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Special Report 84

EVALUATION OF AN ECONOMICAL INSTRUMENT SHELTER FOR MICROCLIMATOLOGICAL STUDIES

by

T.C. Vogel and P.L. Johnson

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U.S. ARMY MATERIEL COMMAND
COLD REGIONS RESEARCH & ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE





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PREFACE

This report was prepared by T. C. Vogel and P. L. Johnson, Photographic Interpretation Research Division (R. Frost, Chief), USA CRREL. Appreciation is acknowledged to M/Sgt Paul Lamb for maintaining the installation during the test period and transcribing portions of the thermal data.

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Introduction

A number of inexpensive, lightweight instrument shelters capable of screening meteorological instruments in the field were required for an ecological research project in northern Alaska. Such a shelter had to be inexpensive, collapsible for shipment, easily assembled in the field, capable of housing recording instruments as large as a Friez hygrothermograph, and comparable to a standard U. S. Weather Bureau shelter or Stevenson screen in its ambient thermal characteristics. These criteria are met by the following design which was fabricated and successfully employed at six sites at Barrow, Alaska, during July and August 1964.

Description

The shelter was fabricated from four 15 x 15-in. aluminum, household double louvers (Sears Roebuck and Co.), which form the front, rear, and side panels (Fig. 1). Each louver has a net free area of 75 in.² Fourteen gauge aluminum angles, 0.5 x 2.5 in. and 15 in. long, formed the corners of the shelter and were secured to the front, side, and rear louvers with bolts. These angles extend the front and rear panels to form a usable inside dimension of 13 x 17 in. and 14.5 in. high. The roof was constructed of two sheets of $\frac{1}{2}$ -in. exterior plywood separated by two $\frac{3}{4}$ x $\frac{3}{4}$ -in. spacers, and the base was made from a single thickness of $\frac{1}{2}$ -in. exterior plywood. The entire shelter was painted with exterior flat white paint.

Access to the shelter is provided through the hinged roof, which extends 1 in. beyond the sides. It is also possible to hinge the front panel instead of the roof. Outside dimensions are 15 x 19 in. and 15 in. high; total weight is 20 lb.

The materials for this shelter cost approximately \$11.50 retail in New Hampshire.

Evaluation

To evaluate the heating and cooling due to absorbed insulation or reradiation to the sky at night, ambient air temperatures were measured in the test shelter and in a standard U. S. Weather Bureau shelter at the Lebanon, New Hampshire, Airport. Both shelters were placed on standard support frames 4.0 ft above a grass turf and separated by 20 ft (Fig. 2). Temperatures were measured with copper-constantan thermocouples, silver-soldered but not moisture-proofed, positioned in the center of each shelter. A Brown and Honeywell Type 153X strip chart recorder was used to record paired temperatures at 24-sec intervals with a 10-sec delay between the two readings.

Cloudy weather was more prevalent than clear sky during much of the test period, 15 October - 13 November 1964. On the 22nd and 29th of October the thermocouples were interchanged to compensate for any inherent thermocouple error. No significant error was detected.

For purposes of data comparison, hourly temperatures were tabulated from the strip chart to the nearest 0.1F for the test period. The assumption was made that the measured temperatures or deviations of the test shelter from the standard

2 INSTRUMENT SHELTER FOR MICROCLIMATOLOGICAL STUDIES

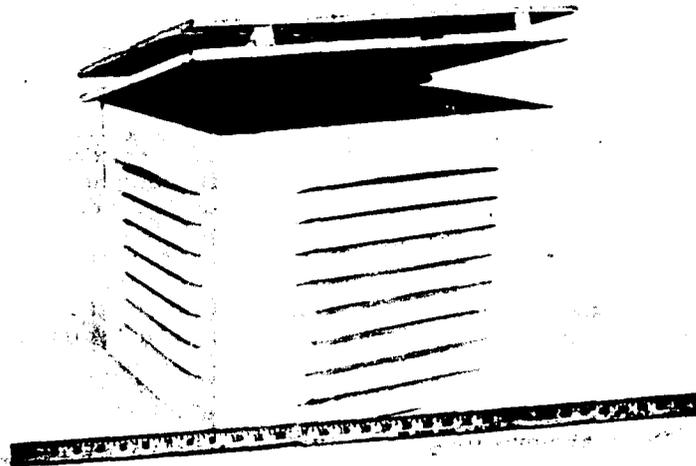


Figure 1. An economical instrument shelter fabricated from aluminum louvers.

