TECHNICAL REPORT

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Solar Energy — Field Pyranometers — Recommended practice for use

Énergie solaire — Pyranomètres de champ — Pratique recommandée pour l'emploi

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 9901, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 180, *Solar energy*.

The scope of ISO/TC 180/SC 1 is the measurement and recording of climatic data in relation to solar energy utilization. This Technical Report on recommended practice for the use of field pyranometers has been prepared as an adjunct to the work of ISO/TC 180/SC 1 on the calibration and specification of pyranometers.

Annexes A, B and C of this Technical Report are for information only.

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Solar energy — Field pyranometers — Recommended practice for use

1 Scope

This Technical Report gives recommended practice for the use of field pyranometers in solar energy applications (e.g. testing of solar collectors or other devices, and monitoring of solar systems). It is applicable for both indoor and outdoor use of pyranometers, when measuring global and reflected solar radiation, or radiation from a solar simulator. The measurements may be carried out on either a horizontal or an inclined surface, and the pyranometer may be combined with a sun-shading device to measure diffuse radiation.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 9060:1990[1]), *Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation.*

ISO 9847:—[1]), *Solar energy — Calibration of field pyranometers by comparison to a reference pyranometer.*

3 Definitions

For the purposes of this Technical Report, the definitions given in ISO 9060 apply.

4 Pyranometer selection

4.1 Selection related to pyranometer type

There are several criteria for selection of the pyranometer type as follows:

a) task-specific criteria, such as the accuracy requirements for the selected incident angle and temperature ranges and maximal response time;

b) operational criteria, such as dimensions, weight, stability and maintenance;

c) economic criteria, such as when networks have to be equipped.

For solar energy applications, only thermoelectric and photoelectric instruments should be used. Thermoelectric pyranometers are generally more accurate over a wide range of conditions. Solar photovoltaic cells (otherwise known as Silicon-pyranometers) also offer a few advantages; they are inexpensive, small in size, have a fast response time and, if properly designed and mounted, a good cosine response. When overall accuracy requirements are not too high, or where constant spectrum conditions exist (as with artificial sources), they may be used to measure the incoming radiation when calibrated under the working conditions.

NOTE 1 First class instruments are not necessary for all applications.

4.2 Selection related to the measuring specifications

As a first step, all possible ranges of measuring parameters (temperature, irradiance, angle of incidence, tilt angle) should be compiled. It should be remembered that the ranges of measuring parame-

1) To be published.

ters met in indoor tests are usually smaller than those met in outdoor tests.

Reference should be made to information about measuring and physical specifications of pyranometers given by

- the ISO classification of pyranometers given in ISO 9060 (which defines the specifications to be met by different categories of instrument), and
- the data specification sheet from the manufacturer, or preferably from an independent test institute.

(Specification items are listed in ISO 9060:1990, table 1. Annex A gives information on ventilation systems. A future International Standard will cover the characterization of pyranometers.)

If the accuracy of secondary standard pyranometers is not sufficient (especially for high incidence angles) it is recommended that the hemispherical solar radiation be measured using both a pyrheliometer and a shaded pyranometer for incident radiation and direct radiation respectively.

5 Recommended practice for use

5.1 General

Unless otherwise stated the use of pyranometers is the same both for the sun as the radiation source and for an artificial light source (solar simulator).

A basic check list for the use of field pyranometers is given in table 1.

Table 1 — Check list for field pyranometers

Equipment	Object	Control	Maintenance
Pyranometer	Glass dome (outside)	Local pollution, sand Frozen snow, rime, frost	Wipe clear and dry De-ice and wipe
	Glass dome (inside)	Condensation water	Remove the outer dome and dry it
	Rubber washer	Perishing	Lubricate or replace
	Sensing surface	Black and even	Report, check the sensitivity and when necessary replace the instrument
	Desiccator	Colour of desiccant	Replace
	Spirit level	Horizontal	Adjust
Ventilator	Operational state	Unusual noise, or air current	Report, and when necessary replace
	Heating	Formation of rime or frost	Electrical check or replace
	Air ducts	Dirt	Clean
Shading device	Shadow	Position relative to the dome (morning and afternoon)	Adjust
	Shading ring	Paint, dirt Angle to horizontal	Clean and paint when necessary Adjust
	Shading disk	Motor Stability of the mount	Replace Adjust or replace
Contact box	Contacts	Corrosion, humidity and dirt Loose junctions	Clean and tighten the box Tighten the junctions or replace
Data acquisition	As a wide variety of data acquisition and recording systems are used with pyranometers it is difficult to give a check list for this equipment. Reference should be made to the manufacturer's instructions.		

