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Abstract

Measuring target temperature in beam lines usually requires fastening thermocouples to the target and monitoring them at some safe, remote distance. Modern, remote sensing devices eliminate the need for the thermocouple attachment to the target. This note describes the testing of one such device, an infrared thermometer. The intended use of the thermometer is in the C target, where the movable shield curtain and removable target would pose problems for wired in thermocouples.

INTRODUCTION

The C target assembly has a movable shield wall and a removable target. Monitoring the temperature of the target will require a device that will remain intact even during target removal. Removing this particular target would shear off any thermocouple attachments, since the wires pass through the 90° port. Some form of remote sensing would not suffer this disconnection. Also, when changing targets, there is no easy way to reconnect thermocouples and still keep exposure levels low. A remote sensing device, such as the infrared thermometer in these tests, allows continuous temperature monitoring unhindered by target manipulations. Meanwhile, the thermometer's time constant is short enough to allow cycle-by-cycle measurements.

To inspire confidence in the use of devices such as these, it is necessary to show that they provide the same temperature readings as the standard thermocouple systems. We performed our tests on an infrared thermometer, a Mikron model M668L, using a platinum block nearly similar in shape to the actual C target. We compared the results of readings from both a type K thermocouple and the thermometer as we heated the platinum from 750°F. to 1250°F.

APPARATUS

Our model of the actual C target had the same cross section to the beam as the actual target, .4 in. $\times$ .2 in., but was shorter by about one inch. A heating coil surrounded with a copper sheath was the heat source, and clamping the platinum to this hotplate provided adequate heating up to about 1250°F. We attached thermocouple wires to the platinum by drilling a small hole near one end of the block and peening the thermocouple wires tightly into the hole. The thermocouple wires were standard Chromel/Alumel, equivalent to BNL stock # A-32505. A five foot length ran from the platinum block to a Fluke digital thermometer, model 2166A. Figure 1 is a schematic diagram of the experimenal setup.

The Mikron infrared thermometer uses a fiber optic cable to transmit infrared radiation to a sensor. A lens at the end of the fiber optic cable nominally focuses the image at 3 feet. We mounted the lens assembly at two distances from the platinum block, 27 inches and 36 inches. The thermometer also has an integral LED that provides some aiming onto the source. At 27 inches, the aiming spot covers almost the full height of the target; at 36 inches, the spot is slightly larger than the target. Among the adjustments on the thermometer is one to correct for source emissivity. This we set at three different values; 0.31, 0.33, and 0.35. The emissivity of platinum is a function of the temperature, and can vary by about 50% over the expected range of C target temperatures. We correct for emissivity variations by empirically finding an emissivity which causes the infrared thermometer reading to agree with the thermocouple (this temperature was 1140°F). We varied the emissivity setting up and down from this point by 6%, giving the three experimental curves.

RESULTS

The graphs in figure 2 show three different temperature cycling measurements. Each graph corresponds to a heating and cooling cycle between temperatures of 750°F. and 1250°F. The straight line represents perfect agreement between the thermocouple and infrared readings. The three data sets lie nearly on top of each other, indicating that the measurements are quite independent of emissivity and small variations in target distance. The maximum deviation from thermocouple temperature is at the high temperature end of the readings and is 32°F. This is a deviation of about 2% from the thermocouple reading. One could argue that the infrared radiation emitted from the surface of a heated body corresponds to a temperature lower than that of the thermocouple imbedded in that body. These measurements are not complete enough to resolve this point. However, this radiative cooling, if it actually does take place to this degree, only lends confidence to the infrared method, if not precision. The infrared thermometer indicates that the surface is cooler than the bulk.

We have shown that standard, industrial methods of remote sensing suit themselves well to the task of monitoring target temperatures in beam lines. The particular device that we used in these tests also allows one to minimize dose rates, since aiming is done with an LED that illuminates the target. Aiming the infrared thermometer at a new target is then a matter of minutes. The accuracy and precision of the thermometer compare well with standard thermocouple methods. And, in the C target case, the infrared measurement scheme is much easier to implement after target removal.

