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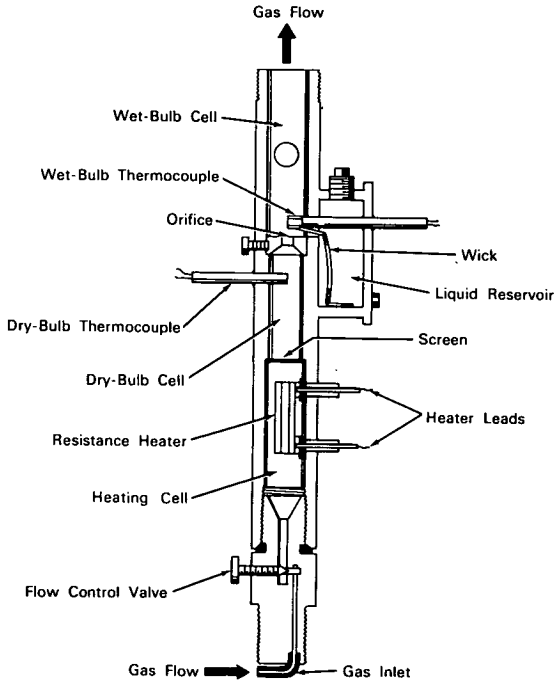
NASA TECH BRIEF

Apparatus Measures Concentration of Suspended Droplets in Gas Streams



The problem: Determining the concentration (mass per unit volume) of droplets of water or other liquids condensed from vapor or mechanically entrained in gas streams subjected to various pressures. In wind-tunnel experiments and in many process industries, for example, it is important to know the concentration of water droplets in air saturated with water vapor at points upstream and downstream of moisture entrainment separators.

The solution: An apparatus, operating on the principle of wet- and dry-bulb thermometry, which permits intermittent or continuous measurement of the concentration of droplets dispersed in a gas stream over a wide range of gas pressure.

How it's done: The apparatus contains an expansion chamber which is divided into three connecting cells: a heating cell, a dry-bulb cell, and a wet-bulb cell. A screen partitions the heating cell from the dry-bulb cell, and an orifice separates the latter from the wet-bulb cell at the top of the chamber. Flow of gas into the tube at the bottom of the apparatus is regulated by a flow-control valve. The heating cell contains an electrical resistance heater in the walls of a hollow tube which provides an unrestricted passage for the

(continued overleaf)

gas. A thermocouple extending into the dry-bulb cell measures the dry-bulb temperature of the gas, and a thermocouple covered with a wick saturated with the liquid in the gas stream measures the wet-bulb temperature of the gas flowing through the wet-bulb cell.

In making a measurement with the apparatus, a sample of the saturated, wet gas at a given pressure and temperature is introduced into the heating cell where it is isothermally expanded. As a result of this expansion, the droplets originally present in the gas are converted into vapor and the gas becomes unsaturated. The gas stream then passes through the screen (which mixes the gas and vapor to ensure a homogeneous unsaturated condition) into the middle cell where the dry-bulb temperature is measured. The wet-bulb temperature of the gas is measured as it passes across the thermocouple in the wet-bulb cell. The orifice between the dry- and wet-bulb cells, which is replaceable to provide desired flow rates, causes the gas to flow across the wick on the thermocouple at the proper velocity for accurate measurement of the wet-bulb temperature.

From the wet- and dry-bulb temperature measurements, the percentage of unsaturation of the gas leaving the top of the apparatus (or relative humidity in the case of water vapor) is easily calculated or read from standard reference tables. The calculated data may then be used to derive the concentration (mass per unit volume) of vapor in the exhaust gas from published tables or by means of a simple formula. This value is then multiplied by the expansion ratio of the gas flow on both sides of the flow control valve to obtain the concentration of the total liquid content (vapor plus droplet concentration) in the original gas stream. Since the original gas stream was saturated with respect to its vapor content (at the inlet temperature) the concentration of vapor in the original stream is readily calculated or determined from tables and subtracted from the total concentration to obtain the concentration of droplets originally present in the stream.

Notes:

1. Liquid-filled thermometers can be used instead of thermocouples for temperature measurement in the apparatus.
2. If only approximate measurements are required, the heater cell may be omitted.
3. Further technical information concerning this ininvention is described in U.S. Patents 2,926,521 and 2,939,311. Inquiries may also be directed to:
   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia, 23365
   Reference: B64-10237

Patent status: NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA Headquarters, Washington, D.C., 20546.

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(Langley-31)