

# Calibration Report: Eppley PIR Pyrgeometer

## SUMMARY

Calibration Date : December 1999

Calibration Due Date : December 2001

Serial No.	$C$ $mV / W / m^2$	$k1$	$k2$	$k3$	$Cs$ $mV / W / m^2$	$K'$
31605F3	3.83	0.0698	1.0000	3.22	3.54	3.24
26181F3	3.57	0.0247	0.9997	3.00	3.47	3.02
26169F3	4.20	0.0316	1.0009	3.09	4.07	3.10

$$E = \frac{U_{emf}}{C} (1 + k_1 s T_B^3) + k_2 s T_B^4 - k_3 s (T_D^4 - T_B^4) - f \Delta T_{S-N} \quad \text{EQN 1}$$

Where:

$E$  = Irradiance,  $W/m^2$

$U_{emf}$  = Thermopile output voltage,  $mV$

$C$  = Sensitivity Coefficient,  $mV / W / m^2$

$k1, k2, k3$  = Correction factors

$s$  = Stephan-Boltzmann Constant,  $5.67 \times 10^{-8} W/m^2 K^4$

$T_B$  = Output of body thermister YSI 44031,  $K$

$T_D$  = Output of dome thermister YSI 44031,  $K$

$f$  = Correction factor for long wave component of direct sun if the instrument is used without a shading disk.

$\Delta T_{S-N} = (T_{SE} - T_N) + (T_{SW} - T_N)$

$T_{SE}, T_N, T_{SW}$  = Output of dome thermisters, southeast, north and southwest respectively,  $K$

$$E = \frac{U_{emf}}{Cs} + s T_B^4 - K' s (T_D^4 - T_B^4) \quad \text{EQN 2}$$

Where:

$E$  = Irradiance,  $W/m^2$

$Cs$  = Sensitivity Coefficient,  $mV / W / m^2$

$U_{emf}$  = Thermopile output voltage,  $mV$

$s$  = Stephan-Boltzmann Constant,  $5.67 \times 10^{-8} W/m^2 K^4$

$T_B$  = Output of body thermister YSI 44031,  $K$

$K'$  = Dome heating constant

$T_D$  = Output of dome thermister YSI 44031,  $K$

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## ABSTRACT

Three Eppley Laboratory, Inc. Precision Infrared Pyrgeometers (PIR) instruments were modified and calibrated. This modification and calibration was performed in order that the instruments comply with specifications set in the Baseline Surface Radiation Network (BSRN) Operator's Manual, V 1.0, 1997. The modification and calibration were performed by Physikalisch-Meteorologisches Observatorium Davos (PMOD) in Davos-Dorf, Switzerland. The calibration date is 14 December 1999. The serial numbers of the units modified and calibrated were 31605F3, 26181F3 and 26169F3.

### 1. Introduction

Three Eppley Laboratory, Inc. Precision Infrared Radiometers (PIR) Pyrgeometer instruments were modified and calibrated to meet the 1997 Baseline Surface Radiation Network (BSRN) specifications. The three instruments were modified by installing three new dome thermistors, model YSI 44031. These engineering and calibration tasks were completed by the Physikalisch-Meteorologisches Observatorium Davos (PMOD) in Davos Dorf, Switzerland.

### 2. Results

Calibration results for each instrument are shown in the above summary page along with the governing equations. The use of Eqn. 1 with the above tabular values is described in each of the Calibration Certificates provided by PMOD. Equation 2, and the associated tabular values are provided as a historical connection to the Albrecht et al. single sensitivity factor method.

### 3. Discussion

These sensors have been modified and calibrated to permit the measurement of diffuse radiation. Global measurements

involve determination of the factor  $f$ . The manufacturer, Eppley Laboratories, Inc., defines an uncertainty of 5%. Field data need to be examined in order to assess the standard uncertainty in the measurements made by the modified instruments.

The single sensitivity factor calibration histories of the three sensors are as follows:

#### 26169F3

Dec 1999	PMOD	4.07	$mV/W/m^2$
Oct-1997	NREL	4.29	$mV/W/m^2$
Jul-1992	CMDL	4.626	$mV/W/m^2$
Oct-1987	NARCK	4.48	$mV/W/m^2$
Jan-1987	Eppley	4.47	$mV/W/m^2$
Apr-1986	Eppley	4.40	$mV/W/m^2$

#### 26181F3

Dec-1999	PMOD	3.47	$mV/W/m^2$
Oct-1997	NREL	3.58	$mV/W/m^2$
Jul-1992	CMDL	3.763	$mV/W/m^2$
Oct-1987	NARCK	3.93	$mV/W/m^2$
Sep-1987	Eppley	3.90	$mV/W/m^2$
Apr-1986	Eppley	3.77	$mV/W/m^2$

31605F3

Dec-1998	PMOD	3.54	$mV/W/m^2$
1997	Eppley	3.79	$mV/W/m^2$

Each instrument single sensitivity factor,  $C_s$ , has remained within a variability of 5% or less through each of the calibrations which did not involve physical changes to the instrument. This variability is within manufacturer stated design specifications.

#### 4. Summary

A modification and calibration of three Eppley Laboratory Inc. Precision Infrared Radiometer, (PIR) instruments has been completed. Data analyses have been performed. The calibration factors are presented in the summary table above and in the Calibration Certificates.

No apparent performance anomalies are indicated from the single sensitivity factor calibration history of the sensors.

These calibration factors can be used with these three instruments from 14 December 1999.

#### REFERENCES

World Climate research Program Baseline Surface Radiation Network Operations Manual, Version 1.0, :J.B. McArthur, June, 1997.

Philipona, R., C. Frolich, Ch., Betz, 1995: Characterization of pyrgeometers and the accuracy of atmospheric long-wave measurements, Applied Optics, 34(9),1598-1605.

Albrecht, B. and Cox, S.K.: Procedures for Improving Pyrgeometer Performance. Journal of Applied Meteorology, 16 1977, P 188-179.