COMPARISONS of SOLAR HEATING in FIVE RADIATION SHIELDS Application Note 24

INTRODUCTION

A brief comparison of temperature readings in two passively-ventilated and three fan-aspirated radiation shields under conditions of low wind and relatively high insolation is presented.

From each of two periods of study, two days were chosen for conditions of high insolation and low wind to illustrate a reasonable sample of the performance of the shields. A single sample of each shield was used in each of the two tests.

The results presented here are not represented as being conclusive. We believe, however, they corroborate results of tests we have been conducting over a period of several years. These results are being presented to encourage similar evaluation by others.

THE TESTS

The first test was conducted on four shields: RM Young Model 41002: passively-ventilated.
Davis Instruments Model 7714: passively-ventilated.
Davis Instruments Model 7755: fan-aspirated, solar powered.
Qualimetrics Model 8150A: fan-aspirated, AC-powered.

The second test was also conducted on four shields, with the RM Young Model 43408 fan-aspirated, AC-powered shield replacing the Qualimetrics shield.

Units were mounted in close proximity at equal heights above irrigated close-cropped grass and positioned such that no shield was wind-shaded when the wind was in the prevailing direction and such that the fan-aspirated shields did not aspirate other shields. Figure 1 shows the setup for the second test.

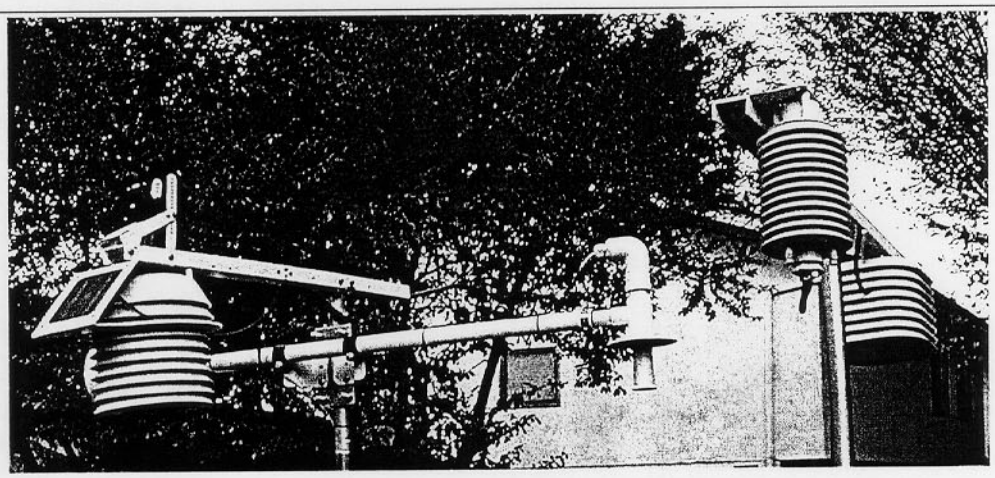

Figure 1. Test Site. Sensors (l to r): Davis Active, RM Young Active, RM Young Passive, Davis Passive.

WIND

The maximum recorded instantaneous wind speed during the selected days was 5 mph (11 m/s) for the first test (Qualimetrics) and 4 mph (9 m/s) for the second test (RM Young).

INSOLATION

During the specified period, the insolation[1] values (intensity of solar radiation) ranged between 1050 and 1200 W/m^2 for the first test and between 800 and 1050 W/m^2 for the second test. Both days were essentially cloudless.

SENSORS

Davis Instruments model 7818 Temperature Probes with 6055 NIST Certification & Characterization. The temperature sensors were characterized in a uniform temperature environment between 80°F (27°C) and 110°F (43°C). Differences in readings between the individual probes were measured and determined. These differences were eliminated in the final data by adding correction values to the recorded values. Each temperature was measured every 20 seconds, and these measurements were averaged and logged every 5 minutes with 0.1°F resolution (Note 1).

Davis Instruments Model 7911 Standard Anemometer. Wind speed was measured every 2.5 seconds and the highest value in each 5-minute period was logged with 1 mph resolution.

Davis Instruments Model 7821 Standard Solar Radiation Sensor. Insolation was measured every 20 seconds; these measurements were averaged and logged every 5 minutes with 1 W/m^2 resolution.

DATES

First Test (Qualimetrics as reference) 28 September 1999. Chosen for wind, temperature, and insolation conditions.

Second Test (RM Young aspirated as reference) 24 October 1999: Chosen for wind, temperature, and insolation conditions.

