THE EPPLEY PYRANOMETER (180° PYRHELIOMETER)

DESCRIPTION

The Eppley pyranometer (formerly referred to as the Eppley 180° pyrheliometer) is primarily intended for the measurement of total sun and sky (i.e. global) radiation received on a horizontal plane near the Earth's surface. However, it may also be employed for the measurement of diffuse sky radiation (with the appropriate Eppley shadow band — see Eppley leaflet on this accessory) or of reflected ground or cloud radiation, i.e. albedo (when operated in the inverted position).

Two types of this instrument are available, differing only in the number of gold-palladium and platinum-rhodium alloy thermojunctions incorporated. These are referred to, generally, as the Model 10 and the Model 50 pyranometers. In each instance, the pyranometer consists of a thermopile mounted under thin flat concentric silver ring receivers, in good thermal contact but electrically insulated from them. The whole radiation receiving assembly is hermetically sealed in a specially blown lamp bulb of soda lime glass approximately 75 mm in diameter.

At the time of final sealing, the bulb is carefully heated and exhausted to expel any absorbed moisture and then filled with dry air at ambient temperature.

The inner silver ring is coated with Parsons' optical black lacquer (topcoat applied over undercoat): behind this ring are attached the hot junctions. The outer silver ring, to which the cold junctions are attached, is coated with magnesium oxide as is the central disc of the supporting cup which is flush with the ring surfaces. The sealed bulb is cemented into a chromium-plated brass socket on which is mounted a circular spirit level.

A pair of teflon covered No. 16 gauge, 12 inches long, leads are furnished. The socket is secured to a chromium-plated tripod which has two leveling screws and also, in one of the tripod legs, a hole for the use of a machine or wood screw to mount the instrument to some firm support. The approximate size of the instrument is 7½ inches diameter and 7 inches in overall height; the weight is 2 lbs. 4 oz.

PRECAUTIONS

All pyranometers are delicate scientific instruments and can be damaged readily. They should not be subjected to mechanical shocks of any sort. When the glass bulb is cleaned, vigorous wiping should be avoided.

INSTRUMENT EXPOSURE

For the most accurate measurement of total or diffuse radiation the site for the pyranometer should be free from any significant obstructions above the plane of the sensing element and, at the same time, should be readily accessible. If it is impracticable to obtain such an exposure, the site selected must be as free from obstructions (artificial as well as natural) as possible, especially (in the N. Hemisphere) from east-northeast, through south, to west-northwest and (in the S. Hemisphere) from east-southeast, through north, to west-southwest. If practicable, the instrument should be so located that (a) a shadow will not be cast on it at any time (e.g. by radio masts, etc.); (b) it is not close to light-colored walls or other objects likely to reflect sunlight onto it; and (c) it is not exposed to artificial radiation sources.

At most places, a flat roof provides the best location for mounting the stand (not supplied) to carry the pyranometer; if such a site cannot be obtained, a rigid stand with horizontal top surface some distance from buildings and other obstructions should be used.

On the initial installation of a pyranometer, or whenever its location is changed, or if a significant change occurs in regard to any surrounding obstructions, the angular elevation above the plane of the receiving surface of the pyranometer and the angular range in azimuth of all obstructions throughout the full 360° around the pyranometer should be observed. If it is at all possible, the site should be so chosen that any obstruction over the azimuth range between earliest sunrise and latest sunset should have an elevation not exceeding 5°. It is also useful, for reference purposes, to note the altitude above M.S.L. of the pyranometer and its geographical coordinates.

Full instructions for the installation, operation and maintenance of the pyranometer are given in the relevant Eppley leaflet, normally supplied with the instrument.

PERFORMANCE CHARACTERISTICS

1. PYRANOMETER ENVELOPE

The glass bulb transmits from about 0.28 to 5 microns with centers of lower and upper cutoff at approximately 0.30 and 4.5 microns; the transmission is essentially uniform over the range 0.35 to 2.5 microns. The influence of the bulb relative to spectral transmission is therefore negligible for all practical purposes.

2. RECEIVER COATINGS

Parsons' optical black lacquer (both topcoat and undercoat) is used on the hot receiver. This coating is non-selective with regard to wavelength of incident energy from the ultra-violet region out into the far infra-red.

Magnesium oxide is used on the cold receiver. This coating has practically constant reflectance from the ultraviolet to about 2 microns. As the absorbing power of magnesium oxide is low, generally, as compared to the black coating and as the proportion of radiation of wavelength longer than 2 microns in the solar integral is small, the response of the instrument, from these aspects, may be regarded as practically independent of the solar spectral energy distribution. It is important, however, when employing sources of energy other than sunlight, to prevent energy of wavelength longer than about 2 to 3 microns from reaching the receivers (because of the increase in absorptance of the magnesium oxide). Otherwise a special pyranometer calibration will be necessary.

The similarity of the two receivers, with regard to absorption of long-wave radiation, minimizes the effect of long-wave emission from the glass envelope.

3. SENSITIVITY

The sensitivity of the 10-junction model is approximately 2.5 millivolts per cal cm^{-2} min^{-1} and that of the 50-junction model approximately 7.5 millivolts per cal cm^{-2} min^{-1}. If temperature compensation of instrument sensitivity is incorporated (see the section below on this special service) these figures are reduced by about 25 percent.

4. CALIBRATION

With every pyranometer, an Eppley certificate of calibration is furnished. The pyranometers are calibrated against a working standard pyranometer which, in turn, is periodically compared, in natural sunlight, with specimens of the Eppley group of primary working reference standards. These consist of four Ångström electrical compensation (normal incidence) pyrheliometers and an Abbot silver disc pyrheliometer. At least one of these primary standards is compared at regular intervals with similar pyrheliometers in the U. S. Weather Bureau or at European institutes.

