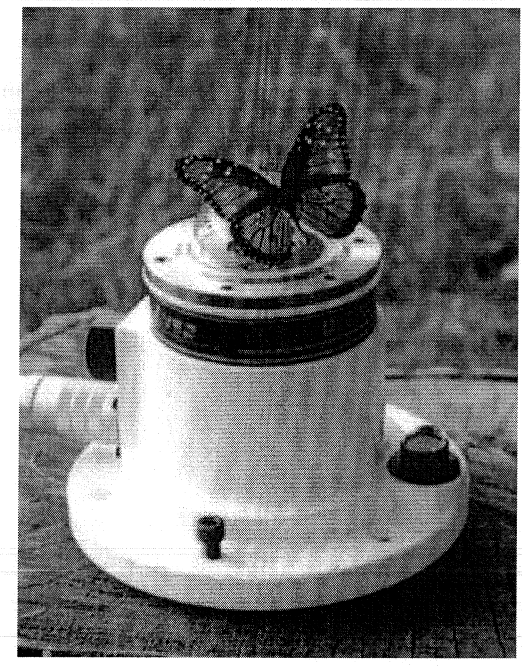
UVB-1
Ultraviolet Pyranometer

Installation and User Guide

Version 2.04



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Contents

In This Manual

The *UVB-1 Installation and User Guide* describes how to set up and use the Yankee Environmental Systems, Inc., UVB-1 Ultraviolet Pyranometer. This manual covers the following topics:

What this manual covers

CHAPTER		CONTENTS
1	Overview	General information about the UVB-1 pyranometer, including specifications and principle of operation
2	Installation	Procedures for setting up the UVB-1
3	Interpreting the Data	Formulas for converting the output voltage of the instrument to physical units
4	Calibration Procedures	Procedures that we use to determine the spectral, absolute, and cosine calibrations of the instrument
5	Maintenance	Routine maintenance procedures that you should perform; information on servicing the UVB-1 and UVPS power supply
	Monitor Thermistor Resistance Versus Temperature	Resistance versus temperature characteristic for the instrument's thermistor

Related manuals

The UVB-1 system includes UV-CALC, a modeling program that enables you to predict the UV-B irradiance at your site. Although the model is an approximation, it is still useful for checking the operation of the instrument. Refer to the UV-CALC manual for information on using this software.

Technical support

If you have a question about operating the UVB-1 and cannot find the answer you need in this manual, contact YES Technical Support using any of the following methods:

- **E-mail:** info@yesinc.com
- **Web:** http://www.yesinc.com (see the *Support* section)
- **FAX:** +1-413-863-0255
- **Phone:** +1-413-863-0200 (9 AM to 5 PM EST, Monday through Friday)

> **Warning**: Please read this manual, especially chapter two before using your system. Be particularly careful not to drive a voltage into the instrument output with a low impedance power source. Avoid "hot-plugging" the instrument, disconnect AC power from the system prior to engaging or disengaging the main connector.

CHAPTER 1
Overview

The UVB-1 Ultraviolet Pyranometer is a precision radiometer that measures global solar ultraviolet-B (UV-B) radiation. The instrument's innovative measurement technique uses colored glass filters and a UV-B phosphor to convert incoming UV-B radiation to green light, which is then measured by a calibrated solid state photodetector.

The rugged design of the instrument ensures stable operation during long-term, unattended use in the field.

Measures global solar irradiance

The UVB-1 measures global solar UV-B irradiance *or* the power per unit area of UV-B radiation received by a horizontal surface from the entire hemisphere of the sky. Global radiation includes both light transmitted directly through the atmosphere and light scattered by atmospheric gases and particulate matter in the atmosphere. Unlike visible light, UV-B radiation consists mainly of the scattered, diffuse component. The design of the UVB-1 ensures proper measurement of both the direct and diffuse components of global radiation.

Applications

The spectral response of the instrument is similar to the erythemal and DNA damage spectra, making it ideal for climatological and biological impact studies. Typical applications for the UVB-1 include

- Erythemal dose rate studies
- Studies of the effects of UV-B on plant communities
- Climatological data gathering and ozone layer depletion impact studies

  Because ozone in the stratosphere strongly absorbs energy in the UV-B portion of the solar spectrum (280 to 320 nm), any changes in the total amount of ozone affect the levels of UV-B radiation reaching the ground. The UVB-1 can be used to monitor changes in the ozone level, cloud cover, and aerosols by measuring changes in UV-B irradiance levels.

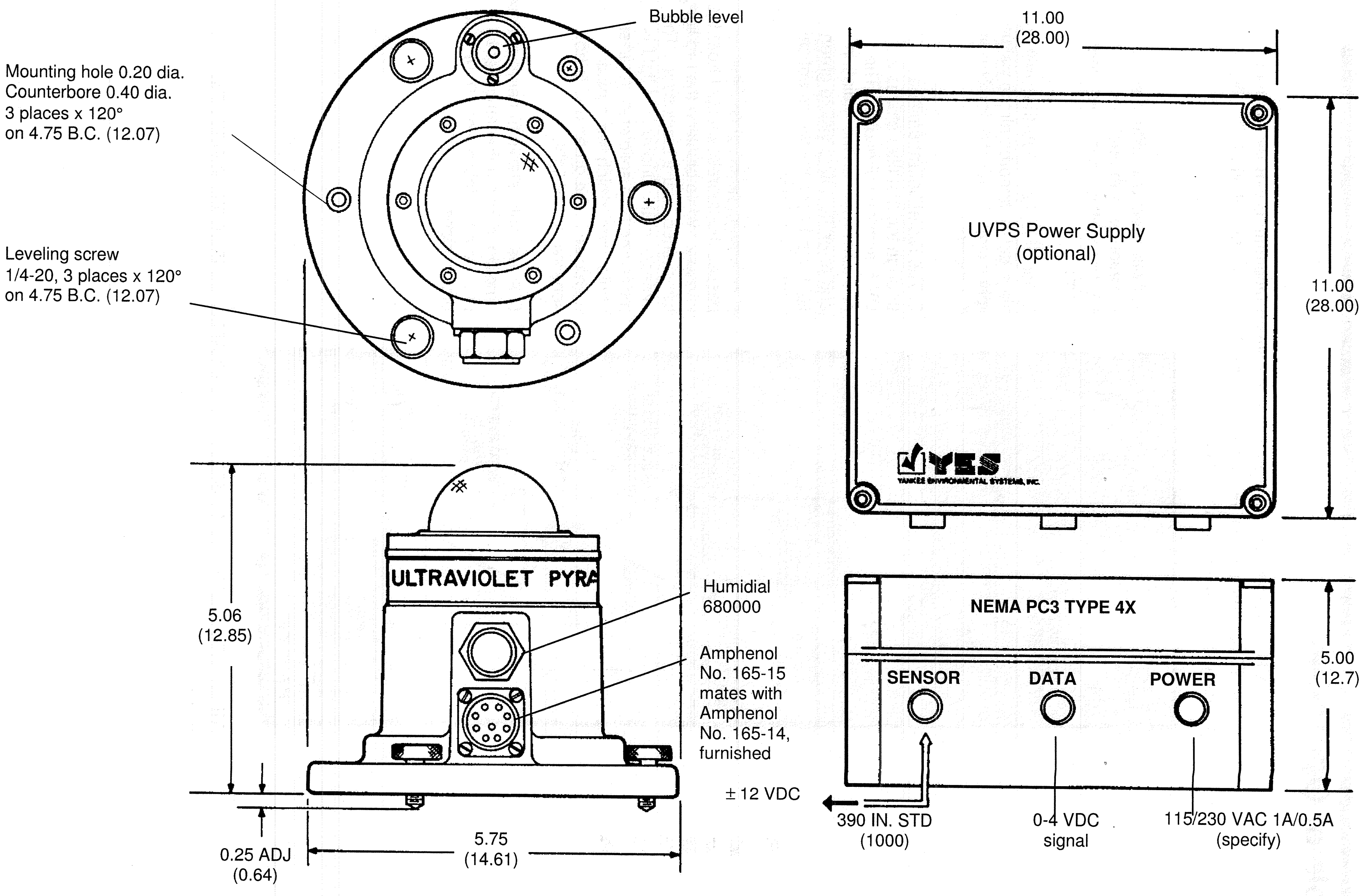
UV-CALC software

The UVB-1 system includes UV-CALC, an IBM PC-compatible software package that allows you to compute the UV-B irradiance at any location, date, and time of day. Although you do *not* need UV-CALC to operate the UVB-1, we recommend that you become familiar with this program as it allows a quick and reliable check of the operation and calibration of the instrument. See the UV-CALC manual for more information on using this program.

Specifications

The operating characteristics for the UVB-1 pyranometer are summarized below.

CHARACTERISTIC	DESCRIPTION
Spectral response	280 to 320 nm
Cosine response	±5% for 0 - 60 degree solar zenith angle
Nominal Calibration Coefficient	≈2 $(W/m^2)/V$ of total UV-B irradiance (see CHAPTER 3 for conversion to weighted irradiance)
Output signals	0 to 4 VDC, low impedance (single-ended) output
Operating temperature	Thermally regulated for operation over an ambient temperature range of -40°C to +40°C; an internal YSI #44011 monitor thermistor (100 KΩ @ 25 °C) is also provided (See Appendix A for the resistance versus temperature characteristic of the thermistor.)
Response time	Approximately 0.1 second
Power requirement	-12 VDC @ 5 mA; +12 VDC load varies with ambient temperature: 120 mA at +20 °C, 500 mA at -40 °C; the maximum allowable supply voltage range is 11 to 14 VDC
Electrical connections	Amphenol #165-15 weatherproof connector, and mating connector, Amphenol #165-14, prewired with 32 feet (10 meters) Belden cable; the opposite end is terminated in pigtail leads for a terminal board or connector, as specified
Size	5.06" (12.9 cm) high; 5.75" (14.6 cm) diameter base
Weight	3 lb. (1.3 kg)

