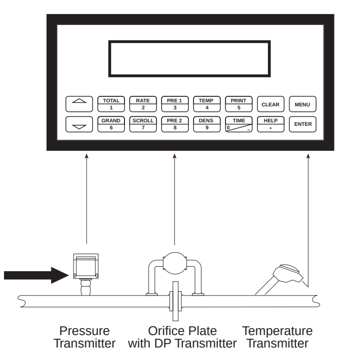
How are fluid properties determined? Fluid properties are stored within the flow computer. Properties are then computed as a function of measured fluid temperature and/or pressure. Density and viscosity are among the most commonly computed fluid properties.

What types of flowmeters typically use flow computers? The most common types used in conjunction with flow computers are turbine, vortex, positive displacement, orifice and similar types, magnetic flowmeters, and a variety of special flowmeter types. Flow computers are often used with other types when the application calls for local information display, data communications, control, alarm, and data logging functions.

What other factors should be considered? Flexibility in use of flow computation and use of inputs and outputs, signal input resolution and accuracy, isolation, 24VDC to power transmitters, networking, communications software and accessories, printing, data logging and remote metering support. Approvals may also be required. Instrument setup software is also of value. Application support from the manufacturer is also important.

Applications & Equations

Steam Mass & Steam Heat Illustration



Calculations

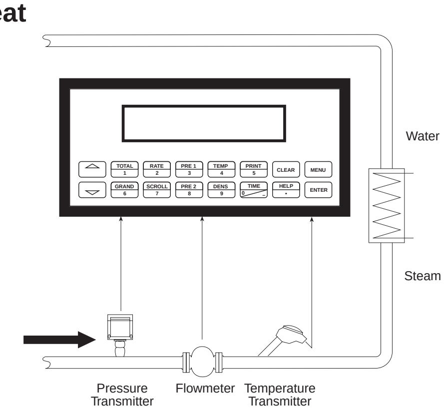
Mass Flow

Mass Flow = volume flow • density (T, p)

Heat Flow

Heat Flow = Volume flow • density (T, p) • Sp. Enthalpy of steam (T, p)

Steam Net Heat Illustration



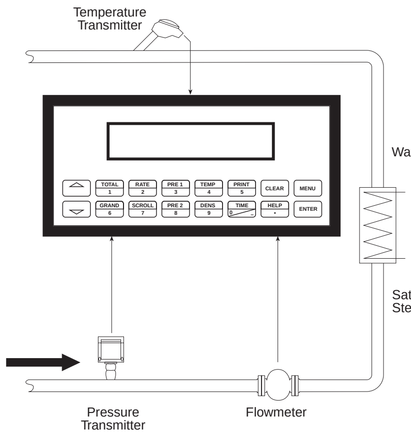
Calculations

Net Heat Flow

Net Heat Flow =
Volume flow • density (T, p) • [E_D (T, p)– E_W ($T_{S(p)}$)]

E_D = Specific enthalpy of steam
E_w = Specific enthalpy of water
$T_{S(p)}$ = Calculated condensation temperature (= saturated steam temperature for supply pressure)

Steam Delta Heat Illustration



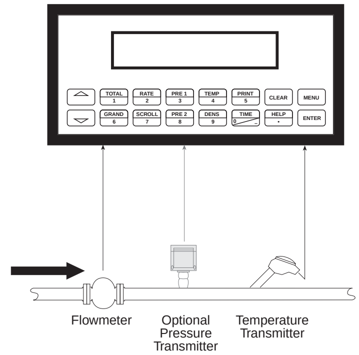
Calculations

Delta Heat Flow

Net Heat Flow =
Volume flow • density (p) • [E_D (p)– E_W (T)]

E_D = Specific enthalpy of steam
E_w = Specific enthalpy of water

Liquid Corrected Volume Flow Mass Flow Combustion Heat Flow Illustration



Calculations

Corrected Volume Flow

Corrected Volume Flow = vol. flow • (1 - α • (Tf-Tref))^2

Mass Flow

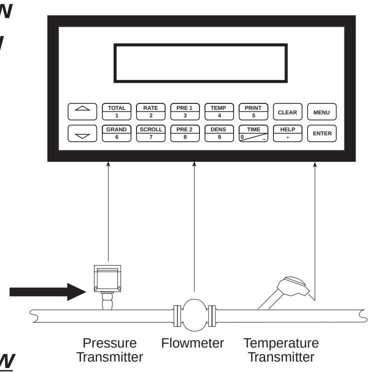
Mass Flow =
volume flow • (1-α • (T-T_{ref}))^2 • ref. density

Heat Flow

Heat Flow =
C • volume flow • (1-α • (T-T_{ref}))^2 • ref. density

α = Thermal expansion coefficient • 10^{-6}
C = Specific combustion heat

Gas Corrected Volume Flow Combustion Heat Flow Mass Flow Illustration



Calculations

Corrected Volume Flow

Corrected Volume Flow =
Volume Flow • P/P_{ref} • T_{ref}/T • Z_{ref}/Z

Combustion Heat Flow

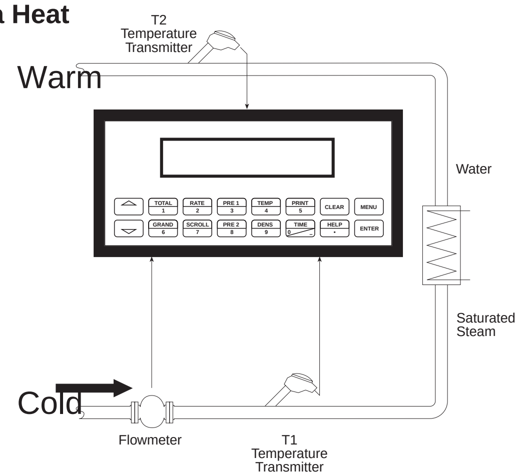
Combustion Energy =
C • ρ_{ref} • Q • P/P_{ref} • T_{ref}/T • Z_{ref}/Z

Mass Flow

Mass Flow =
Actual Volume Flow • ρ_{ref} • P/P_{ref} • T_{ref}/T • Z_{ref}/Z

ρ_{ref} = Reference density
T_{ref} = Reference temperature
P_{ref} = Reference pressure
Z_{ref} = Reference Z-factor
C = Specific combustion heat
Q = Volume flow

Liquid Delta Heat Illustration



Calculations

Water

Heat = Volume Flow • ρ(T1) • [h(T_2) – h(T_1)]

Other heat carrying liquids

Heat = C • volume flow • (1-α • (T_1-T_{ref}))^2 • ρ_{ref} • (T_2 - T_1)

α = Thermal expansion coefficient • 10^{-6}
C = Mean specific heat
ρ(T1) = Density of water at temperature T_1
h(T1) = Specific enthalpy of water at temperature T_1
h(T2) = Specific enthalpy of water at temperature T_2
ρ_{ref} = Reference density
T_{ref} = Reference temperature