5.2 Pyranometer for measurement of global radiation on a horizontal or tilted plane

5.2.1 Installation

In solar energy applications the pyranometer is generally mounted on the object to be tested (e.g. a solar collector) to measure the incoming solar radiation.

5.2.1.1 Selection of the installation site

The test object and the pyranometer shall be equally exposed; that means that the test surface and pyranometer shall receive the same irradiance and have the same inclination angle.

When the test object is not uniformly exposed, either a correction should be applied or more than one pyranometer should be used.

The need for easy access during maintenance shall be considered in selecting the installation site.

5.2.1.2 Stand or support

The pyranometer should be securely attached to whatever mounting stand is available, using the holes provided in the tripod legs or in the baseplate. Precautions should always be taken to avoid subjecting the instrument to mechanical shocks or vibration during installation. The stand shall be a rigid construction able to resist severe storms, temperature variations, etc. A metal or concrete support is suitable. A wooden support should not be used because of its susceptibility to temperature and humidity effects.

If the pyranometer is to be used in an inclined position it is recommended that it be mounted on a plate parallel to the pyranometer sensor, and in a way that will ensure that the instrument is parallel to the test object.

5.2.1.3 Levelling of pyranometer

First the spirit level shall be checked. This may be tested in the laboratory on an optical levelling table using a collimated lamp beam at an elevation of about 20°. The levelling screws of the instrument are adjusted until the variation in response is a minimum during rotation of the sensor in the azimuth. If necessary, the spirit level is then adjusted to indicate the horizontal plane.

This is called radiometric levelling and should be the same as levelling the thermopile; this may not be true if the thermopile surface is not uniform.

5.2.1.4 Mounting of the pyranometer on the stand

Wherever possible, the pyranometer should be oriented so that the cable or connectors are located north of the receiving surface in the northern hemisphere (and south of the receiving surface in the southern hemisphere). This minimizes radiant heating of the electrical connections. Instruments with Moll-Gorcynski thermopiles should be oriented so that the line of hot thermojunctions (the long side of the rectangular thermopile) points east-west. The latter requirement sometimes conflicts with the former, depending on the type of instrument. In such a case, the requirement for orientation of the Moll-Gorcynski thermopiles should take precedence since the cable may be shaded if necessary.

If during calibration the pyranometer was not oriented in the directions recommended above, the cable should point in the same direction as when the pyranometer was calibrated (if its orientation during calibration is known) and the connector shall be shaded by an additional cap.

When the instrument is outdoors and mounted in an inclined position, the cable should point downwards to avoid rain reaching the electrical connection. Radiation reflected from the ground or the base should not irradiate the instrument body from underneath; a cylindrical shading device may be used, but care should be taken to permit sufficient natural ventilation to maintain the instrument body at ambient temperature.

The pyranometer should then be secured lightly with screws or bolts and levelled with the aid of the levelling screws and spirit level provided. After this, the retaining screws should be tightened, taking care that the setting is not disturbed so that when properly exposed, the receiving surface is horizontal, as indicated by the spirit level.

Alternatively, the levelling arrangements may comprise spring-loaded adjusting bolts (see figure 1) which allow the pyranometer to be firmly fastened to the mounting, and then levelled, without the need for an iterative procedure.