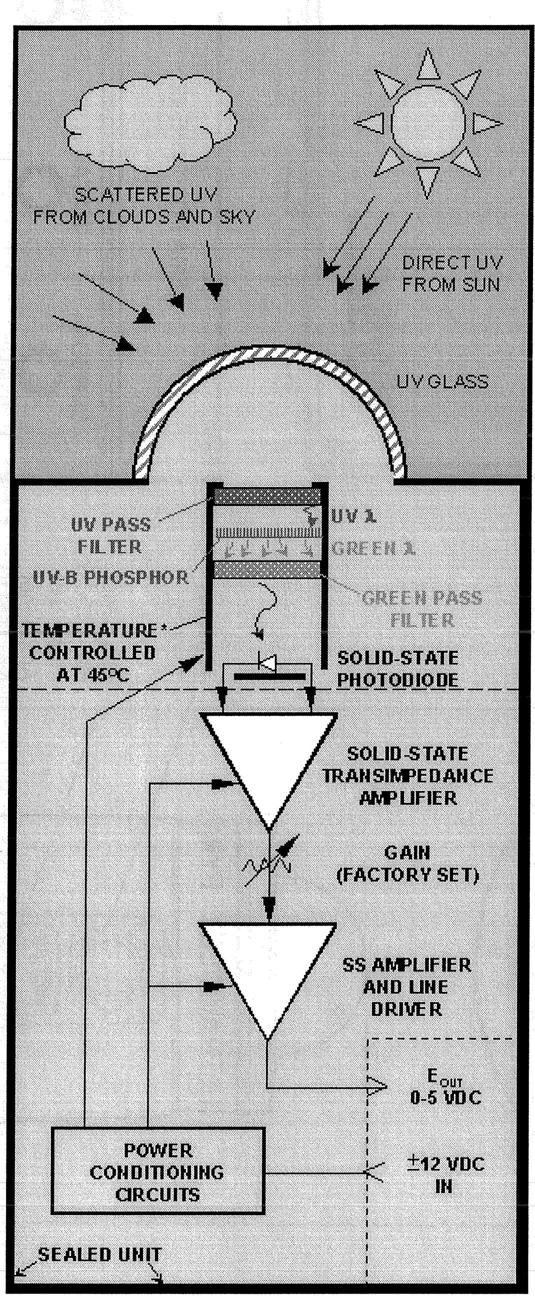


UVB-1 Ultraviolet Pyranometer and Optional UVPS Power Supply

Dimensions in inches (cm)

Principle of Operation

The UVB-1 uses a fluorescent phosphor to convert incoming UV-B radiation to visible light, which is then precisely measured by a solid state photodiode. The principle of operation is shown below.



1. Both direct and diffuse solar radiation pass through a UV-transmitting, quartz weather dome.

2. The first filter, a UV-transmitting black glass, absorbs all the visible light except for a small fraction of the red light.

3. The radiation transmitted through the first filter strikes a UV-B sensitive phosphor. The phosphor absorbs the radiation and re-emits it as a visible green light (a process known as optical down conversion).

4. A second, green-glass filter passes the fluorescent light from the phosphor while blocking the red light transmitted by the black glass. The intensity of the fluorescent light is measured by a solid state (GaAsP) photodiode, which has a peak response in the green and is not sensitive to red light.

5. A thermally-stable transimpedance amplifier drives a line amplifier to provide a low impedance 0 - 4 VDC output signal.

All optical components, the detector, and phosphor are thermally stabilized at +45°C.

Amplifier and Power Regulation Circuits

The circuitry in the UVB-1 is designed to provide the most reliable operation possible with today's technology. Highly stable components reduce the long-term drift in the output voltage to less than 100 PPM/year. Temperature induced errors from the amplifier, when referred to the output, are smaller than ±0.1% for an ambient temperature span of -40 °C to +40 °C.

Amplifier

A two-stage amplifier circuit converts the photodiode output current into a usable output voltage span of 0 to 4 volts full scale.

1. A transimpedance amplifier in the first stage of the circuit uses a precision electrometer op-amp to produce a transimpedance gain of $1 \cdot 10^7$ V/A.
2. An inverting voltage amplifier in the second stage buffers the transimpedance amplifier from any output loading effects and produces a positive signal that increases as the UV-B level increases.

Power regulation

Onboard regulators provide input power conditioning for all signal amplifiers to eliminate fluctuations in supply voltage often found in field installations. Transient pulse suppressors are used on input power lines to clamp voltage spikes caused by lightning strikes.

The DC power input voltage range is ±11 VDC to ±14 VDC. The maximum power consumption is 6 Watts (500 mA from the +12 VDC supply) and occurs when operating at -40 °C. At an ambient temperature of +20 °C, the +12 VDC current draw is approximately 200 mA.

Thermal Control System

The UVB-1 is equipped with an internal temperature control system for the phosphor and related optical components. The system maintains these components at a fixed temperature of +45 °C (±1 °C) for ambient temperatures in the range of -40 °C to +40 °C.

The thermal control system also prevents snow, ice, and dew from accumulating on the quartz dome and helps to prevent failures that result from constant thermal cycling of the optics and electronics.

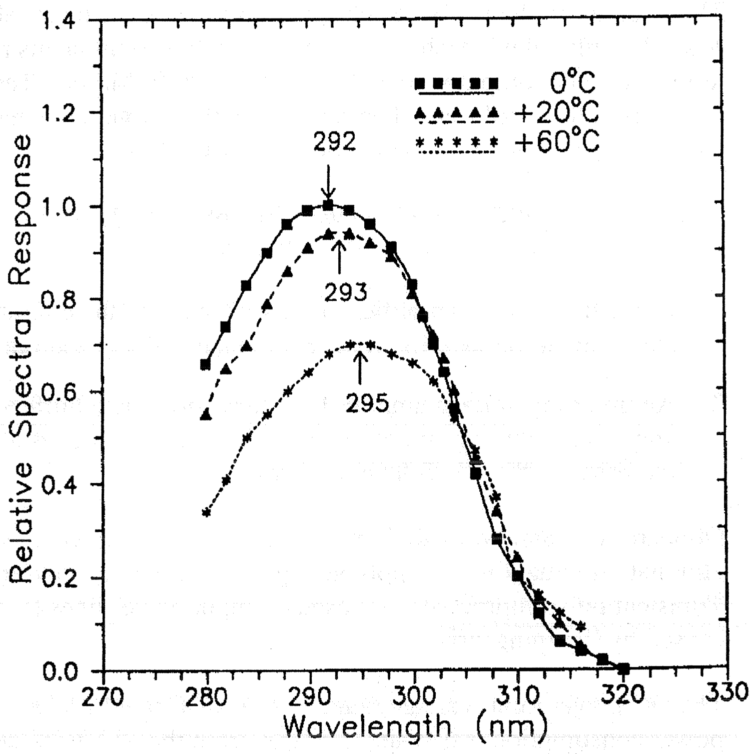
The thermal control system is activated by connecting a +12 VDC supply to pin K (the orange lead on cable) and connecting the power return to pin B (the green lead on cable); see page 2-1 for detailed information on the electrical connections.

If the thermal control system is not used

We strongly recommend that you use the thermal control system. However, if you are using solar energy to power the instrument and power consumption is a concern, you might decide not to enable the thermal stabilization circuitry. In this case, the UV-sensitive phosphor determines the temperature response of the instrument, and two competing thermal effects must be considered: phosphor absolute efficiency and phosphor spectral response.

- The **absolute efficiency** of the phosphor when converting UV-B radiation to visible light decreases by roughly 0.5% per 1 °C.

- The **spectral response** of the phosphor shifts to slightly higher wavelengths as the temperature increases — approximately 1 nm per 10 °C increase.



Relative instrumental spectral response curves at three temperatures. Arrows indicate wavelength of peak spectral response.

If you have a Xenon (Xe) or Deuterium (D_2) arc lamp, you can use its UVB-rich output to measure the response of a thermally unstable UVB-1 instrument as a function of temperature. The conversion efficiency determines the instrument response, resulting in a temperature coefficient of approximately -0.5% per °C. The solar spectrum, however, increases very rapidly with increasing wavelengths in the UV-B region. Consequently, the thermal spectral shift produces an effective output increase with increasing temperature. Therefore, *without* thermal control, the overall thermal response of an instrument exposed to the solar spectrum is approximately +1% per °C — the combination of the conversion efficiency and spectral shift.

CHAPTER 2
Installation

The UVB-1 system

The UVB-1 system consists of

- The Model UVB-1 Ultraviolet Pyranometer and cable
- An optional UVPS power supply

  If you ordered a UVPS power supply, the UVB-1 cable is prewired to the supply.
- A cleaning kit for the quartz dome
- The UV-CALC software program (Refer to the UV-CALC manual for information on installing this software.)
- Calibration documents that contain absolute calibration certification and spectral response data

Save the shipping containers

After unpacking the system, you should save the shipping containers in case you need to return the system to YES for recalibration or service. For more information on repackaging the instrument, see Chapter 5.

Installation process

The installation process consists of the following tasks:

1. Performing some experiments to become familiar with the instrument.
2. Installing the instrument at the site.
3. Making the necessary electrical connections.

This chapter describes each task in detail.

> **Caution**: Avoid "hot-plugging" the instrument. Always disconnect AC power from the system power supply prior to engaging or disengaging the main connector.

Bench Tests

Before installing the UVB-1 permanently in the field, we recommend that you become familiar with its performance on the bench. This section describes some experiments to perform to try out the instrument. For these tests, you will need a power supply (or batteries) and a readout meter. You might find it convenient to place the instrument, batteries, and meter on a tray so that you can easily move them indoors and out.

Connect to a power source and check the response

Connect the UVB-1 to the UVPS power supply, batteries, or another supply.

- **UVPS.** Connect the UVB-1 to the UVPS as shown below. For detailed information on the connections, see Electrical Connections on page 2-6.