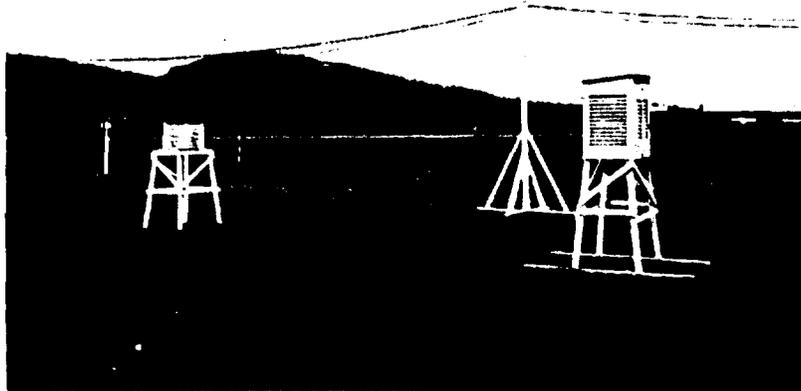


Figure 2. Test site for thermal comparison of two instrument shelters.

Weather Bureau shelter comprise a near normal or Gaussian population as a function of solar radiation flux. Data from an earlier test* support this premise. Therefore, we can describe the comparability of these two instrument shelters in terms of the mean and the variance of the temperature differences within the range of values tested. The mean or average temperature difference between shelters and the variance, the average value of the squared deviations of the aluminum shelter from the standard shelter, are presented in Table I. The analysis indicates that the temperatures in the aluminum shelter will agree with those in a standard shelter within $0.5F \pm 0.7F$, 95% of the time. That is, 95% of the comparisons are within two standard deviations of the mean.

Although the data were tabulated and analyzed to the nearest 0.1F, the accepted level of accuracy for this type of instrumentation is usually 0.5F. Of the 666 paired hourly values, 70.9% were within $\pm 0.5F$, 15.6% were greater than +0.5 and 13.5% were greater than -0.5F in the aluminum shelter relative to the standard shelter. The greater number of positive differences could mean that the aluminum shelter is more sensitive to temperature fluctuations or that incident insolation is reradiating within the shelter causing somewhat higher readings.

Discussion

The aluminum shelter has many advantages over the standard wooden shelter, particularly in cost, weight and portability. But most important, it compares favorably with a standard wooden shelter for recording ambient temperature. During cloudy overcast days and during the night, temperature differences are small and within permissible deviations for use with large mass thermal sensing instruments of the Bourdon tube type. During days of high insolation, tests on a similar shelter, before painting and with a single-layer roof, recorded temperatures up to 6F higher than in a standard shelter (Vogel and Johnson, 1964). The maximum temperature difference after painting and addition of a double roof was 2.2F (Fig. 3).

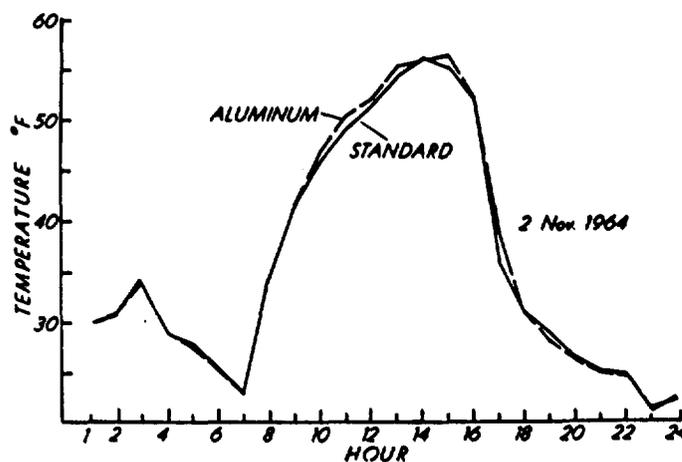


Figure 3. Comparison of hourly temperatures in an aluminum shelter and standard shelter on a clear day.

*Vogel, T. C. and P. L. Johnson (1964) An economical instrument shelter for microclimatological studies, United States Army Cold Regions Research and Engineering Laboratory (USA CRREL) Technical Note (unpublished), 8p.

4 INSTRUMENT SHELTER FOR MICROCLIMATOLOGICAL STUDIES

When data from either shelter is compared against an aspirated thermocouple, there is a marked difference; the shelters have a much higher temperature. Hence, the use of either type of shelter imposes an artificial environment on the thermal sensor.

If the primary objective of the instrumentation is the recording of relative differences rather than absolute temperatures, and all shelters are exposed to an essentially similar solar radiation load, then the aluminum shelter appears to have distinct advantages in terms of cost, portability, and comparable shielding, particularly for remote field stations. If the ambient thermal measurements can be made with thermocouples or thermistors rather than large mass thermal sensors, then either of these large volume shelters is inappropriate.

Table I
Temperature comparison
between an aluminum and standard shelter.

Observations	Aluminum	Standard
Number of paired observations	666	666
Maximum temperature of test	72.2F	74.0F
Minimum temperature of test	15.0F	15.4F
Mean hourly temperature	40.3F	40.2F
Mean difference between shelters		0.5F
Standard deviation, σ		0.7
Variance, σ^2		0.5
Maximum deviation recorded, plus or minus		2.2F