

## Availability and Limitation of Alcohol Thermometer in a Survey of Air Temperature

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This study examines the use of an alcohol thermometer in an environmental education program related to a heat island survey. The air temperature measured by an alcohol thermometer showed a very high linear correlation with that measured by a thermometer calibrated with a thermostat, showing that it is possible to use an alcohol thermometer in an environmental education program related to a heat island survey. Alcohol thermometers, however, must be corrected before starting a survey program.

### I INTRODUCTION

Heat islands are receiving worldwide attention as the focus of surveys and studies<sup>1-4)</sup>. Environmental issues are extremely important aspects of the curricula for elementary and junior high school programs. The phenomenon of urban heat islands is one of the environmental issues most closely affecting our daily life. The air temperature can be easily measured. Thus, we planned a joint investigation campaign with an elementary school to measure the air temperature. Through this type of joint investigative study, a desired result would be an increased interest and awareness of environmental issues.

If the data obtained from such a study happens to be scientifically valid, this type of campaign could contribute to an increased understanding of the environment. This is because a considerable amount of data would be collected during such a study. Many types of equipment are used for measuring air temperature. The Japan Meteorological Agency currently employs a forcibly aspirated shelter in

the network of the Japan Meteorological Agency when measuring the air temperature. When a forcibly aspirated shelter is used to measure the air temperature, the most precise data are obtained; however, the instrument requires electricity for its use. On the other hand, the measurement of the air temperature under conditions when adequate equipment and materials were not accessible was evaluated<sup>5)</sup>. Budget limitations did not permit the purchase of the equipment and materials needed for a comprehensive study. Therefore, before starting the campaign, we tried to examine the availability of data acquired through the same type of thermometer as that used in the campaign. The findings are reported below.

### II MATERIALS AND METHODS

#### 1 Air temperature measurement

##### 1.1 Research site and period

In March 2006, air temperatures were measured at one six-story building, the Hyogo Prefectural Institute of Public Health and Environmental Sciences. The air temperature was measured inside a naturally aspirated thermometer shelter placed on the roof (about 25 m above ground). The roof where the thermometer shelter was placed was covered with a waterproof

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### 1.2 Thermometer

Air temperatures were measured by three kinds of thermometers (type I: Thermo Recorder TR-72U, T&D Corporation, Nagano, Japan; type II: Alcohol thermometer (measurement range 0-50°C), AS ONE CORPORATION, Osaka, Japan; type III: Alcohol thermometer (measurement range -20-100°C), AS ONE CORPORATION, Osaka, Japan). Alcohol thermometer is at a low price. It is, therefore, suitable for the investigation that needs a lot of measurement points. The air temperature measured by the Thermo Recorder TR-72U (type I) was calibrated with a thermostat; thus, the type I thermometer was concluded to provide more controlled air temperature than the air temperature measured by the type II and type III thermometers.

The measurement resolution of the Thermo Recorder TR-72U was 0.1°C. The measurement accuracy of Thermo Recorder TR-72U was ± 0.3°C. The scale of an alcohol thermometer at the minimum was 1°C. The temperature was read by viewing to one-tenth of a scale at the minimum. Alcohol thermometers such as type II and type III thermometers are cheap enough to use in an environmental education program related to a heat island survey.

## 2 Data acquisition

Instantaneous air temperatures measured at 10:00 and 14:00 JST were evaluated.

## III RESULTS AND DISCUSSION

### 1 Correlation

Figure 1 shows the relationships of the air temperature measured by the type II and type III alcohol thermometers with the air temperature measured by the type I thermometer. The correlation coefficients of the linear regression were  $R^2 = 0.997$  (slope: 1.01; intercept: -1.7) and  $R^2 = 0.996$  (slope: 1.06; intercept: -2.9) for type II and type III thermometers, respectively; thus, both type II and type III alcohol thermometers have a very high linear correlation with the type I thermometer. On the other hand, the intercepts were -1.7 and -2.9 for type II and