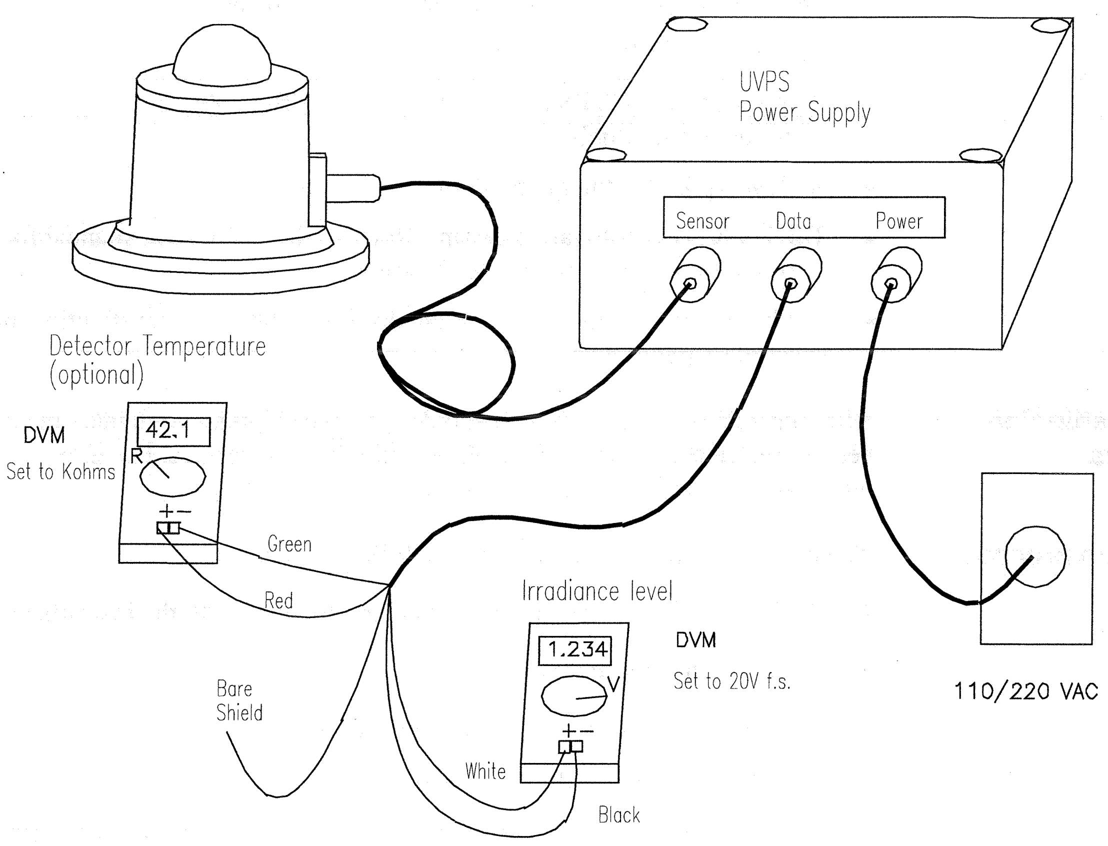


Figure 2-1 Bench Test Configuration with UVPS Power Supply

Apply AC power and monitor the output of the sensor on the white (positive) and black (negative) leads using any voltmeter that displays up to 4 VDC. Indoors, away from any sources of UV-B, the instrument should read zero (or less than ±1 mV).

Optionally, you can monitor the resistance of the thermistor on the red (positive) and green (negative) leads. Within a few minutes of applying the power, the resistance should be ≈42 KΩ, which corresponds to about 48°C. This internal temperature setpoint is fixed.

- **Batteries or another supply.** Apply +12 VDC to the red lead, -12 VDC to the black lead, and bring both power returns to the green lead. Refer to page 2-7 for detailed information on the wire connections.

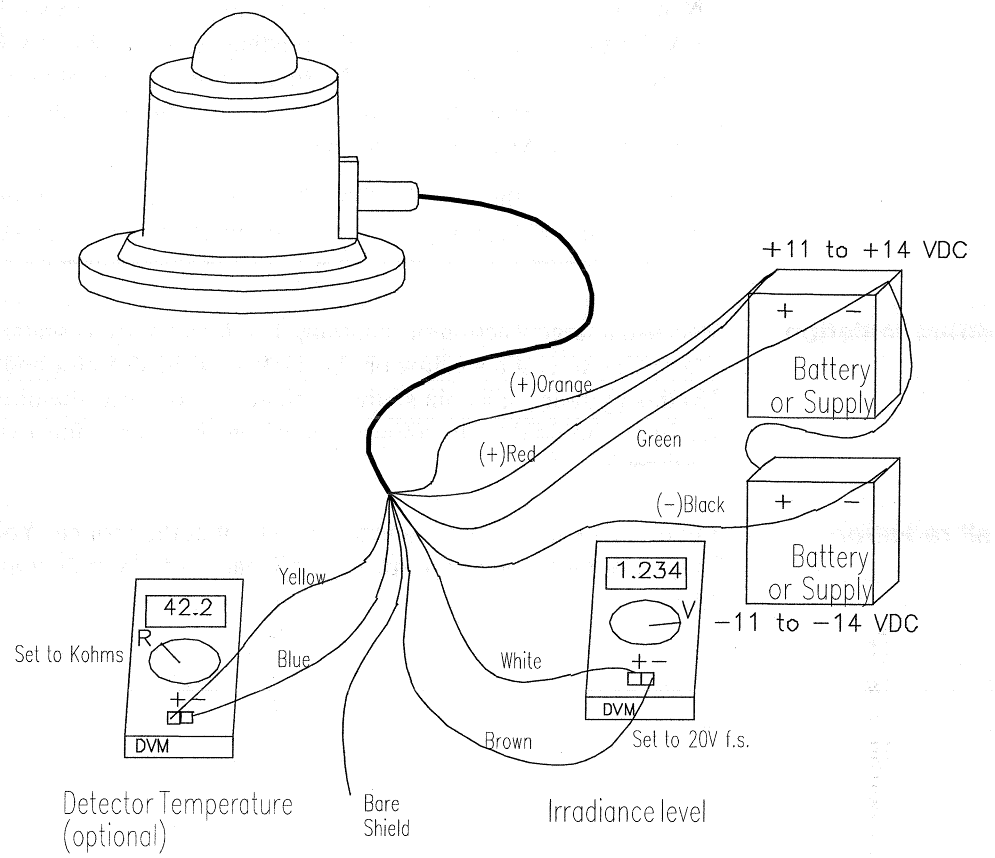


Figure 2-2. Bench Test Configuration without UVPS

Monitor the output of the sensor on the white (positive) and brown (negative) leads using any voltmeter that displays up to 4 VDC. Indoors, away from any sources of UV-B, the instrument should read zero (or less than ±1 mV).

Optionally, you can monitor the resistance of the thermistor on the yellow and blue leads. Within a few minutes of applying power, the resistance should be ≈42 KΩ.

Check solar blindness

Shine a 100-watt incandescent lamp at the detector to verify that it is not sensitive to visible light. The typical response is 20 mV.

Measure UV-B irradiance

Next, move the instrument outdoors so that it has good exposure to the sun and sky. On cloudy days the UV-B level is lower than on sunny ones, but the UV-B will still be measurable.

The instrument should now show a reading. On a clear day, it is interesting to compare this signal to the UV-B level calculated by the UV-CALC software package.

> **Note:** Be sure to read the calculated value from the proper column in the UV-CALC output file. If you are reading the value directly from the screen, divide the screen value by the Normalization Factor value (also displayed on the screen) to obtain the proper UVB-1 pyranometer calculated irradiance. See the UV-CALC manual for details.
>
> Also, be aware that the UV-CALC value is an approximation — although it is a useful reference, it typically will not match the UVB-1 to better than 10%.

Block direct radiation

Because a large fraction of incoming UV-B radiation is scattered light, it is interesting to cast a shadow on the surface of the detector and observe the effect. Do this by holding a coin so that it blocks (or occults) the direct component. The readings should drop by approximately one half when this experiment is performed.

Block all radiation

Finally, pick up the pyranometer and aim it at the ground. You should see much lower UV radiation as the surface reflectance of UV radiation is typically quite low.

Installing the System at the Site

The UVB-1 detects both direct and scattered (diffuse) UV-B radiation from the sky hemisphere. Therefore, for proper exposure, the UVB-1 should be installed in an area free of shadow-causing obstructions for all sun angles. The area should have a clear view of the total sky, with as few obstacles on the horizon as possible. The middle of a large open field is always a good choice.

Allow access for maintenance

When installing the instrument, be aware that the quartz weather dome must be cleaned periodically and the humidity indicator inspected. A 5- to 6-foot (approximately 1.75 meters) high pedestal with a simple platform around the base is usually adequate. Be sure that the platform is stable. A platform is especially desirable for areas in which deep snow can be encountered.

For more information on routine maintenance procedures you should perform, see Chapter 5.

Level the instrument

The UVB-1 has three leveling screws and a circular bubble level that enable you to level the instrument. Although most of the radiation comes from the diffuse component, it is still important to level the instrument.

Bolt to platform

The leveled instrument should be screwed or bolted into place using the three mounting holes on the UVB-1. Each mounting hole is 0.20" (0.51 cm) in diameter and is located on a 4.75" (12.07 cm) diameter bolt circle. The UVB-1 cable should also be secured to minimize its motion in the wind.

Make the necessary electrical connections

Once the instrument is level, complete the installation by connecting the instrument to a power supply and data acquisition system. Ensure that the cables form a drip loop so that water drains away from the connectors.

For detailed information on the electrical connections, see page 2-6.

Electrical Connections

This section explains how to connect the UVB-1 instrument to a

- UVPS power supply or another power supply
- Data acquisition system

Using the UVPS Power Supply

If you are using the UVB-1 with a UVPS power supply, set up the instrument by connecting the cables on the UVPS as follows:

1 Connect the cable labeled SENSOR to the receptacle on the UVB-1 sensor. To do this, align the pins and then rotate the connector until you hear a click. On a new instrument, the connector might be difficult to turn because of its tight fit.

2 Plug the cable labeled AC POWER into an AC power outlet. The UVPS is configured for input power voltages of either 105 to 120 VAC or 210 to 240 VAC, depending on your specifications.

If you need to make a direct connection and bypass the plug, the proper connections are:

WIRE COLOR	DESCRIPTION
Black or brown	AC hot
White or blue	AC neutral
Green	Ground

3 Connect the cable labeled DATA to your data logging system.

This cable is a four-connector cable with four output leads and one shield:

WIRE COLOR	DESCRIPTION
White	UVB-1 output signal (0 - 4 VDC)
Black	UVB-1 output signal return
Red	Monitor thermistor
Green	Monitor thermistor
Clear	Cable shield (connected to the instrument case)

> **Caution**: Avoid "hot-plugging" the instrument, disconnect AC power from the system prior to engaging or disengaging the main connector

Disconnecting the UVB-1 from the UVPS

If you need to replace the instrument cable or run the UVB-1 with another power supply, you can disconnect the UVB-1 cable from the UVPS box by performing the following steps:

1. Open the UVPS box.
2. Loosen the weatherproof fitting for the SENSOR cable.
3. Disconnect the nine wires from the left-hand side of the lower terminal block (labeled SENSOR CABLE).
4. Pull the sensor cable out through the opening in the box.
5. Connect the wires to the new supply. Refer to the table on page 2-1 for the wire connections.

To reattach the sensor cable to the UVPS after it has been disconnected, follow these steps:

1. Loosen the weatherproof fitting for the SENSOR cable on the UVPS box.
2. Pull the pigtailed end of the sensor cable through the opening in the UVPS box.
3. Attach the nine sensor cable leads to the left-hand side of the lower terminal block (labeled SENSOR CABLE), referring to the instructions on the label next to the terminal block for the connections.
4. Tighten the weatherproof fitting.

Servicing the UVPS

Refer to page 5-6 for information on replacing fuses or changing the AC line voltage of the UVPS.