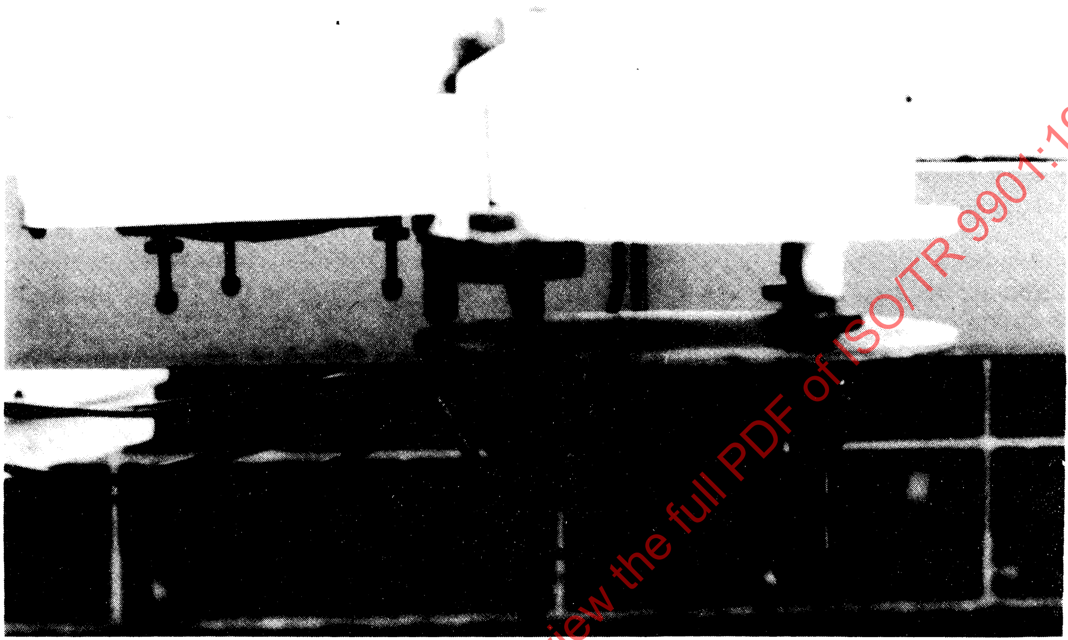


Figure 1 — Mounting of a pyranometer with spring-loaded adjusting bolts

5.2.1.5 Electrical installation

The cable connecting the pyranometer to its recorder should have twin conductors and should be waterproof. The cable should be secured firmly to the mounting stand to minimize the chance of breakage or intermittent disconnection in windy weather. Wherever possible, the cable should be protected and buried underground if the recorder is located at a distance. The use of shielded cable is recommended, with the pyranometer, cable and recorder being connected by a very low resistance conductor to a common earth.

Care must be exercized to obtain a good copper-to-copper junction between all connections prior to soldering. All exposed junctions shall be weatherproofed and protected from physical damage. After identification of the circuit polarity, the other extremity of the cable may be connected to the recorder in accordance with the relevant instructions.

5.2.2 Ventilation systems

Where high accuracy and reliability are required it is necessary to ventilate the pyranometer to ensure that

a) dew and frost formation are inhibited, especially from the outer dome,

b) rain droplets on the outer dome are evaporated quickly, and

c) the temperature of the instrument is maintained near to that of the ambient air.

The ventilation system should be designed to achieve a uniform and possibly strong flow of air around the instrument, especially around the outer dome, to keep the windows for solar radiation clean, and to compensate for the effects of the smaller thermal conductivity of glass than that of the metallic body of the unit.

The temperature difference between the ventilating air and the ambient air should be no more than about 1 K unless heating is necessary (for example, to inhibit heavy dew or frost formation — see annex A).

Since pyranometer manufacturers do not generally provide ventilation systems, the users, especially the various meteorological institutes, have designed different ventilation arrangements for field application; these arrangements are briefly described in annex A. Some ventilation systems are commercially available, however. These are usually special systems designed for special pyranometer types. The information given in annex A may be of assistance in deciding on a suitable system for a given application. Consultation with experts of national radiation centres or regional radiation centres of meteorological services established by the World Meteorological Organization, Geneva, may also be helpful.

5.2.3 Care

5.2.3.1 Inspection

Pyranometers in continuous operation should be inspected at least once per day. Inspections of specific attributes as described in 5.2.3.2 to 5.2.3.5 should be carried out as daily, weekly, monthly and yearly routines. It should be noted that, for radiation measurements, the quality of the data depends strongly on the amount of personal attention given during the observation programme.

Attention must be paid during the planning of installations, especially of systems with difficult access, to ensure the reliability of the observations. To provide a certain amount of redundancy at critical sites, installation of duplicate measuring systems may be desirable.

5.2.3.2 Daily routine

During these inspections the glass dome of the instrument should be wiped clear and dry. If frozen snow, glazed frost, hoar frost or rime is present, an attempt should be made to remove the deposit very gently, initially with the sparing use of a de-icing fluid, after which the glass is wiped clean. A check should also be made to determine whether any condensation is present inside the dome and that the sensing surfaces are still black and even.