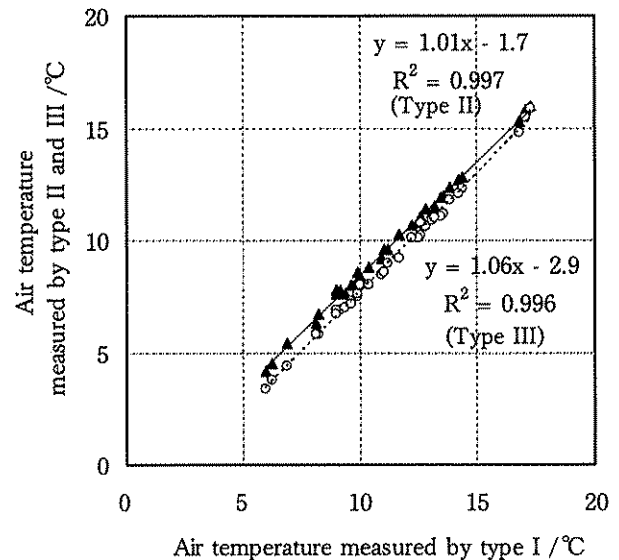


Figure 1 Relationships of the air temperature measured by the alcohol thermometer type II (solid line) and type III (dotted line) with the air temperature measured by the thermometer type I.

type III thermometers, respectively, which is mentioned and discussed in detail in the following section.

## 2 Availability of an alcohol thermometer in an environmental education program

### 2.1 Error

#### 2.1.1 Linearity

As shown in section 1 Correlation in III results and discussion, both type II and type III alcohol thermometers had a very high linear correlation with the type I thermometer; therefore, it is possible to correct the air temperature measured by type II and type III thermometers.

#### 2.1.2 Intercept

The intercepts in the linear regression were -1.7 and -2.9 for type II and type III thermometers, respectively, showing that the intercept must be considered when alcohol thermometers are used in an environmental education program related to a heat island survey. In the present preliminary study, all thermometers were set in the thermometer shelter. Nevertheless, the measured air temperature showed intercepts of -1.7 and -2.9. In addition, there was a difference of 1.2 (= 2.9 - 1.7) between type II and type III thermometers. The intrinsic error of the device and the error in the measurement are the

chief causes of the difference. The intrinsic error of the device might be, however, the main reason for the difference because we read the temperature by viewing to a one-tenth of a scale at the minimum. The intrinsic error must be corrected before the survey starts; otherwise, the results of the survey may not be worthy of evaluation.

## 2.2 Correction

When the air temperature distribution is surveyed, it is necessary to measure the air temperature at the same time based on the Japan Standard Time. It is possible to measure the air temperature at the same time when the air temperature is measured automatically by a device which has a timer function. When an alcohol thermometer is used in an environmental education program related to a heat island survey, the air temperature, however, will be measured by a person by viewing. It is desirable to measure the air temperature at the planned time. In reality, it will be difficult to measure the air temperature at the planned time under various circumstances. In such a case, when analyzing the results, the air temperature actually measured at the various times needs to be corrected to the planned time. The Hyogo prefectural government has fortunately constructed a monitoring network which measures air temperatures at 15-minute intervals. Using the 15-minute-interval air temperatures measured by the Hyogo prefectural government as controlled air temperature data will make it possible to correct the air temperature measured in an environmental education program related to a heat island survey.

## IV CONCLUSIONS

The air temperature was measured by three kinds of thermometers: one was calibrated with a thermostat (the controlled air temperature), and the others were alcohol thermometers. The air temperatures measured by the alcohol thermometers had a very high linear correlation with the controlled air temperature, and the intercepts in the linear regression were -1.7 and -2.9. The main cause of the intercepts is the intrinsic error of the device, not

the error in the measurement. It is possible to use alcohol thermometers in an environmental education program related to a heat island survey when alcohol thermometers are corrected before the survey is started.

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### 〔ノート〕

気温測定調査におけるアルコール温度計の利用の有効性と限界

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## 要 約

ヒートアイランド現象調査を通じた環境教育におけるアルコール温度計の利用可能性について検討した。アルコール温度計により測定した気温は恒温槽で校正した温度計により測定した気温と高い直線相関を示した。このことからアルコール温度計はヒートアイランド現象調査を通じた環境教育に十分使用できると考えられる。但し、使用するアルコール温度計は校正した後に使用することが求められる。