If You Are Not Using the UVPS Power Supply

The UVB-1 is shipped with 8 feet (2.4 meters) of cable. A waterproof 9-pin connector is prewired at one end of the cable; the other end is terminated with pigtail leads. Do not disassemble the connector because special tools and skills are required to reassemble it.

> **Caution**: Avoid "hot-plugging" the instrument, disconnect AC power from the system prior to engaging or disengaging the main connector

The leads should be connected to a terminal board mounted within a weatherproof enclosure; use extension wires as necessary. The wire connections for the instrument are as follows:

PIN	WIRE COLOR	DESCRIPTION
A	Red	Connect to +12 VDC, 15 mA (Transimpedance amplifier power only)
B	Green	Power return
C	Black	Connect to -12 VDC, 5 mA
D	Blue	Monitor thermistor
E	White	Output signal 0 to +4 VDC
F	Brown	Signal return
H	Clear/Shield	Connect to ground rod; do not connect to AC ground
J	Yellow	Monitor thermistor
K	Orange	Connect to the red wire and provide +12 VDC, 500 mA (Operates the thermal control circuitry.)

Considerations for connecting wires

When connecting the wires, keep in mind the following:

- The instrument will operate properly provided that a power supply with a voltage in the range of +11 to +14 VDC is connected to the red and orange wires *and* a power supply with a voltage of -11 to -14 VDC is connected to the black wire. These voltages are usually provided by a dual-output supply or two separate batteries.
- If you do not want to monitor the instrument temperature, do not connect the blue and yellow monitor thermistor wires.
- The thermal control system is activated by connecting a +12 VDC supply to pin K (the orange lead on cable) and connecting the power return to pin B (the green lead on cable). The +12 VDC supply need not be regulated, but it should be capable of delivering 500 mA. The typical current at an ambient temperature of +20°C is 100 mA. Allow 2 minutes for thermal stabilization at an ambient temperature of +20°C and 20 minutes at -40°C. See Appendix A for a schematic of the control circuit.

If you need to run the instrument *without* internal thermal stabilization, leave the orange wire disconnected and do not connect the red wire to a power supply.

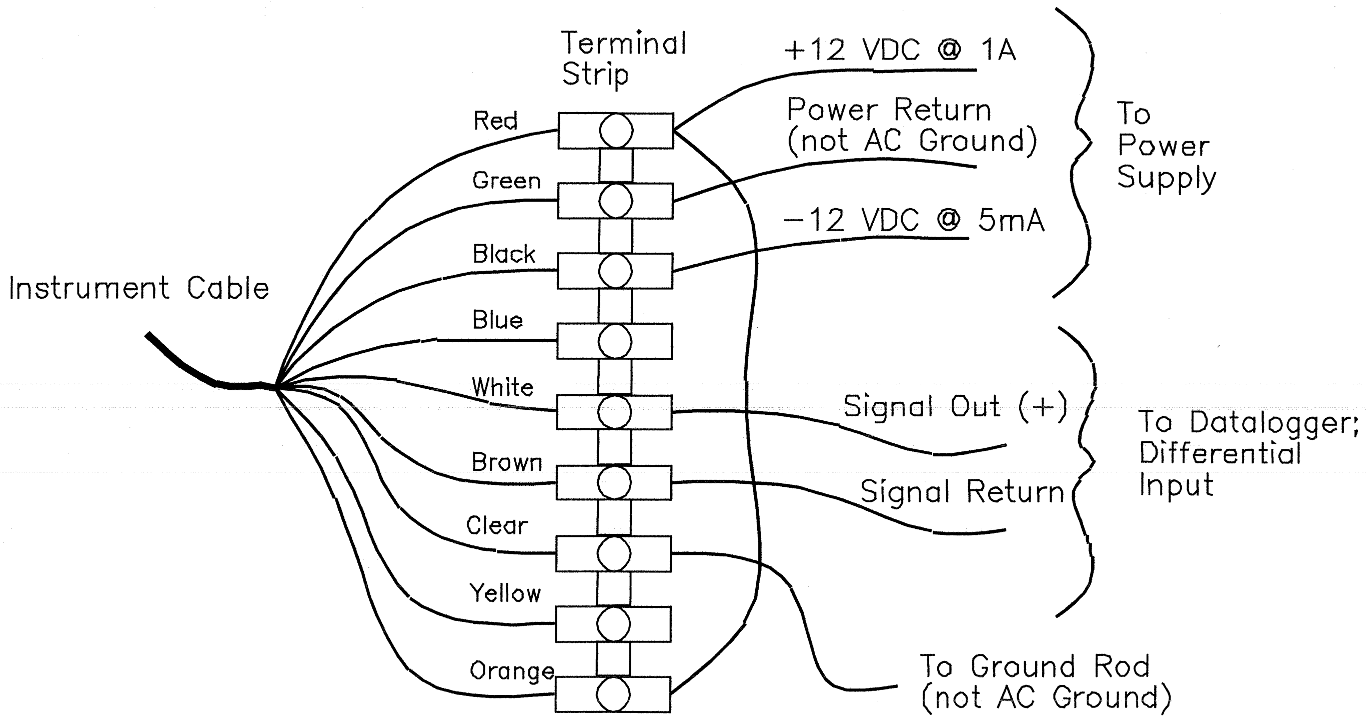
> **Important:** The UVB-1 has been calibrated with the thermal regulation circuitry activated, and we recommend that you operate the instrument with thermal control for highest accuracy. Although the instrument itself will not be damaged without thermal stabilization, the output signal of the instrument will become sensitive to the ambient temperature (see **Thermal Control System** on page 1-5 for more information).

Connecting the UVB-1 to a Data Acquisition System

The UVB-1 is designed to interface directly to a differential input datalogger or chart recorder. Verify that your recording device can handle the 0 - 4 V output produced by the UVB-1. The UVB-1 has isolated output to support differential inputs, which we recommend to prevent ground loops.

If your datalogger does not support the 0 to 4 V span (for example, it has a 0 to 2.5 V input), you must install a precision resistor divider in the datalogger to divide the UVB-1 output down to the appropriate span. Use 1% (or better) RN55C resistors.

Connect the output leads of the UVB-1 to the terminal inputs of the datalogger, observing polarity. Do not connect the shield ground to AC power ground; connect the shield to a ground rod or a cold water pipe.



Interfacing With the Monitor Thermistor

You can optionally monitor the instrument's temperature with your data acquisition system. Because the monitor thermistor produces a variable resistance, you may need to excite the resistor in order to produce a voltage that your data acquisition system can monitor. Be sure to use a regulated DC voltage to excite the bridge, and do not pass too much current through the thermistor. A 1% (RN55C) 200 KΩ resistor to +12V works well.

Checking Electrical Connections

The UVB-1 is an *active* electronic system. At night, the output should be close to 0 mV. If your data acquisition system is reporting small values at night, the system has a ground loop. Ensure that

- The case ground (clear/shield) is not connected to AC ground (but is connected to a ground rod or cold water pipe)
- The datalogger uses differential (and not single-ended) inputs
- AC ground is not connected to DC ground at any point in the system (The UVPS is designed such that this does not occur.)

CHAPTER 3

Interpreting the Data

If you are using the UVB-1 to calculate erythemal or total UV-B irradiance at your site, be aware that the spectral response of the UVB-1 differs slightly from the erythemal action spectrum (see below) and is not uniform in the UV-B region. To account for these differences, a weighting factor must be applied to the calibration constant of the instrument to convert the volts into physical units for the irradiance of interest. (The YESDAS data acquisition system can apply the conversion factors automatically.)

This chapter explains how to convert the output voltage of the instrument into physical units of total UV-B irradiance (W/m^2) and erythemally effective irradiance (erythmal W/m^2).

In this chapter

Converting the Output Signal to Physical Units

The conversion factor that you apply to the output of the instrument is the ratio of the energy measured by a detector with an ideal cosine and spectral response to the energy measured by the UVB-1 instrument. In practice, this factor is determined by taking the ratio of the measured erythemal or total UV-B irradiance to the value of the UVB-1 output signal at the time of measurement. The erythemal or total UV-B irradiance is determined by integrating the product of the measured solar spectral irradiance and the action spectrum of interest.

Instrument calibration constant

The UVB-1 instrument has a nominal calibration constant of 2.0 W/m^2 of total UV-B irradiance per volt output. The actual calibration coefficient is given on the instrument's label and calibration certificate. Calibration constants are determined by plotting a standard UVB-1 sensor's output voltage against the integrated spectral data from a co-located, precisely calibrated narrow band UV spectroradiometer on a clear summer day (see Figure 4-2). The calibration constant is derived from high and low zenith angle samples to compensate for variations in cosine response between the UVB-1 and the reference.

Multiplying the output of the instrument by the calibration coefficient yields the *total* UV-B irradiance in W/m^2. In practice, this raw unit is useful only as a calibration tracking mechanism. To translate the UVB-1 output voltage into more meaningful physical units, you should use your calibration coefficient multiplied by the *weighting factor* for your specific application. Thus

$$Irradiance = V_{UVB-1} \times C \times F_{WEIGHTING}$$

Where V_{UVB-1} is the instrument output in volts, C is that instrument's calibration constant (units of $Wm^{-2}V^{-1}$), and $F_{WEIGHTING}$ is the weighting factor (no units or [erythemal W/m^2] / [W/m^2]). Note that the weighting factor you use also depends on the solar zenith angle at the time of the measurement, where the zenith angle indicates degrees away from the zenith (overhead).

Irradiance in the 280-320 nm Wavelength Band (Total UV-B)

Most researchers define the UV-B portion of the spectrum as the spectral region between 280 and 320 nm. To convert the UVB-1 output voltage into the total, zenith corrected, UV-B irradiance (280-320 nm) in W/m^2, multiply the output voltage by the calibration coefficient times the weighting factor for the solar zenith angle at the time the sample was taken.

SOLAR ZENITH ANGLE	WEIGHTING FACTOR	ACCURACY
Smaller than 50°	1.018	10%
Between 50° and 60°	1.187	6%
Between 60° and 70°	1.349	8%

If you require better accuracy, use the weighting factor in the appropriate column of the table on page 3-5.

Irradiance in the 280-315 nm Wavelength Band (Total UV-B)

Some researchers define the UV-B portion of the spectrum as the spectral region between 280 and 315 nm. To convert the UVB-1 instrument output voltage into the total (280-315 nm) UV-B irradiance in W/m^2, multiply the output voltage by the calibration coefficient times the weighting factor for the solar zenith angle at the time the sample was taken.

SOLAR ZENITH ANGLE	WEIGHTING FACTOR	ACCURACY
Smaller than 55°	0.555	5%
Between 55° and 70°	0.572	2%

If you require better accuracy, use the weighting factor in the appropriate column of the table on page 3-5.