If air pollution forms a deposit on the dome, the cleaning process should be carried out in a gentle manner, by either blowing off as much of the loose material as possible or wetting it a little, in order to prevent scratching the surface. Abrasive cleaning actions can appreciably alter the original transmission properties of the material.

The operational state of the ventilator should be checked and any unusual noise noted for attention.

If it is possible, a rough check of the output data should be performed, to determine whether the data being recorded is plausible in relation to the conditions being experienced. Note that it is generally easier to remember the weather of the previous day than the weather of a week or a month earlier.

Maintenance of data acquisition systems is system dependent but should include recording of the time and date, sensitivity checks, and zero-point tests.

5.2.3.3 Weekly routine

Desiccators should be kept charged with active material (usually a colour-indicating silica gel).

Normally the desiccant should remain active for several months. If the desiccant is consumed rapidly, the cause might be a defective or missing O-ring. If the glass dome is glued to the metal ring (as in the Kipp and Zonen[2] CM5 pyranometer) the cause is likely to be leakage at the joint, in which case the gluing shall be renewed.

5.2.3.4 Monthly routine

Inspection of the inclination angles (in the horizontal position by using the spirit level) should be carried out at different hours of a fine day (because of possible temperature effects).

Attention should be paid to the transmission and amplification of the signals. Both visual and electrical checks of the cable and amplifier should be carried out monthly, and also when any of the equipment has been replaced and after any anomalies have been detected in the data.

5.2.3.5 Yearly routine

Special attention should be paid (in particular for new instruments) to check for any drift of the sensitivity and any general deterioration of the instrument, including the domes, paint and sealant. In such cases replacement of the instrument or an *in situ* calibration check should be considered.

Inspection and cleaning of the air channels of the ventilator should also be carried out on a yearly basis.

5.2.4 Recording of measured data

In solar energy applications the pyranometer output is just one of the parameters to be monitored. Special attention should be given to ensure that the measurements are made simultaneously, or at a time interval much shorter than the rate of change of the irradiance and the response time of the instruments. When this is not possible, consideration should be given to using only that data obtained under slowly changing conditions.

2) Kipp and Zonen is the trade-name of an instrument available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the instrument named.

5.2.4.1 Type of recording systems

Recording systems fall into three principal classes:

a) those providing a series of individual values;

b) continuous-line or intermittent-dot recorders providing autographic traces;

c) automatic data acquisition systems which can deliver either individual values or integrated totals over a specified period of time.

Although a variety of equipment is available for data-recording and processing purposes, potentiometric strip-chart recorders with integration, and voltage-time integrators, are in wide use. More recently, microprocessor-controlled data loggers using a variety of support systems for data storage have become common.

5.2.4.2 Sampling rate

With instantaneous individual readings, the length of the interval over which the series of readings extends and the number of readings comprising the measurement should be chosen to ensure that the derived mean affords a representative value for the desired time interval. This applies equally to a series of readings recorded by means of a fast-response multi-channel automatic data-logging system and to a series recorded manually using a millivoltmeter or potentiometer. The frequency of the readings depends on the application and the system characteristics as illustrated by the following questions.

a) What is the smallest time interval of interest?

b) What are the response time and accuracy of the pyranometer?

c) Are the measurements to be instantaneous values obtained from a sample-hold instrument or short time-integrated values obtained with an integrator (i.e. a voltage/frequency converter and a counter)?

d) Does the data acquisition system compress data?

Depending on the answers to these questions the sampling rate can range from one sample per minute, to one sample per second, or even faster. Generally, for the calculation of average values over periods of between 6 min and 1 h, 100 samples allow the average values to be estimated with sufficient accuracy. (For more information on sampling frequency, see Olivieri [1].)

The recommended method is to take readings with a short-term integration, to apply a data check and then to perform data compression corresponding to a suitable interval. This is only possible with a complex data acquisition system.

5.2.4.3 Integration of data

There are two systems of data integration as follows.

a) Analogue (using an operational amplifier connected to the integrator)

   In this case it is necessary to check the precision and linearity of the integration system at appropriate intervals (e.g. monthly).

b) Digital (by sampling the voltage output from the pyranometer)

   In this case it is necessary to check the precision of the analogue-digital converter, as well as the validity of the sampling frequency, at appropriate intervals.