LOCATION: Danville, CA

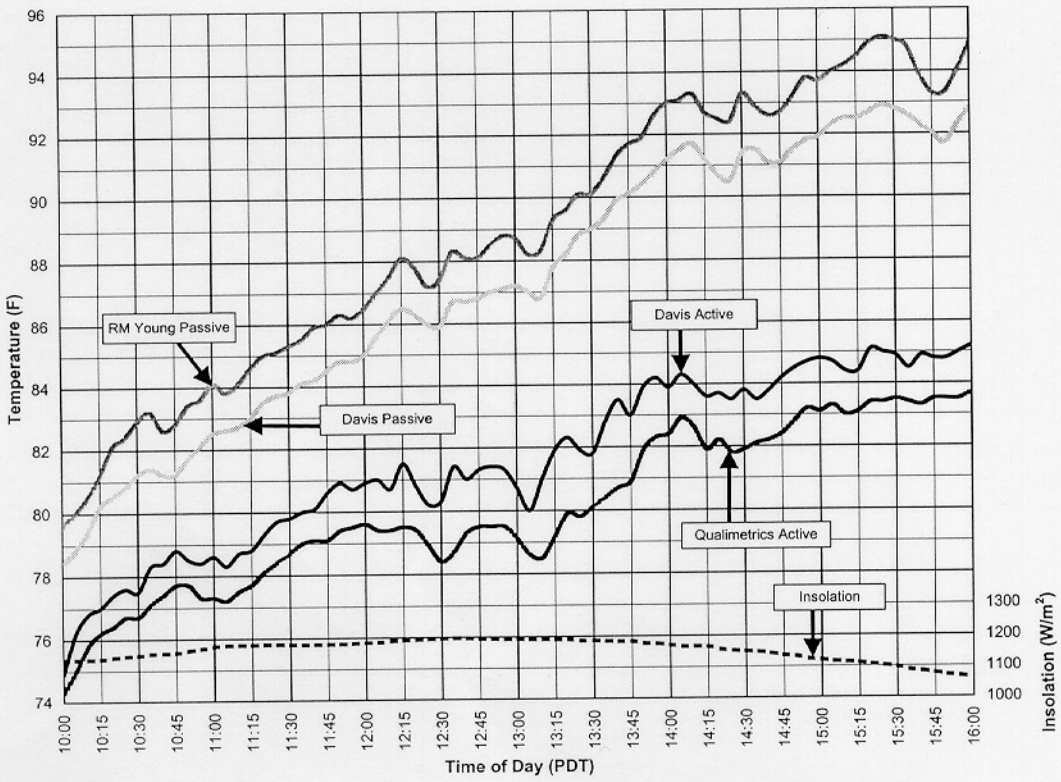

Figure 2.

Temperatures in Four Shields, Including the Qualimetrics 8150A

RESULTS of the FIRST TEST (Qualimetrics 8150A as reference)

Figure 2 shows temperature readings from within the four shields during the period from 1000 to 1600 PDT. Only this portion of the day was shown because insolation at the test site rises abruptly earlier in the morning and drops abruptly later in the afternoon due to topography and obstructions.

ASPIRATED SHIELDS

The plots of Figure 2 indicate that during the two hours following solar noon (12:45 to 14:45) the temperature in the Davis fan-aspirated shield was approximately 1.5° to 2°F (0.8° to 1.1°C) above that in the Qualimetrics shield.

PASSIVELY-VENTILATED SHIELDS

During the same two hours, temperatures in the passive shields varied from approximately 6 to 11°F (3.3 to 6.1°C) above those in the aspirated shields. At 15:30, the approximate time of maximum temperature in the passive shields, the temperature in the RM Young unit was about 2°F (1.1°C) higher than that in the Davis passive shield and about 11.5°F (6.4°C) higher than that in the Qualimetrics. The Davis passive shield temperature was approximately 8°F (4.4°C) higher than that in the Davis aspirated shield and about 9°F (5°C) higher than that in the Qualimetrics at this same time.

TEMPERATURE DIFFERENCE PLOT

When looking at the temperature plots we noted that the Qualimetrics shield temperatures appear to lag in time from those of the other shields. To test this hypothesis, we plotted the differences between the shield temperatures with the Qualimetrics values moved forward in time by 5 minutes. In other words, we compared each of the other three readings with those of the Qualimetrics unit taken 5 minutes later.

The results are plotted in Figure 3, using the Qualimetrics readings as the reference.