Erythemal Irradiance (Diffey Action Spectrum)

The Commission Internationale de L'Eclairage (CIE) human erythemal action spectrum (see page 3-1) is given by McKinlay and Diffey (1987). To convert the UVB-1 instrument output voltage into the CIE-defined erythemal irradiance in effective W/m^2, multiply the output voltage by the calibration coefficient times the weighting factor for the solar zenith angle at the time the sample was taken.

SOLAR ZENITH ANGLE	FACTOR	ACCURACY
Smaller than 65°	0.0716 (erythemal W/m^2)/(W/m^2)	4%
Greater than 65°	0.0782 (erythemal W/m^2)/(W/m^2)	6%

If you require better accuracy, use the weighting factor in the appropriate column of the table on page 3-5.

Erythemal Irradiance (Parrish Action Spectrum)

Another widely used erythemal action spectrum is given in the work of Parrish (1982); see page 3-1. To convert the UVB-1 instrument output voltage into the Parrish-defined erythemal irradiance in effective W/m^2, multiply the output voltage by the calibration coefficient times the weighting factor for the solar zenith angle at the time the sample was taken.

SOLAR ZENITH ANGLE	FACTOR	ACCURACY
Smaller than 45°	0.0797 (erythemal W/m^2)/(W/m^2)	8%
Between 45° and 70°	0.0665 (erythemal W/m^2)/(W/m^2)	6%

If you require better accuracy, use the weighting factor in the appropriate column of the table on page 3-5.

Conversion to Erythemal MED Units

Minimal Erythemal Dose (MED) units are sometimes used to measure erythemal radiation doses. In the medical and photobiological fields, this unit is defined by the CIE as the UV-B radiation dose that can cause minimal reddening on untanned average Caucasian (fair) skin. Although medical studies often cite MED units, the long integration times typically used in calculating the MED unit reduces the overall precision level of this unit. In addition, the measured values of MED units vary considerably due to experimental variations and the large range in Caucasian skin response. The standard definition of the MED unit is 201 J/m^2 (with a standard deviation of ±52 J/m^2), where J is joule.

Example

For example, suppose you take one UVB-1 instrument voltage reading (V_i) every k minutes and a total of N readings during the day. If the instrument has a calibration coefficient of *C*, then the total daily MED dose, as defined by the Diffey erythemal action spectrum, is given by the following equation:

$$MED\ Dose = \frac{1}{201}\sum_{i=1}^{N} C \times 0.0716 \times (60k) \times V_i = 0.021\sum_{i=1}^{N} V_i$$

where the factor $C \times 0.0716$ converts the measured voltage to erythemal (Diffey) W/m^2, the factor 60k converts the W/m^2 to erythemal J/m^2, and the factor 201 converts the erythemal J/m^2 dose to MED units (Parrish et al, 1982).

International UV-Index

To convert the instrument output into the international UV-B index, first convert the output to erythemal units as described above and then multiply the result by 25. The international UV-Index is a simple 0 to 10 *open-ended* (may exceed 10) scale recommended and ratified by scientists attending a 1994 WMO meeting in Switzerland. The UV-Index provides a way to report UV-B health warnings in a consistent way around the world. In some countries, UV-Index forecasts are supplemented by satellite data and prediction algorithms. Like MED units, the UV-Index trades precision for ease of interpretation but remains useful in many applications.

Irradiance in the 280-315 nm Wavelength Band (Total UV-B)

Some researchers define the UV-B portion of the spectrum as the spectral region between 280 and 315 nm. To convert the UVB-1 instrument output voltage into the total (280-315 nm) UV-B irradiance in W/m^2, multiply the output voltage by the calibration coefficient times the weighting factor for the solar zenith angle at the time the sample was taken.

SOLAR ZENITH ANGLE	WEIGHTING FACTOR	ACCURACY
Smaller than 55°	0.555	5%
Between 55° and 70°	0.572	2%

If you require better accuracy, use the weighting factor in the appropriate column of the table on page 3-5.

Erythemal Irradiance (Diffey Action Spectrum)

The Commission Internationale de L'Eclairage (CIE) human erythemal action spectrum (see page 3-1) is given by McKinlay and Diffey (1987). To convert the UVB-1 instrument output voltage into the CIE-defined erythemal irradiance in effective W/m^2, multiply the output voltage by the calibration coefficient times the weighting factor for the solar zenith angle at the time the sample was taken.

SOLAR ZENITH ANGLE	FACTOR	ACCURACY
Smaller than 65°	0.0716 (erythemal W/m^2)/(W/m^2)	4%
Greater than 65°	0.0782 (erythemal W/m^2)/(W/m^2)	6%

If you require better accuracy, use the weighting factor in the appropriate column of the table on page 3-5.

Erythemal Irradiance (Parrish Action Spectrum)

Another widely used erythemal action spectrum is given in the work of Parrish (1982); see page 3-1. To convert the UVB-1 instrument output voltage into the Parrish-defined erythemal irradiance in effective W/m^2, multiply the output voltage by the calibration coefficient times the weighting factor for the solar zenith angle at the time the sample was taken.

SOLAR ZENITH ANGLE	FACTOR	ACCURACY
Smaller than 45°	0.0797 (erythemal W/m^2)/(W/m^2)	8%
Between 45° and 70°	0.0665 (erythemal W/m^2)/(W/m^2)	6%

If you require better accuracy, use the weighting factor in the appropriate column of the table on page 3-5.

Conversion to Erythemal MED Units

Minimal Erythemal Dose (MED) units are sometimes used to measure erythemal radiation doses. In the medical and photobiological fields, this unit is defined by the CIE as the UV-B radiation dose that can cause minimal reddening on untanned average Caucasian (fair) skin. Although medical studies often cite MED units, the long integration times typically used in calculating the MED unit reduces the overall precision level of this unit. In addition, the measured values of MED units vary considerably due to experimental variations and the large range in Caucasian skin response. The standard definition of the MED unit is 201 J/m^2 (with a standard deviation of ±52 J/m^2), where J is joule.

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For example, suppose you take one UVB-1 instrument voltage reading (V_i) every k minutes and a total of N readings during the day. If the instrument has a calibration coefficient of *C*, then the total daily MED dose, as defined by the Diffey erythemal action spectrum, is given by the following equation:

$$MED\ Dose = \frac{1}{201}\sum_{i=1}^{N} C \times 0.0716 \times (60k) \times V_i = 0.021\sum_{i=1}^{N} V_i$$

where the factor $C \times 0.0716$ converts the measured voltage to erythemal (Diffey) W/m^2, the factor 60k converts the W/m^2 to erythemal J/m^2, and the factor 201 converts the erythemal J/m^2 dose to MED units (Parrish et al, 1982).

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Detailed Tabulation of Weighting Factors

If you require better accuracy for the determination of the erythemal or total UV-B irradiances than given by the prescriptions earlier in this chapter, you can use the detailed tabulation of the weighting factors for the UVB-1 instrument in the table below.

The weighting factors for total UV-B are dimensionless; those for erythemal response have units of (erythemal W/m^2) / (W/m^2). The solar zenith angle indicates the degrees away from the zenith, 0°.

SOLAR ZENITH	TOTAL UV-B		ERYTHEMA	
ANGLE (°)	280-315 nm	280-320 nm	Diffey	Parrish
21.8	0.5381	0.9680	0.0731	0.0802
25.0	0.5472	0.9914	0.0726	0.0802
30.0	0.5548	1.0183	0.0716	0.0797
35.0	0.5594	1.0457	0.0706	0.0782
40.0	0.5599	1.0685	0.0701	0.0761
45.0	0.5624	1.0985	0.0690	0.0736
50.0	0.5645	1.1371	0.0690	0.0706
55.0	0.5660	1.1868	0.0695	0.0680
60.0	0.5736	1.2660	0.0711	0.0665
65.0	0.5716	1.3492	0.0736	0.0640
70.0	0.5604	1.4513	0.0736	0.0635

Weighting Factors as a Function of Zenith Angle

The magnitudes of the weighting factors, relative to value at the solar zenith angle of 30°, together with 5% and 10% accuracy limits, are plotted in Figure 3-1.

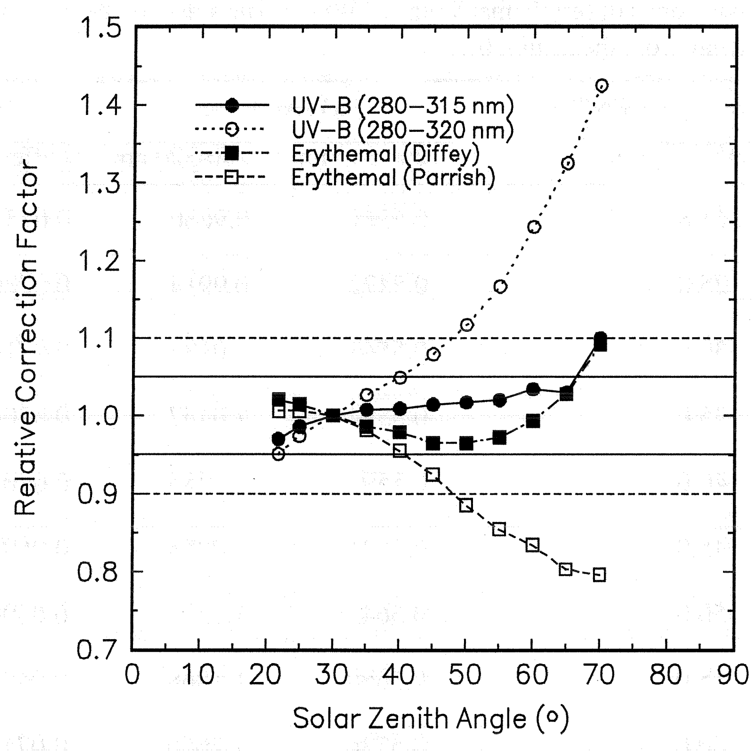

Figure 3-1. UVB-1 instrument weighting factors (relative to the value at solar zenith angle of 30°). Solid horizontal lines show 5% deviations; dashed horizontal lines show 10% deviations.

Cited References

1. McKinlay, A. F. and B. L. Diffey, 1987: A reference action spectrum for ultraviolet induced erythema in human skin. CIE J. **6**, p. 17-22.

2. Parrish J. A., K. F. Jaenicke and R. R. Anderson, 1982: Erythema and melanogenesis action spectra of normal human skin. Photochem. Photobiol. **36**, p. 187-191.

3. R. L. McKenzie, P.V. Johnston, A. Bittar and J.D. Hamlin, 1992: Solar ultraviolet spectroradiometry in New Zealand: Instrumentation and sample results from 1990. Appl. Opt., **31**, p. 6501-6509.