The considerations outlined in 5.2.4.2 apply here also. Except in studies of transient behaviour of dynamic systems, it is preferable to take a sequence of at least ten readings for each measurement series recorded. In this way one achieves greater accuracy in the pyranometer measurement because of the smoothing of the data. With thermoelectric pyranometers the electronic integration of the data should be over a period of at least 1 s.

5.2.4.4 Time base

For the use of pyranometers outdoors, the position of the sun is very important, and attention should be given to the time of day used in the calculation of sun angles. Time accuracy to a recognized universal time reference should be better than 1 s. Internal clocks of automatic data acquisition systems are usually accurate; however, a check of the reference time is still necessary. All measurements and data should be displayed and analysed with reference to solar time. When using solar time as reference for data collection one must adjust the clock at least once a day, and, using the local time, apply the equation of time correction during the data evaluation. The relationship between the time base of the data collection system and universal time must be accurately known.

5.2.4.5 Impedance considerations

The internal impedance of the amplifier or recorder shall be at least 1 000 times the value of the impedance of the instrument. If this is not possible, corrections should be applied.

The length of the cable and its cross-section should be such that the resistance of the cable will not be greater than the internal impedance of the instrument, and in any case both together shall be less than one-thousandth the internal resistance of the amplifier. When this is not possible, for example when using very long cables, a voltage/current converter should be introduced near the pyranometer.

5.2.4.6 Accuracy of the electronics

Pyranometer outputs are of the order of millivolts and solar energy applications of pyranometers require values of the irradiance determined over short time intervals; hence attention must be given to short-term accuracy. Although the electrical equipment is shielded, the sensor, the body of the instrument and the cable are still vulnerable to electromagnetic noise, which produces the so-called "pop-corn" effect, i.e. very-short-term voltage changes. For this reason it may be desirable to integrate the output signal electronically, for example with a voltage/frequency converter and a counter using an integration time of at least 1 s for each reading. Alternatively the integration may be done over an integer number of line voltage periods (e.g. for 50 Hz or 60 Hz).

The resolving power of the data acquisition system should be at least one order better than that of the pyranometer (in terms of microvolts). Careful consideration should be given to the fact that millivoltmeter accuracy is generally given for full-scale values while the pyranometer output can vary over two orders of magnitude (actually over three, but the lowest values are generally not of interest).

Temperature is a source of deviation in the electronics and this deviation may be significant. It is necessary to ascertain the precision of the integrator in the temperature range specified by the manufacturer, and to use the integrator only within this temperature range.

5.2.4.7 Check of the electronics

After all the equipment has been installed a check on the electronics should be carried out. This check consists of replacing the pyranometers by an equivalent direct voltage source of the same impedance to determine any differences between input values and recorded signals. This check should be extended over the anticipated range of outputs of the pyranometer (normally the output signal equivalent to irradiance levels of 20 W/m^2 to 1 400 W/m^2, in several steps).

5.2.4.8 Redundancy considerations

For high-quality data, cross-checking of different radiation quantities and, when no data loss is acceptable, some redundancy in each measurement shall be considered.

5.2.5 Quality control procedures and data correction

For data used in solar testing some redundancy of the solar radiation measurement programme is desirable for data collaboration. As a general rule, one should disregard doubtful data.

Corrections for linearity, temperature and tilt should be applied as given in the data specifications for the instruments.

One must always be careful to use individual values, especially for rapidly changing irradiance conditions. This restricts somewhat the use of pyranometers in investigating the performance of solar energy devices under transient conditions.

A simple method of quality control in outdoor applications is to note the solar noon value during clear sky (or with less than one-eighth cloud) conditions. Records of these values may be plotted, showing any long-term drifts in sensitivity, as well as cross-correlation with calibration results. If a significant drift is detected, the pyranometer will require recalibration.

Another simple method is to compare the totally cloudy day values of irradiance with those measured by a diffuse pyranometer in the same orientation. One should be careful in comparing these data if the diffuse radiation pyranometer is shaded by a ring.

5.2.6 *In situ* calibration check

The *in situ* calibration checks shall be carried out using the calibration method described in ISO 9847. This check should be carried out at least every 6 months, preferably in winter and summer for pyranometers used outdoors. The reference pyranometer should be an instrument which has a well-known response and calibration. It is essential that pyranometers which will be used in an inclined position be calibrated in the same position.