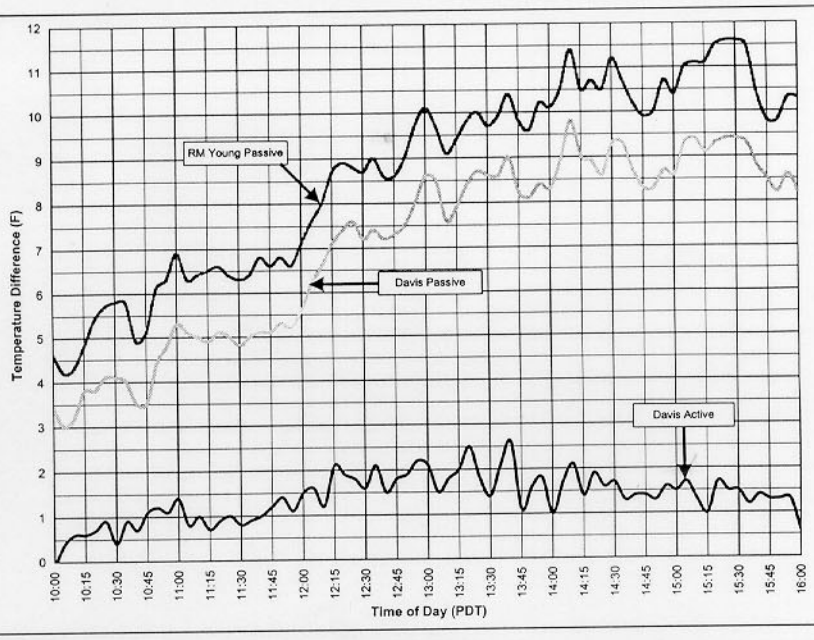

Figure 3

Temperature Errors, Qualimetrics 8150 (Time-shifted) as Reference

Linear approximations to the plots for the two-hour period after maximum insolation show that the error temperatures of the passive shields are rising and that of the Davis aspirated shield is falling, approximately as follows:

Davis aspirated:	2.1 to 1.7°F	1.2 to 0.9°C
Davis passive:	7.9 to 9.3°F	4.4 to 5.2°C
RM Young passive:	9.4 to 10.7°F	5.2 to 5.9°C.

RESULTS of the SECOND TEST (RM Young Aspirated Shelter as Reference)

Figure 4 shows temperature readings from within the four shields during the period from 10:00 to 16:00 PDT. The time-frame was chosen for the reasons cited for the first test. The error temperatures, using the RM Young aspirated unit as reference are shown in Figure 5 with no time-shift.

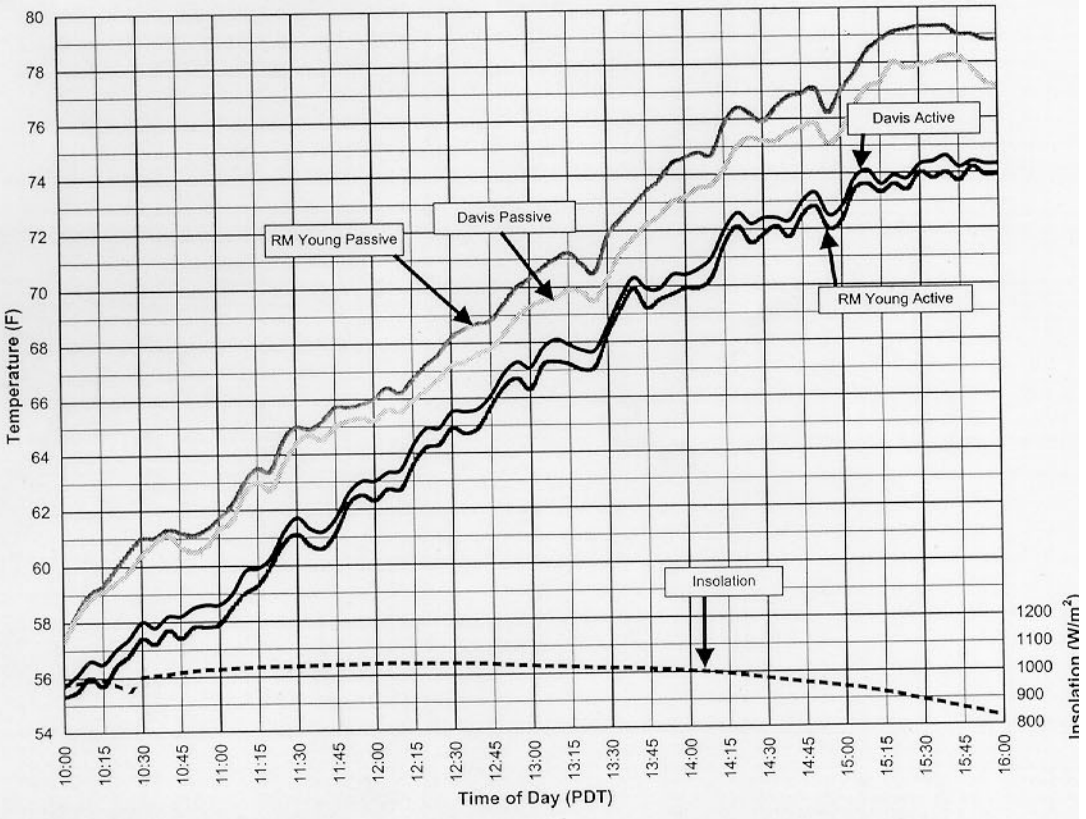

Figure 4.