CHAPTER 4

Calibration Procedures

This chapter describes the calibration theory for the UVB-1 pyranometer as well as the procedures used to obtain the spectral, absolute, and cosine calibrations for the UVB-1. Although you can use these procedures to check your UVB-1, they are presented mainly as background information. Special test equipment is required to perform the procedures and unless you are familiar with the equipment and techniques described, *we strongly recommend that you return the instrument to YES for recalibration.*

Calibration interval

If the UVB-1 is used continuously in the field, we recommend 12- to 18-month recalibration intervals to track absolute response and spectral changes.

Design ensures uniform response

The UVB-1 pyranometer is a completely new design of a Robertson-type broadband solar UV-B radiation detector. Each component and technique used in the fabrication of the UVB-1 has been carefully evaluated to ensure that it meets the overall design goals: *excellent stability and long-term reliability*. Because of this design discipline, there is very little variation in the spectral, absolute, and cosine responses of the UVB-1 from instrument to instrument.

In this chapter

Calibration Theory

In order to make the characterization of the UVB-1 pyranometer consistent with characterizations of any broadband UV instrument, we apply the calibration theory presented by Grainger, Basher and McKenzie (1993). This theory can be applied to any broadband instrument. The work of Grainger *et al.* is summarized below.

The output signal, S, of a horizontally positioned UVB-1 instrument, when exposed to a temporally invariant radiance field $L(\lambda, \theta, \phi)$, can be expressed as

$$S = \int_{\lambda_1}^{\lambda_2} \int_0^{2\pi} \int_0^{\pi/2} R(\lambda,\theta,\phi) L(\lambda,\theta,\phi) \sin\theta d\theta d\phi d\lambda \tag{1}$$

where $R(\lambda, \theta, \phi)$ represents the response function of the instrument to an incident beam L of wavelength λ, direction zenith angle θ, and azimuth angle ϕ. The integrals over angles (θ and ϕ) sum the contribution to the output signal from all parts of the sky hemisphere, while the integral over wavelength incorporates the broadband response of the instrument. Equation (1) states that the instrument signal is a measure of the power per unit area produced from the incident radiation field weighted by the instrument sensitivity with respect to wavelength and direction.

If we assume, as is supported by experimental evidence, that

- The instrument response is independent of the azimuth angle
- The zenith angle and spectral dependence are separable

then R can be written as

$$R(\lambda,\theta,\phi) = KA(\theta) r(\lambda) \tag{2}$$

where the constant K determines the absolute calibration of the instrument, $r(\lambda)$ is the relative spectral response of the instrument (see Figure 4-1) and $A(\theta)$ is the relative angular response.

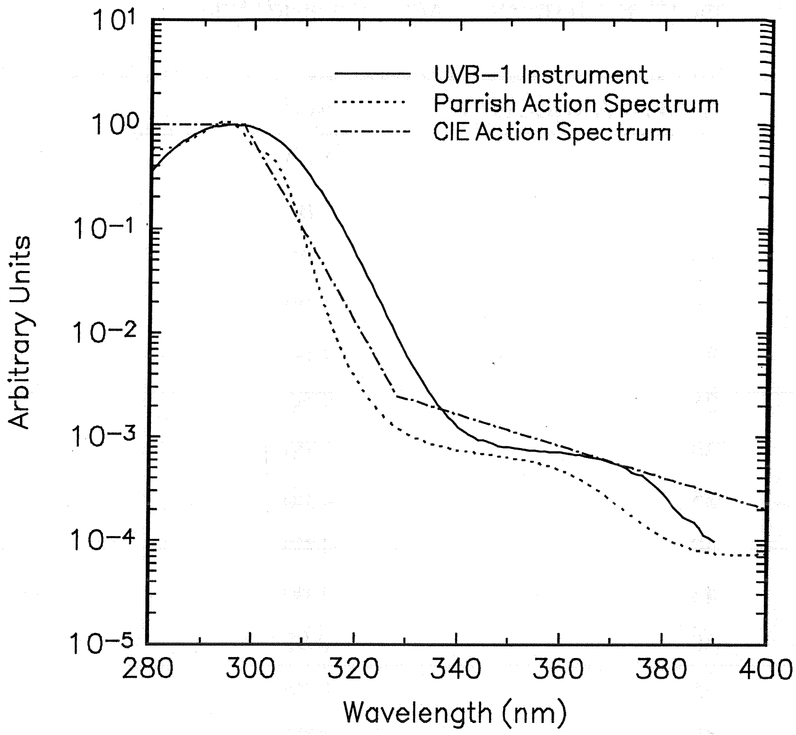

Figure 4-1. Relative Spectral Response of the UVB-1 Instrument Plotted With the Parrish and CIE (Diffey) Erythemal Action Spectra

In effect, A(θ) is the ratio of the measured angular (zenith) response of the instrument, C(θ), to the ideal cosine response

$$A(\theta) = \frac{C(\theta)}{\cos\theta} \qquad (3)$$

Experimentally determined values of the measured relative angular response of the UVB-1 instrument, A(θ), are listed below.

ZENITH ANGLE (θ)	A(θ)
0	1.00
5	1.00
10	1.00
15	1.00
20	1.00
25	1.00
30	1.00
35	1.00
40	1.00
45	1.00
50	0.98
55	0.96
60	0.92
65	0.88
70	0.79
75	0.67
80	0.53
85	0.36

In general, the energy measured by an instrument with a relative cosine response A(θ) is less than that measured by an instrument with an ideal cosine response. For an isotropic radiation field, the ratio of the measured to the actual irradiance, D, can be expressed as

$$D = \frac{1}{\pi} \int_0^{2\pi} \int_0^{\pi/2} A(\theta) \cos\theta \sin\theta d\theta d\phi \qquad (4)$$

Evaluating eq. (4) for A(θ) in the table above gives D = 0.93.

Combining eqs. (1), (2), and (3), we can write

$$S = K \int_{\lambda_1}^{\lambda_2} r(\lambda) \int_0^{2\pi} \int_0^{\pi/2} A(\theta) L(\lambda, \theta, \phi) \cos\theta \sin\theta d\theta d\phi d\lambda \qquad (5)$$

The total radiation field can be split into its direct and diffuse components

$$L(\lambda,\theta,\phi) = L^{dir}(\lambda,\theta,\phi) + L^{dif}(\lambda,\theta,\phi) \tag{6}$$

and therefore, if we assume that the diffuse radiation is uniform in the sky hemisphere,

$$S = K'\left[D\int_{\lambda_1}^{\lambda_2} r(\lambda)E^{dif}(\lambda,\theta_o)d\lambda + A(\theta_o)\cos(\theta_o)\int_{\lambda_1}^{\lambda_2} r(\lambda)E^{dir}(\lambda,\theta_o)d\lambda\right] \tag{7}$$

where E^{dif} and E^{dir} are the diffuse and direct spectral irradiances, θ_o and ϕ_o denote the position of the sun, and K' is the absolute calibration constant ($K' = \pi K$).

In practice, only the total spectral irradiance, E^{tot}, is measured and an additional calculation is used to obtain the diffuse and direct irradiances. A clear-sky ratio of the direct to diffuse irradiance, $\eta(\theta_o)$, is calculated (Green, 1980) and E^{dif} and E^{dir} are given by

$$E^{dif}(\lambda) = \frac{E^{tot}(\lambda)}{1+\eta} \tag{8}$$

and

$$E^{dir}(\lambda) = \frac{\eta \bullet E^{tot}(\lambda)}{1+\eta} \tag{9}$$

Instrument Calibration Constant

Figure 4-2 shows UVB-1 instrument readings plotted against the right-hand side of eq. (7). Concurrently measured spectral irradiances and eqs. (8) and (9) were used in evaluation of eq. (7). The relationship between the two quantities is nearly linear, with an r^2 value of 0.999. The calibration constant K' is the slope of the linear regression line fitted to the points. The best fit line has the slope 1.968 ± 0.011 (watt/m^2)/volts. Given the 5% uncertainty of the spectral irradiance measurement, in this case the best value for K' is 1.97 ± 0.16 (watt/m^2)/volts.

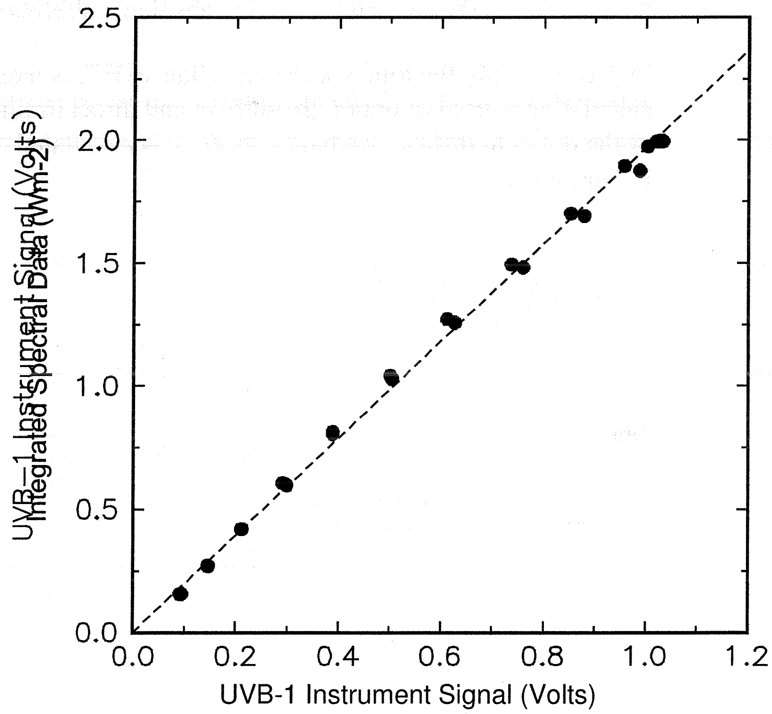

Figure 4-2. UVB-1 Instrument Readings Plotted Against the Integrated Spectral Data (right-hand side of eq. (7))

This value of K' is referenced to the 296 nm monochromatic radiation (the peak of the instrumental spectral response function r(λ)). If we choose to make the K' value referenced to 300 nm radiation (Grainger, 1993), it becomes 2.12 ± 0.17 (watt/m^2)/volt.

Spectral Response

This section describes the equipment and procedure that we use to determine the spectral response of the UVB-1. A 150-watt Xenon arc lamp is used as the UV light source. A Schott UG-11 glass prefilter is used to block the visible light in the lamp beam (we air-cool this filter with a small fan to prevent the glass from fracturing due to heat stress). The filtered light illuminates a holographic grating monochromator, which is used to select a narrow range of wavelengths (2 nm wide) to pass through its exit slits. The monochromatic light is focused into a 10" (25.4 cm) integrating sphere. A calibrated, NIST-traceable normalization detector is mounted in one port while the UVB-1 under study is mounted in a second port. Specific optical instruments are referenced in the diagram, but other types could be used.