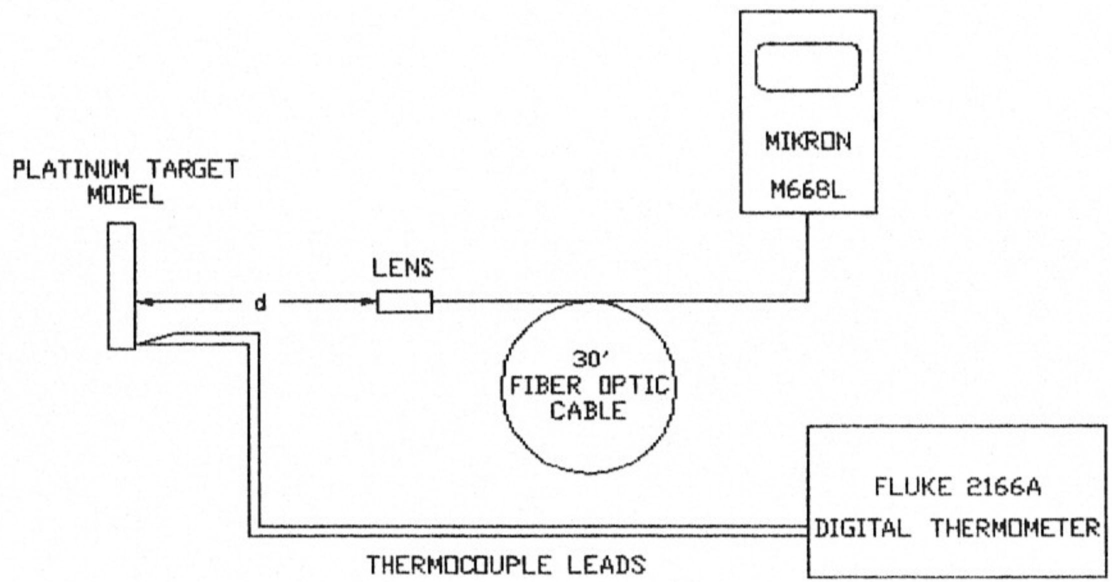

Fig. 1 Test Setup For Temperature Measurement
The distance d is the nominal focus at 3 feet. The actual distance was 27 inches for one measurement and 36 inches for the other two measurements. The heat source is not shown.

Infrared Thermometer vs. Thermocouple Readings, °F.

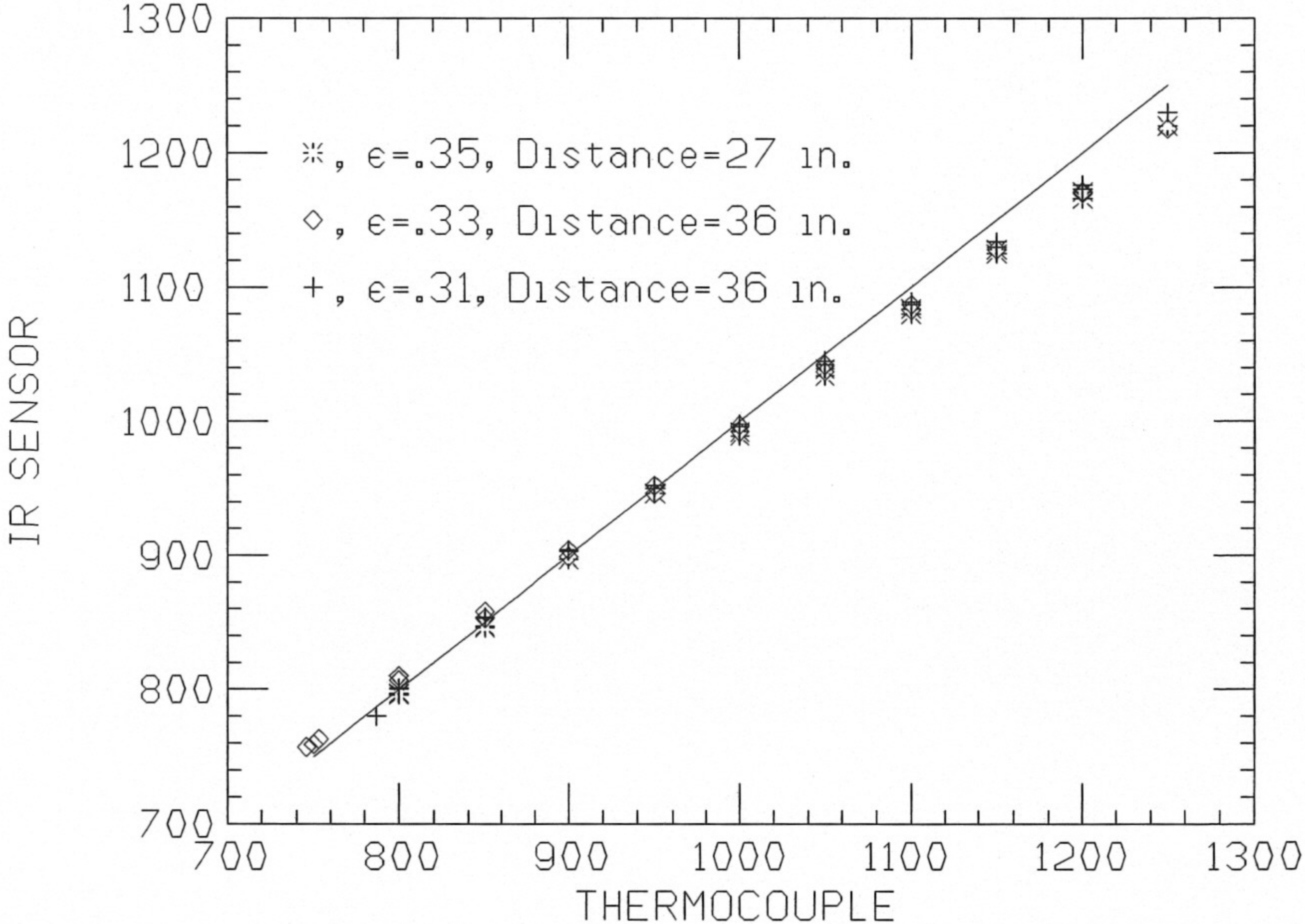

Fig. 2