Most of these calibrations are now undertaken in an integrating hemisphere (i.e. artificial diffuse sky) which provides controlled and closely repeatable conditions; the radiation intensity, at the test location, is about 1 cal cm^{-2} min^{-1} and the ambient temperature $25 \pm 3°$ C. Periodic checks are made between this method and the former one entailing outdoor exposure.

The solar radiation reference adopted is the International Pyrheliometric Scale (1956). Prior to July 1, 1957 the reference in use was the Smithsonian (1913) Scale. Values of radiation intensity expressed according to the current reference (green, or red instrument nameplate if temperature compensation is provided) are 2.0 percent lower than the corresponding figures for the earlier reference (black instrument nameplate).

Experience indicates that, with proper care, stability of calibration to within 1 percent or so may be obtained over several years; but where the highest accuracy is desired, it is recommended that the calibration be verified at, say, annual intervals.

5. RADIATION INTENSITY VERSUS PYRANOMETER EMF

The relationship between radiation intensity and pyranometer output has been demonstrated, under natural conditions and in the laboratory, to be linear to within ± 1 percent over the intensity range 0.1 to 1.5 cal cm^{-2} min^{-1}.

6. TEMPERATURE DEPENDENCE OF INSTRUMENT SENSITIVITY

The value of the temperature coefficient of sensitivity is not constant and lies between -0.1 and -0.15 percent per 1° C rise in ambient temperature over the range -50 to $+40°$ C. Ambient temperature at the time of calibration is noted on the relevant calibration certificate.

For information on the greatly reduced variation of sensitivity with temperature when a temperature compensator is fitted, see the section which follows on this aspect.

7. COSINE RESPONSE

The extent of deviation from the Lambert cosine law has been determined from laboratory experiments. After due allowance is made for the diffuse sky radiation component, the following figures are typical for conditions of cloudless sky: percentage error in sensitivity for solar elevation 90°, 0; 70°, +1; 50°, +2; 30°, +3; and 15°, +5.

8. EFFECT OF INSTRUMENT TILT

On account mainly of the effect of air convection inside the sealed bulb, the sensitivity of this type of pyranometer becomes reduced when the instrument is so tilted that the receiver is vertical instead of in the normal upwards facing horizontal position. This error, in sensitivity, is variable at +2 to 5 percent in general (average about +3 percent). When inverted (i.e. receiver horizontal but facing downwards) the effect on the pyranometer sensitivity is negligible.

9. IMPEDANCE

The basic impedances of the 10- and 50-junction models (i.e. without temperature compensation) are, respectively, approximately 40 and 100 ohms. Introduction of temperature compensation of sensitivity results in an effective total value of about 450 ohms at +25° C.

10. RESPONSE TIME

Response time, for 98 percent signal, of the 10- and 50-junction models is of the order, respectively, of 20 and 30 seconds.

More detailed information regarding the performance characteristics of this type of pyranometer will be found in the relevant Eppley leaflet. It should be noted that the errors in instrument sensitivity discussed above refer to the basic calibration value expressed in the form of millivolts per cal cm^{-2} min^{-1}.

TEMPERATURE COMPENSATION

A thermistor (bead type)-resistor circuit can be inserted inside the socket of the pyranometer, to provide temperature compensation of sensitivity for the variation in this value which otherwise arises on account of changing ambient temperature. The standard range of compensation is −20 to +40° C, although alternative ranges of −40 to +20°C and −10 to +50°C can be offered (on customer request). Over any of these ranges, the matching is usually within ±1 percent. Through replacement of the precision wire-wound resistors with a combination of silicon and wire-wound ones, it is possible to provide temperature compensation over the extended range −70 to +50° C, usually to within better than ±2 percent.

It must be noted that with the standard compensation circuit in place, the impedance of the arrangement is variable between about 650 ohms at −50° C and 350 ohms at +50° C, and with the extended-range silicon resistors inserted, the resistance is increased to about 700 ohms at +25° C. The temperature-compensated pyranometer is therefore specifically intended for employment with a modern electronic-type potentiometric recorder. It is not suitable for use with microammeters and microammeter-type recorders.

READOUT INSTRUMENTATION

Several manufacturers supply the type of recording potentiometers especially designed for use with Eppley pyrheliometers and pyranometers. These instruments incorporate variable range rheostats which can be set to the value of the radiation sensor as given in the calibration certificate or on the nameplate. When so set, the recorder reads directly in calories per square centimeter per minute and so yields chart deflections in the range of 0 to 2 cal cm^{-2} min^{-1}. Built-in integrators with auxiliary print-out equipment can also be supplied. For further information, reference should be made to the Eppley recorder literature.

If a continuous record is not required and it is desired to take readings periodically, a portable potentiometer of suitable range and precision may be used.

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PRICES

EPPLEY PYRANOMETER (10-junction type 180° pyrheliometer model: non-compensated but inclusive of calibration) **$330.00**

EPPLEY PYRANOMETER (50-junction type 180° pyrheliometer model: non-compensated but inclusive of calibration) **$440.00**

Standard (or equivalent) temperature compensation of either of above models .... **$100.00 extra**

Extended range temperature compensation of either of above models .... **$150.00 extra**

TERMS

F.O.B. Newport, R.I., U.S.A., Net Cash (N. Y. Funds) in thirty days. No cash discount.

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