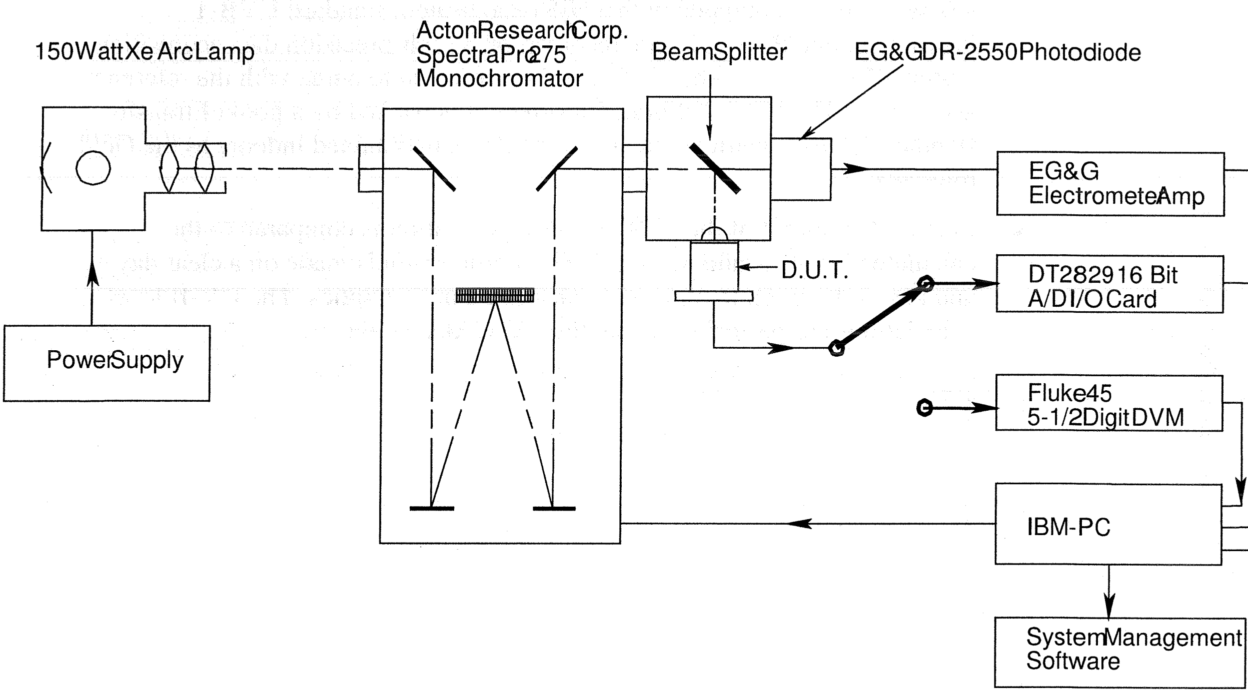

Figure 4-3. Spectral Calibration Facility

Because the DUT is designed for exposure to broadband sunlight, the output is very low in some portions of the scan, for example in the 320-400 nm portion of the UV-A spectrum on the Model UVB-1. The spectral characterization procedure is fully automated and the analog signal from the DUT detector is directly measured using a custom designed data acquisition system with 1 Hz analog filtering. The monochromator is stepped through the 270-400 nm wavelength range, in 2 nm increments. At each wavelength, the reference detector and the DUT outputs are recorded and saved to a data file.

After the spectral scan is completed, the program applies the wavelength-dependent normalization response using the reference detector to obtain the DUT's unique spectral response function plot for its calibration document.

Absolute Calibration

Performing an absolute calibration on a broadband UV pyranometer is not an easy task because no laboratory standard source of UV radiation exists as a reference. In addition, the solar spectrum

- Is subject to large variations due to changes in ozone levels and aerosols
- Varies strongly in the UV region with the solar zenith angle

The UVB-1 is subjected to three types of absolute calibration before it is shipped.

- First, the spectral calibration configuration shown in Figure 4-3 on page 4-7 is used to provide a NIST-traceable measurement of the absolute responsivity near the peak of the spectral response.
- Second, the instrument is operated for a several week period on an outdoor test stand that is equipped with a NIST-calibrated, standard UVB-1 instrument, and the results are recorded on a high-precision data acquisition system. The output of the UVB-1 is then adjusted to agree with the reference instrument. The NIST-calibrated instrument is backed by a pool of transfer standard UVB-1 instruments, one of which is maintained indoors as the Gold reference.
- Finally, the output of the UVB-1 under calibration is compared to the calculated UV-B irradiance level. This comparison is made on a clear day and near solar noon to minimize calculation uncertainties. The UV-B level calculations are performed using the UV-CALC program.

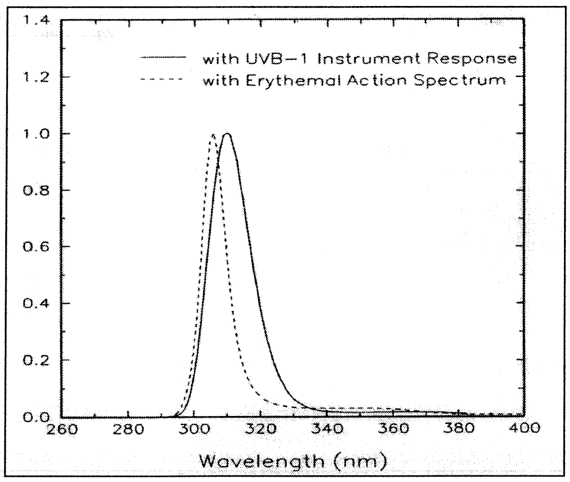

Figure 4-4. Comparison of Model UVB-1 spectral response convolved against a typical solar spectrum and one using the Erythemal Action Spectrum.

Cosine Response

The cosine response of the UVB-1 is measured by rotating the sensor in a uniform, parallel UV-B radiation beam. This beam is generated using a Xenon arc lamp, precision quartz optical elements, and a pinhole aperture. The lamp arc is imaged at the pinhole using primary and secondary condenser lenses. The pinhole permits light from only a small and uniform portion of the image to pass through. This rapidly diverging beam is then re-collimated into a parallel beam with another quartz lens. The resulting beam spot is uniform to better than 1% over its area. The detector, mounted on a rotating turntable, is then rotated through a ±90° arc, and the output is recorded as a function of the angle.

The cosine response of the UVB-1 is highly stable because of its dependency on machined optical geometry, which does not change over time and exposure.

Field Check of Calibration

If you do not have access to the equipment described in the previous sections but have a freshly factory-characterized sensor, you can use the *transfer detector* method. Note that this method has two major requirements:

- The sun must be high in the sky (near the local summer solstice), and
- The two instrumental relative spectral responses must be very similar

Using this transfer detector method can ascertain overall instrument performance and extend the period between factory re-characterizations, however, overall accuracy will be reduced. To use this method you need wait until near solar noon on a clear, sunny day and setup and carefully level both the device under test and the co-located transfer detector. Log data using a suitable multi-channel data acquisition system (such as a YESDAS-2). Avoid periods of cloud activity and tie the two data sets together using a suitable linear regression model around solar noon.

Cited References

1. Grainger, R. G., R. E. Basher and R. L. McKenzie, 1993: UV-B Robertson-Berger meter characterization and field calibration. Appl. Opt., **32**, p. 343-349.

2. Green, A. E. S., K. R. Cross and L. A. Smith, 1980: Improved analytic characterization of ultraviolet skylight. Photochem. Photobiol., **31**, p. 59-65.

CHAPTER 5
Maintenance

The UVB-1 has been designed to provide long-term, trouble-free service in severe environments. Only a few basic maintenance procedures are required to keep the instrument in good working order. This chapter describes these procedures and provides information on servicing the instrument. It also provides information on servicing the UVPS power supply (see page 5-6).

Routine maintenance

To obtain the best possible data, you should perform the following maintenance procedures on a routine basis.

- **Clean the exterior surface of the quartz dome** — Carefully wipe the quartz dome clean with a damp, soft cotton cloth. If it is dirty, it should be cleansed with a small amount of *ethyl alcohol* (provided with the cleaning kit).

> **Warning:** Use only ethyl alcohol to clean the quartz dome; other solvents, such as isopropyl alcohol, leave a slight film residue that absorbs UV-B, changes the response of the instrument, and causes a calibration error.

- **Check the humidity plug** — The humidity plug should appear blue, indicating that the various vapor tight seals are intact. If the humidity indicator appears pink, a significant amount of moisture has entered the instrument. We strongly recommend that you return the instrument to YES for service; see page 5-2 for information on repackaging an instrument for shipment.

  If returning the instrument is not feasible, follow the procedures later in this chapter for drying out the humidity indicator plug.

- **Check the connecting cable** — Inspect the electrical connector and associated cable for wind-wear, bird or animal damage, or general deterioration.

Recalibration

In addition to the routine maintenance tasks above, we recommend that you recalibrate the instrument every 12 to 18 months to track changes in response. You should return the instrument to YES during our local spring or summer, April through August, when we can provide the most accurate calibrations. For more information on our calibration procedures, see Chapter 4.

Servicing the UVB-1

We recommend that you return instruments that need repair to YES for service and recalibration. However, if you have the proper equipment and technical expertise, there are certain repairs you can make yourself:

- Replace a broken or leaky quartz dome
- Dry out the humidity indicator plug
- Dry out the instrument

This section describes how to return an instrument to YES as well as how to make the above repairs.

> **Caution**: Avoid "hot-plugging" the instrument, disconnect AC power from the system prior to engaging or disengaging the main connector

Repackaging for shipment

If you're shipping the instrument back to YES for repair or recalibration, be sure to

- Contact YES for a return authorization number (visit www.yesinc.com and go to the support section for instructions).
- If you ordered the flight case, wrap the UVB-1 in bubble plastic and place the instrument in the plastic reusable shipping container. Then place the shipping container in a cardboard box to discourage tampering in-transit.
- Insure the instrument for its full replacement cost and ship prepaid "door-to-door". For overseas shipping, it is especially important to *not* to simply ship to a US port of entry. Finally, do not ship COD as we do not accept COD packages.

Replacing a Damaged or Leaky Dome

You can order a replacement quartz dome from YES.

Bake out moisture

If the humidity indicator is pink, you must first dry out the humidity plug before you install the new dome. For more information, see page 5-3.