Calibration entails the simultaneous operation of two pyranometers mounted parallel, side by side, and outdoors, for a sufficiently long period of time to acquire representative results. If the instruments are of the same type, a few days should be sufficient. The more pronounced the difference between the two types, the longer the period of comparison required. A long period could be replaced by several shorter periods covering typical conditions (e.g. clear, cloudy, overcast, rainfall and snowfall conditions). The derivation of the instrument factor is straightforward. If chart recorders are used, selection of data should be made from those occasions when the irradiance is greater than 100 W/m^2 and its rate of change is less than the response time of the pyranometers.

Each mean value of the ratio R of the response of the test instrument to that of the reference instrument may be used to calculate $k_d = Rk_r$, where k_r is the calibration factor of the reference and k_d is the calibration factor being derived. If voltage integrators or fast-scanning data loggers are used, then conditions of fluctuating radiation may also be used provided that the time constants of both pyranometers are comparable.

The mean temperature of the instruments or the ambient temperature should be recorded during all outdoor calibration work so that any temperature effects can be corrected.

Short-period comparison (for instance, during half a day) provides only a check of sensitivity.

5.3 Pyranometer for diffuse solar radiation

5.3.1 General

For measuring or recording sky radiation separately, the direct solar radiation shall be screened from the sensor by a shading device. Where continuous records are required, the pyranometer is usually shaded either by a small metal disc held in the sun's beam by a powered equatorial device, or by a shadow band mounted on a polar axis.

In the first arrangement, which entails the rotation of a slender arm synchronized with the sun's apparent motion, frequent inspection is essential to enable proper operation and adjustment, since spurious records are otherwise difficult to detect. A shade disc configuration is shown in figure 2.

Figure 2 — Kipp and Zonen CM 10 ventilated pyranometer on a suntracker in the shade disc configuration, at the SETIM Observatory at Carpentras, France

The second arrangement involves less personal attention at the test site, but necessitates corrections to the records to take account of the appreciable screening of the diffuse radiation by the shadow band. For details of the construction of a shading ring and the necessary corrections to be applied, reference should be made to Dehne [2]. It should, however, be borne in mind that these corrections are not perfect.

Thus, it is preferable to use a shade disc, or to use a shade band of large diameter and small width so as to minimize shading of diffuse radiation.

It is recommended that the same model pyranometer be used as for global radiation measurements, if both quantities are required. Since the diffuse irradiance is normally lower than the global irradiance in other than totally cloudy conditions, the pyranometer should show a good linearity. Cosine error is not as critical as for global radiation measurements.

5.3.2 Installation

The installation of a diffuse pyranometer is similar to that of a pyranometer for the measurement of global radiation except that there are additional complications because of the shading device. The relevant differences to the requirements specified in 5.2.1 are given in 5.3.2.1 and 5.3.2.2.

5.3.2.1 Selection of the installation site

The diffuse pyranometer should be sited so that it never shades a neighbouring pyranometer.

It is recommended that the global pyranometer be located to the south of the diffuse sensor for locations in the northern hemisphere (or to the north of the diffuse sensor for locations in the southern hemisphere). Such an arrangement should be satisfactory for latitudes up to about 60°. For high latitudes where the sun-angle can be very low, the question of shading may need special attention.

Suitable non-reflecting non-specular paint should be used on all components above the view angle of the pyranometer.

5.3.2.2 Installation of the shading device

Generally the diffuse pyranometer mount is part of the shading device, and therefore the shading device has to be installed first. On a clear day one can adjust the mount precisely so that it shades symmetrically at solar noon. The precise positioning of the pyranometer depends upon the geographic latitude, and the design of the shading device.

5.3.3 Ventilation systems

The recommendations given in 5.2.2 apply equally for diffuse pyranometers. Dew and frost can cause an offset in irradiance if the glass dome is not shaded totally.

5.3.4 Care

In addition to the requirements specified in 5.2.3, the following requirements apply.

The shading device shall always shade the entire glass dome of the pyranometer, and not only the sensor, from direct solar radiation. For this reason, frequent inspection is required to determine the position of shade on the instrument, especially after a period of days without sunshine, or during the months around the equinoxes when the shading devices require frequent adjustment. When the shading device is adjusted precisely, the shift of the ring or disc due to the sun's declination can be recorded, calculated and tabulated for future use on cloudy days.

5.3.5 Recording of measured data

In addition to the requirements specified in 5.2.4, owing to the fact that the diffuse radiation from a cloudless sky may be less than one-tenth the global radiation, careful attention should be given to the sensitivity of the recording system so that adequate precision is maintained.