Temperatures in Four Shields, Including RM Young Model 43408.

ASPIRATED SHIELDS

The plot in Figure 5 indicates that the temperature in the Davis fan-aspirated shield matches within an average of approximately 0.6°F (0.3°C) and a maximum of 0.8°F (0.4°C) that in the RM Young shield throughout the day.

ALL SHIELDS

In the period from 12:15 to 13:15, the hour of maximum insolation, the average temperature errors were approximately as follows:

Davis aspirated:	0.7°F	0.4°C
Davis passive	2.5°F	1.4°C
RM Young passive	3.5°F	1.9°C

In the period from 15:15 to 15:45, the half hour of maximum temperature readings in the passive shelters, the average temperature errors were approximately as follows:

Davis aspirated:	0.5°F	0.3°C
Davis passive:	4.3°F	2.4°C
RM Young passive:	5.5°F	3.1°C

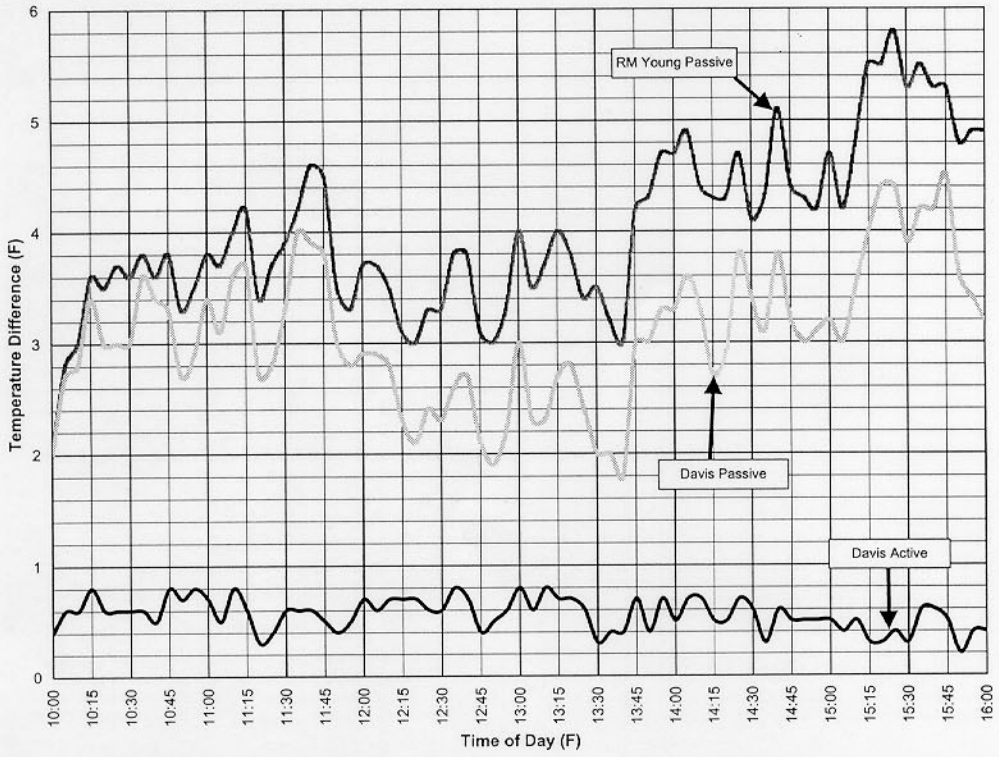

Figure 5.

Temperature Errors, RM Young #43408 as Reference.

NOTE 1: The solar sensor was tilted to directly face the sun at local solar noon. Values for insolation at other times were estimated and plotted using the cosine correction below (where R = Insolation and H = angular distance of the sun from solar noon).

$$R_{plot} = \frac{R_{measured}}{\cos(H)}$$

Model		Air Flow ft/min	Air Flow m/s	Retail Price (1999)
Davis 7755	Aspirated, Solar power	220*	1.1	$ 250
Davis 7750	Aspirated, AC power	220	1.1	175
RM Young 43408	Aspirated, AC power	590 to 1380**	3 to 7**	664
Qualimetrics 8150A	Aspirated, AC power	360	1.8	1,295
Davis 7714	Passive	---	---	65
RM Young 41002	Passive	---	---	158

* 120 ft/min. (0.6 m/s) when no sunlight.

** Depends on sensor size.

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