INTRODUCTION

TO

THERMO-SYSTEMS

HEAT FLUX SYSTEM

TB-3A

THERMO-SYSTEMS INC.

2500 CLEVELAND AVENUE NORTH SAINT PAUL, MINNESOTA 55113

The Heat Flux System measures nearly instantaneous heat transfer rates between an internally cooled sensor (0.006 in. O.D. by 0.08 in. long) and its external environment. In many applications the measured parameter, heat flux, is the variable of interest. Since velocity, temperature, and composition all influence heat transfer, when only one is varying, the system can be calibrated as an anemometer, thermometer, or two-component gas analyzer, respectively. The most common application of a device of this type in the past has been the hot-wire anemometer, where the heat flux from a fine wire is calibrated in terms of velocity. For the Heat Flux System the interior cooling, high temperature capabilities, and aspirating probe greatly extend the range and applicability.

The sensor for the Heat Flux System consists of a glass tube with a platinum surface as the resistance element. With no interior cooling the power input from the control circuit (read directly in Watts on the panel meter or in Watts/volt at the output terminal) is equal to the heat loss from the sensor to the environment. With water cooling on the interior of the sensor, power input from the control circuit is equal to the heat transferred to the water minus the heat transferred from the environment to the sensor.

The following calibration procedure can be used to determine the heat transfer rate to the water:

1) With the sensor protected to minimize heat transfer between it and the environment, the circuit output gives the heat input, C, to the sensor cooling water. This can be obtained before the test is started or before the sensor is mounted in the system to be tested.
2) With the sensor exposed to the test environment, the heat transfer to the sensor from the environment is:

$$C - P$$

P = Circuit reading under test conditions, Watts.

Although both C and P are positive, a negative value of C - P simply means heat is being transferred from the sensor to the environment. Maximum heat transfer from the environment to the sensor occurs when P equals zero. At this condition, the heat transfer from the environment to the sensor surface just equals the heat transfer from the sensor surface to the cooling water, and the control circuit is turned off.

The following is a list of some of the specifications and features of the Heat-Flux System:

1) The circuit maintains the surface of the sensor at an essentially constant temperature.
2) The circuit can maintain this surface temperature for heat flux change frequencies greater than 20 kilocycles per second.
3) The average output of the circuit can be read directly on the panel meter in Watts of electrical power to the probe. Transients can be read on external indicating or recording devices.
4) The "standard" film sensor is a cooled tube with a 0.006 in. O.D. by 0.004 in. I.D. and a 0.08 in. sensitive length. Sensors are either straight with the cooling water discharged into the environment, or they are "U" shaped making a closed system that returns cooling water. Other sizes and shapes can be constructed for special applications.
5) The supporting structure used depends on the application and the information desired. The two "standard" types are (1) the Heat Flux Probe, where the sensor is exposed directly to the environment and (2) the Aspirating Probe, where the sensor is placed in a constant Mach Number section of a probe that removes a sample from the environment.

Either of these probes can be made for "straight" or "loop" type sensors. The latter substantially removes the effect of environment velocity on the output of the Heat Flux System. Other supporting structure for special applications can be considered.

6) Heat transfer between the sensor and its environment is obtained directly. Interpreting these results in terms of temperature, velocity, or composition requires previous calibration or the use of heat-transfer relations.