5.3.6 Quality control procedures and data correction

The initial control procedure of diffuse and global radiation data is to check that the diffuse radiation is always less than or equal to the global radiation, after correction for the shading device (see 5.3.1).

5.4 Pyranometer for reflected global radiation

5.4.1 Installation

The ground beneath the pyranometer should have a covering which is typical of the desired measurement conditions. For climatological purposes, short grass is preferred, and the grass coverage should be such that the soil is not visible.

The height above the ground or other surface should be between 1,5 m and 2 m. Lower mounting heights cause increasing errors due to self-shading (see annex B). Mountings higher than 2 m render maintenance of the pyranometer difficult. For regions with snow in winter, means should be available to adjust the height of the pyranometer above the snow in order to maintain a constant height above the surface.

Access to the pyranometer for means of levelling it should be possible with a minimum of disturbance to the surface beneath, particularly when the surface is snow.

The mounting device and other nearby objects should not interfere appreciably with reflections or shadows in the field of view of the instrument. Accordingly, the mounting arm of the pyranometer should be to the north in the northern hemisphere (and to the south in the southern hemisphere).

5.4.2 Care

In addition to the requirements specified in 5.2.3, the instrument should be cleaned frequently, especially during snowy conditions.

5.4.3 Recording of measured data

In addition to the requirements specified in 5.2.4, owing to the fact that reflected radiation is only a small fraction of the global radiation (except when the ground is snow covered), the output values of the pyranometer are low and careful attention should be given to the sensitivity of the recording system so that adequate precision is maintained.

5.4.4 Quality control procedures and data correction

If the reflecting surface is not uniform and horizontal, it is possible that the reflected radiation may be greater than the global radiation when the ground surface is covered with fresh snow. Snow is not always a perfect Lambertian surface, and therefore one must be careful when using reflected radiation data obtained over surfaces covered with fresh snow.

Annex A
(informative)

Commentary on ventilation systems

A.1 Need for ventilation

The combination of pyranometers and ventilation systems is only required where the natural wind speed is low (with the exception of frost and snow storm conditions, which present special problems). The need for ventilation is thus not the same for all locations.

Generally, pyranometers are ventilated continuously in order to provide a high level of reliability. In the case of systems with encapsulated pyranometer bodies [see clause A.2, c) and d)], continuous ventilation of the body is essential.

The only practical alternative to providing ventilation of the pyranometer is to select radiation data which is known to be reliable according to meteorological criteria (e.g. wind speed of greater than 2 m/s and no advection of humidity). The effects of dew and frost can be partly corrected for by an experienced technician if strip-chart records are taken. Treatment of the glass dome with anti-dewing solution requires thorough testing to detect any possible changes in the spectral transmittance of the glass due to the anti-dewing solution.

The zero offset, which is produced for instance by the cooling of the glass dome under calm clear sky conditions, cannot be reduced by the use of such solutions.

A.2 Types of ventilation systems

The main types of ventilation systems used in different meteorological institutes are as follows.

a) Remote ventilation of the glass dome by free nozzles

(The nozzles should not be more than 5° above the horizon of the pyranometer.) The temperature of the air stream results from the heating by the ventilator motor, and, in the case of small nozzles, the Doule-Thompson cooling effect.

The advantage of this system is that the ventilation is also effective in the zenith of the dome.

The disadvantage is that there are power and space requirements for a strong ventilator.

b) Flanged blowers to ventilate the glass dome via a slit around the base of the dome (see the example shown in figure A.1)

If the temperature of the ventilation air does not exceed the ambient temperature by more than 1 K, the offset produced by the temperature difference between the glass dome and the unventilated body is negligible.

The advantage of this system is that low-power ventilators can be used, which generate only a small heating of the ventilation air, and allow a compact design.

The disadvantage is that ventilation of the zenith of the dome is relatively small, especially when the speed of the airstream is low.

c) Arrangements as for b) but where the air is first blown along the pyranometer body which is encapsulated in a casing (see the example shown in figure A.2)

Since the body of a pyranometer is usually a thick metallic cylinder, the non-uniform ventilation of the body surface should have no influence on the measurement signals.

