LETTER SYMBOLS (Continued)

v_{as} = $v_s - v_a$, the difference between volume of moist air *at saturation*, per pound of dry air, and the volume of the dry air itself, cubic feet per pound of dry air.

v_s = volume of moist air at saturation per pound of dry air, cubic feet per pound of dry air.

v_T = total volume, cubic feet.

V = velocity, feet per minute.

$\overline{V}$ = average velocity, feet per minute.

W = humidity ratio, of moist air, pounds of water per pound of dry air.

ΔW = water to be removed from (or added to) conditioned space, pounds per hour.

W_s = humidity ratio, *at saturation*, weight of water vapor per pound of dry air, pound per pound.

W_s^* = humidity ratio corresponding to thermodynamic wet-bulb temperature t^*, pounds of water per pound of dry air.

Z = elevation above any datum, feet.

$\overline{Z}$ = average elevation, feet.

REFERENCES

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Chapter 4

FLUID FLOW

Theory; Pressure Loss in Circular and Non-Circular Pipes; Compressible Fluids; Nozzles and Orifices; Steam Flow Measurement; Metering Liquids; Nozzle Coefficients and Expansion Factors; Pitot Tube; Installation of Nozzles and Orifices

THE flow of fluids is part of the branch of engineering science known as fluid mechanics, which will be discussed here insofar as it applies to the work of engineers in the fields of heating, ventilating, and air conditioning. Probably air is the most frequently handled fluid, but other gases and liquids are often involved. Compressible fluids (gases) and incompressible fluids (liquids) vary somewhat in behavior, though in cases where pressure and density changes are small, the gases may be treated as incompressible fluids.

THEORY OF FLUID FLOW

The following head equation based on energy considerations for steady flow processes will serve as a basis for the theory of the flow of fluids. This equation is presented in several ways in various texts, but a suitable form is:

$$\frac{V_1^2}{2g} + Ju_1 + p_1v_1 + E + Jq + z_1 = \frac{V_2^2}{2g} + Ju_2 + p_2v_2 + z_2 \qquad (1)$$

where

V = velocity in feet per second.
g = acceleration due to gravity = 32.17 ft per (second) (second).
J = mechanical equivalent of heat = 778 foot pounds per Btu.
u = internal energy, in Btu per pound of fluid.
p = pressure in pounds per square foot.
v = specific volume, in cubic feet per pound.
E = mechanical work, in foot pounds per pound of fluid flowing.
q = heat transferred to the fluid, in Btu per pound of fluid flowing.
z = elevation above some arbitraty datum, in feet.
Subscript 1 refers to the entrance, subscript 2 to the exit.

Introducing the enthalpy h, which by definition is $u + \frac{pv}{J}$, expressed in Btu per pound of fluid, Equation 1 becomes

$$\frac{V_1^2}{2g} + Jh_1 + E + Jq + z_1 = \frac{V_2^2}{2g} + Jh_2 + z_2 \qquad (2)$$

The steady flow energy equation is applicable to a wide range of problems in the flow of fluids. Obviously it applies to flow through pipes, orifices, and nozzles, and to the flow through turbines and centrifugal pumps. Reciprocating engines and pumps are essentially intermittent, but the flow tends to become steady as the number of cylinders increases, and becomes practically uniform at the entrance and exit if the system includes receivers and pipes of sufficient size.

By substituting $\frac{p}{\rho}$ (where ρ is density in pounds per cubic foot) for