It's a good idea to wear non-powdered latex gloves when handling the dome.

To install a new quartz dome:

1. Remove the six #4-40x1/4" cap screws in the stainless steel dome holder, and lift off the entire dome assembly.
2. Inspect the UG-11 glass filter for fragments of broken glass, dirt, and so on. To clean the filter:

   a. Thoroughly rinse a cotton swab in ethyl alcohol several times to remove any oils.

b Allow all alcohol to evaporate, and then re-moisten the swab slightly with fresh alcohol.

> **Important:** The alcohol must not run out of the swab when pressed to the glass surface, or it might seep under the filter and contaminate the phosphor.

c To minimize the chances of any excess alcohol getting under the surface of the glass when cleaning the filter, invert the instrument such that the glass faces downward. Then carefully wipe the surface with the moistened swab to remove all the dirt.

3 Remove the replacement dome from its protective shipping bag, taking care not to touch the inside surface of the dome. If this occurs or there is any dirt on the inside surface, clean the dome with *ethyl alcohol.*

The glass-to-metal seal has been pressure-tested at manufacture to ensure leakproof performance.

4 Install the replacement dome using the new O-ring provided.

To ensure proper seating of the O-ring in its groove in the stainless steel ring, turn the instrument upside down and place the dome/O-ring assembly in position; then rotate the instrument to an upright position. This procedure prevents the O-ring from falling out of its groove or being pinched during assembly.

5 Install and tighten the six retaining screws, using care to tighten the screws in an alternating fashion. Avoid pinching the O-ring.

Drying Out the Humidity Indicator Plug

If the humidity indicator appears pink, precipitation has entered the instrument. It is possible that the humidity plug has absorbed all of the moisture and that the instrument is now dry. So, first try drying the humidity indicator as described below. If the indicator turns pink again within a few days, the instrument has a serious leak that must be corrected; see 5-4 for more information on how to open and dry out the instrument.

To dry out the humidity indicator plug:

1 Carefully unthread the humidity indicator plug from the instrument.

2 In a laboratory oven preheated to 40 °C, place the humidity plug on a cookie sheet or similar flat metal sheet.

3 Keep the plug in the oven for about one day to allow it to bake out completely. Try to keep the UVB-1 instrument in a dry environment during this period; do not leave it outdoors.

4 Removed the baked-out humidity plug from the oven.

The plug should have returned to its original blue color and can now be re-installed. If it is still pink, it must be replaced.

Ensure that the plug is fitted with an O-ring and that the O-ring is not cracked or worn.

5 Install the dry humidity plug in the UVB-1, turning it clockwise *by hand* until the O-ring becomes compressed.

> **Warning:** Hand-tighten the plug; do not use any tool to tighten the humidity plug. Over-tightening the plug will deform or damage the O-ring and break the O-ring seal.

Opening and Drying the UVB-1

We do not recommend opening the UVB-1 unless service is required. The instrument contains a humidity-sensitive phosphor in a vapor-proof, O-ring sealed, desiccated enclosure. The UVB-1 has been assembled in a clean, dry environment and pressure-checked. It contains a desiccant packet in addition to the desiccant visible in the humidity indicator. Therefore, you should open the instrument only in a dry environment that has less than 40% relative humidity (RH).

To open and dry the UVB-1:

1 Disconnect the cable from the UVB-1.

2 Unthread the humidity indicator plug from the instrument.

Open the instrument

3 In a *dry* environment (RH < 40%), remove the six #4-40x3/8" Phillips-head screws that hold the base plate in place.

4 Carefully slide the sensor body and electronics out of the housing, taking care not to strain the wiring, which will remain attached to the connector. A slight counterclockwise turning motion facilitates this procedure.

Dry entire instrument

5 Remove the desiccant bag from the instrument. Place the entire opened instrument body, desiccant bag, and humidity indicator plug on a cookie sheet or similar flat metal sheet in a 40 °C oven for 24 hours.

> **Important:** Ensure that there are no sources of direct radiant heat (as in the case of typical household ovens) that could cause excessive heating of the instrument and permanently damage the optical filters.

6 Remove the baked-out components into a *dry* environment, and install either a fresh desiccant pack or the baked-out desiccant pack.

Reassemble the UVB-1

7 Carefully slide the sensor assembly into the casting, allowing the wires to wind around the printed circuit board to take up any slack. Avoid pinching the wires.

8 Align the amplifier gain control pot (the blue PC pot in the center of the board) with the humidity indicator port in the casting so that this control can be accessed when the humidity indicator plug is removed.

9 Check that the O-ring is properly seated in its groove, and that the connector wires are properly dressed and do not block access to the gain control.

10 Slide the assembly the rest of the way into the casting.

The Delrin detector ring at the top of the assembly fits tightly with the dome retainer ring. Do not force the sensor into the dome ring; instead, rock and turn it slightly to allow the detector ring to slide all the way into the housing.

11 Check that the bottom O-ring is properly seated, and then install the retaining screws, using an alternating tightening pattern.

Install humidity plug

12 The humidity indicator plug should have returned to its original blue color during the bake-out procedure and can now be reinstalled. If the indicator is still pink, it must be replaced.

a Ensure that the humidity indicator plug is fitted with an O-ring and the O-ring is not cracked or worn.

b Install the humidity indicator plug into the UVB-1 instrument housing, turning clockwise *by hand* until O-ring becomes compressed.

Warning: Hand-tighten the plug only; do not use any tool to tighten the humidity indicator plug. Overtightening the plug will deform or damage the O-ring and break the O-ring seal.

Servicing the UVPS

This section explains how to replace fuses or change the AC line voltage of the UVPS power supply.

Fuse values

The following fuses are used in the UVPS power supply:

LINE VOLTAGE	FUSE TYPE AND VALUE
115 VAC	1A 3AG Slow Blow type
230 VAC	0.5A 3AG Slow Blow type (two fuses)

> **Caution**: Avoid "hot-plugging" the instrument, disconnect AC power from the system prior to engaging or disengaging the main connector

To replace fuses or change the AC line voltage:

1 Disconnect the power supply from AC power.

2 Remove the UVPS cover.

3 Remove the power supply cover by unthreading the four screws.

4 To change the line voltage, set the jumpers and fuses as shown:

INPUT	JUMPER	APPLY AC TO	FUSE
115 VAC	1-3, 2-4	1,4	1A Slow Blow
230 VAC	2-3	1,4	0.5A Slow Blow

> **Important:** For 115 VAC operation, only the AC Hi line is fused. For 230 VAC, both the AC Hi and AC Lo lines must be fused.

5 Replace the power supply cover.

6 Replace the UVPS cover.

Important Product Safety and Disclaimer Information

Important: READ THIS PAGE BEFORE USING THE SYSTEM!

Lethal voltages present inside enclosure

The sensor should be mounted such that it is out of reach or anyone not authorized to use it. If you cannot do this, install it inside a secure fence line such that children and unauthorized personnel are denied physical access to it *at all times*. There are lethal voltages inside the system, therefore no work should be performed on it while it is connected to line power - always disconnect AC line power before servicing the system. Only operators familiar with the detailed operation of the system should be allowed to maintain it, and all servicing is to be performed by qualified, technically trained personnel only.

Danger: Use extreme care when working on the system where the ground is wet, you can be killed! Always disconnect AC power first before opening the enclosure or touching the sensor head.

Advisory use only

The accuracy of radiometric measurements depend on complex physics that by their nature tend to be difficult to control. While best practices have been employed in the design and manufacture of the system, malfunctions can and will occur that require periodic user-maintenance and intervention. Further, due to the complex and varied nature of the automatic measurements made within the instrument, this equipment is not designed or intended for hazardous or otherwise life-critical applications. Yankee Environmental Systems, Inc. (YES) provides this equipment *as-is* and makes *no warranty as to the suitability of purpose of the product or the data it produces*. All data provided by the system are for "advisory" use only.

Disclaimer

You agree to use the product and the data it provides *at your own risk*. YES, its agents, distributors, assigns, shareholders or employees are not responsible for any damages whatsoever, resulting from either proper or improper use of this product, or application of data it provides. Further, YES, its agents, distributors, shareholders or employees are not responsible for any injury or injuries that may result from improper installation, malfunction, system design elements, improper or normal operation, or as a result of real or perceived negligence on the part of anyone. By using the instrument, you agree to these terms herein included in this User Manual as provided with the system at time of purchase. If you have any questions about this policy or on using the equipment in your application, contact technical support before proceeding with installation or use via any of the methods listed in *In This Manual* located just after the table of contents.

Important: All servicing is to be performed by qualified technically trained personnel only.

Product Warranty

Warranty Terms

The YES standard product warranty applies only to defects in manufactured parts as described by its general product warranty located at www.yesinc.com.

Documentation Feedback

While we have tried to provide the highest level of technical accuracy in this document, our documentation team welcomes any comments you may have, both positive and negative. Please do not hesitate to contact us via any of the methods listed in the section *In this Manual,* located just after the table of contents.

Also, be sure to check our corporate web site for the latest technical information —look in the *support* section, under the data sheets and in the *frequently asked questions* link. In addition to providing the latest development news, the YES web site www.yesinc.com offers downloadable software updates to licensed customers, and tutorials on topics too changeable or complex to be covered in a printed manual (such as videos demonstrating complicated service procedures). You can also submit feedback and questions directly to the YES engineering team via email links.

APPENDIX A

Monitor Thermistor Resistance Versus Temperature

Because of the temperature-dependency of the phosphors, it is critical that the system maintain its internal temperature over the full environmental temperature range. The UVB-1 contains a monitor thermistor that is independent of the internal temperature control. You can connect this to temperature-dependent resistor your data acquisition system as a quality control function to check that the internal temperature control is working. The following table shows the resistance versus temperature characteristic for the temperature monitor thermistor in the UVB-1.

RESISTANCE (KΩ)	TEMPERATURE (°C)
3356	-40
2951	-38
2589	-36
2292	-34
2025	-32
1791	-30
1586	-28
1407	-26
1250	-24
1111	-22
989.8	-20
882.7	-18
788.2	-16
704.7	-14
630.9	-12
565.5	-10
507.5	-8
456.0	-6

RESISTANCE (KΩ)	TEMPERATURE (°C)
410.2	-4
369.4	-2
333.1	0
300.6	2
271.6	4
245.7	6
222.5	8
201.7	10
183.1	12
166.3	14
151.3	16
137.7	18
125.5	20
114.5	22
104.5	24
95.51	26
87.38	28
80.00	30
73.32	32
67.26	34
61.75	36
56.75	38
52.19	40
48.04	42
44.26	44
40.81	46
37.66	48
34.78	50
32.15	52
29.74	54
27.53	56
25.50	58
23.65	60