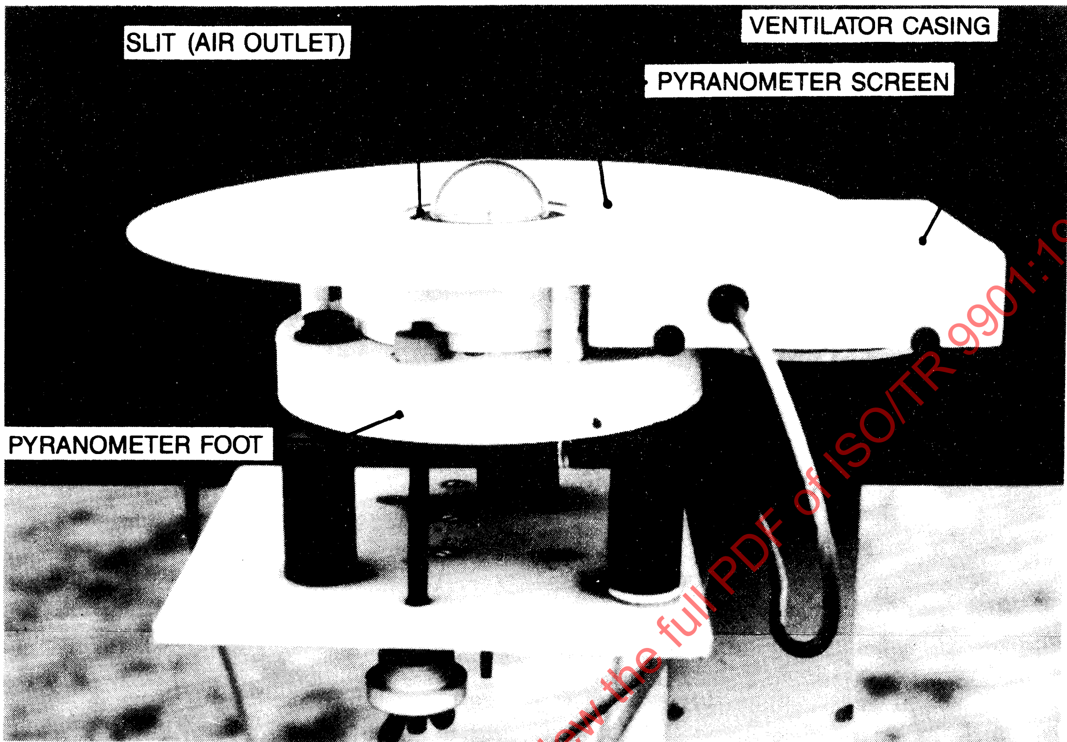
The advantage is as for b), but in addition, the body is also ventilated to approximate the ideal temperature equality in all parts of the pyranometer senior, independent of the temperature differences between the ventilation air and the ambient air.

The disadvantage is as for b), but also, the advantage mentioned above is turned to a disadvantage if the natural wind speed exceeds the speed of the ventilation air. Then the dome is at ambient air temperature, while the body is at the ventilation-air temperature.

d) Arrangements as for c), but where the blower is enclosed beneath the pyranometer in a common enclosure

The advantage is as for c).

The disadvantage is that a large proportion of the dissipated power heats the body and the ventilation air.



The ventilator is a commercially available system equipped with a Papst ventilator, model RL 90-18/10 (24 V; 5 W) and two heating resistors (24V; stage 1, 7 W; stage 2, 14 W)

Figure A.1 — Kipp and Zonen CM6 pyranometer with a flanged ventilator, as used in the radiation network of the Deutscher Wetterdienst

e) Ventilating systems with heating resistors

The systems mentioned in a) to d) can be equipped with heating resistors. This is recommended during cold seasons if the air heating due to the ventilator itself is less than 1 K. In some devices the heating may be regulated in steps to allow the heating to be adjusted to the lowest level appropriate for the weather conditions. It is desirable that the heating resistors be automatically controlled by a thermostat.

A.3 Specifications for ventilation systems

The following characteristics should be considered when specifying a ventilating system:

a) electrical power requirements;

b) space requirements;

c) availability of heating resistors (for stepwise heating of the ventilation air);

d) temperature difference between the ambient air and the ventilation air;

e) temperature difference between the ambient air and the pyranometer body;

f) offset (in watts per square metre) of the pyranometer due to operation of the ventilator;

g) time needed for artificial drying of deposits of dew and frost (especially in the zenith of the dome).