

UV PROCESS SUPPLY, INC.

CON-TROL-CURE® COMPACT RADIOMETER INSTRUCTION MANUAL

PART # M007-008

The Compact Radiometer is a self contained UV dose measuring instrument designed with a low profile for use in UV curing ovens, printed circuit (photoresist) and printing plate exposure systems. The unit has been engineered to tolerate the harsh environments associated with these applications. The polished aluminum housing is able to withstand the high temperatures and UV irradiance encountered in the ovens without degradation. The housing as well as high "G" force mounts on all critical components enable the unit to withstand physical punishment often associated with accidents on conveyor belt systems.

The Compact Radiometer's one button operation enables quick, easy and accurate measurements by non-technical personnel without disruption of production schedules. The instrument is placed in the same location as the product to be irradiated so that it receives the same dose of UV irradiance as the product it quantifies and displays this dosage providing a reliable means of process control from run to run. The Compact Radiometer will certainly pay for itself by minimizing product rejects.

The same button is used for battery test, by pressing and holding for more than two seconds, so that no other external test device is required on hand to keep track of it. A typical application procedure is as follows. First, the belt speed is adjusted to produce a fully cured product. Next, the total dose at that belt speed is measured using the Compact Radiometer. Finally, at the start of each day, before sending product through the oven, the belt speed is adjusted to give the same dose as measured by the Compact Radiometer in the previous steps.

OPERATING INSTRUCTIONS

The CON-TROL-CURE® Compact Radiometer is easy to use for determining the proper level of energy for curing inks and coatings in UV reactors.

- 1.** There are two sides to the Compact Radiometer. The topside has the instruction label, an on/off button and a liquid crystal display. The bottom side is all chrome except for a quartz window to allow the light into the device.
- 2.** On the Topside you will see an arrow, indicating the direction which the Compact Radiometer must travel through your curing system. This will ensure the direction of the light matches the way the radiometer was calibrated. **ALWAYS USE IN THE DIRECTION OF THE ARROW.**
- 3.** There are two numbers inscribed in the front label. The larger number is the serial number that we use to keep track of each radiometer. The smaller number is a calibration number. It is designed to indicate a battery check. When you press the on/off button longer than two seconds, a number will be displayed. This number is the battery check. The number displayed after a second press should be greater than the inscribed number. If you find that the battery checks low, the Compact Radiometer needs to be returned for calibration and battery change.
- 4.** The correct usage may vary from installation to installation. Here are some suggested uses: To establish repeatable curing results, run samples in a UV drier until satisfactory results are achieved: that is, the acceptable physical properties are noted. Run the Compact Radiometer to determine the amount of energy that was required to achieve the successful results. Record this number and use it to adjust conveyor (processing speed) each time you run that formula. Periodically check the energy level and be sure that the product is getting a consistent level of energy throughout the production run.

UV PROCESS SUPPLY, INC.

CON-TROL-CURE® COMPACT RADIOMETER INSTRUCTION MANUAL

PART # M007-008

As the lamps get older or the UV energy diminishes, the speed at which the production line is running will become slower. When the speed is too slow to run production, or too slow causing too much heat in the product, you have the option to clean the lamps or change them.

To establish the output of a lamp, first we must establish a testing speed that is easily repeatable. With that speed as a constant, we then can pass the Compact Radiometer through the system and record the energy that is received. As the lamps grow older and emit less energy, the number recorded will decrease (the speed must be at a constant rate, note our CON-TROL-CURE® Digital Tachometer Product #M004-001). This type of test is useful in comparing different types of UV dryers.

NOTE ON THE DISPLAY:

The liquid crystal display will turn black if the unit is passed through a very hot drier such as those used in the PC industry. In those cases when the display has turned black, simply allow the Compact Radiometer to cool and the LCD will display the units of energy that is recorded. This is a good indication that any more heat should be avoided.

For consistent and repeatable results, it is desired that consistent operating temperature be used. You may see variations in readings if a cold radiometer is run and later passes when the radiometer has gotten hot. It is suggested that the radiometer be passed through the drier once or twice until it has achieved an average temperature (and allowed to cool between passes). Typically 2 to 5 minutes will prove adequate.

The display shows unit in millijoules per square centimeter. This is a very low number in most ink or coating curing applications. Most readings will be in joules. This means the first three digits on the display have little meaning in recording the effective curing energy. Typically a Solder Mask used in the PC industry, will require 2 to 5 joules of energy.

The speeds used to achieve this level of energy are approximately 6 feet per minute with three 300 watt per inch lamps. The Compact Radiometer in these types of energy levels will display 2000.0 for 2 joules of energy. It is therefore recommended in most curing applications, the first three digits be disregarded, so your readings are really 2.0 joules rather than 2000.0 millijoules.

Compact Radiometers require calibration every 12-18 months depending on use. Typically, the intensity of the UV light in the curing processor eventually degrades or deteriorates the lamps and reflector material and will also affect the components of a frequently used radiometer. This is why calibration is suggested every year. When re-calibrating your Compact Radiometer, we completely overhaul it with new optics and a new battery. Re-calibration of the Compact Radiometer is normally completed after 1-2 weeks, from the time we receive it and costs \$375.00. In order that you will not be without a radiometer while we are in the process of re-calibrating it, we have created the *Compact Radiometer Loaner Program*.

We can ship you an immediate replacement from our "pool" of recently calibrated radiometers. Once your Compact Radiometer is re-calibrated, it will then be shipped to you upon receipt of your radiometer. How do you go about the Loaner Program? First, call UV Process Supply, Inc. for a **Return Authorization Number (RA#)** before returning your radiometer. Mark on the return package the Return Authorization number assigned to you. Upon receipt of an order for the exchange, the replacement radiometer will be shipped and billed for the current quoted price.

Upon receipt of your radiometer, a credit is issued for all costs except \$375.00 for the replacement radiometer. Your original radiometer will be repaired or re-calibrated and returned to the Loaner Program. If your Compact Radiometer only needed re-calibration, the order is completed. If the repair was major, you will be billed \$375.00 plus any additional charges that exceed a normal calibration. If you have any questions, call us at (773) 248 0099.

UV PROCESS SUPPLY, INC.

CON-TROL-CURE[®] COMPACT RADIOMETER INSTRUCTION MANUAL

PART # M007-008

Please feel free to call or write us if you have any technical questions regarding the operation of this instrument, or if you have any suggestions.

NOTE: *We now have a very large inventory of replacement lamps. Consider us for your next order.*

COMPACT RADIOMETER BOTTOM PANEL

A. Serial number and original calibration date of unit

B. LCD readout of Integrated Irradiance In units of millijoules/lcm²

C. SHORT FORM INSTRUCTIONS NOTE: Unit is run with other side exposed not label side

D. BATTERY TEST:

1. Press & hold ON/OFF button on for 2-5 seconds.
2. Release button & read battery level on LCD.
3. Compare reading with minimum acceptable battery level indicator inscribed above.
4. Return unit to UV Process Supply for factory IER CALIBRATION if value displayed is less than scribed value. **NOTE:** After periods of non-use the Compact Radiometer lithium batteries will revert to shut-down state where false low battery reading may be indicated, The unit should be left on for at least two full auto-shutdown cycles (approximately 14 minutes) before true battery level will be indicated when unit is new or has not been used regularly.

E. ON (RESET)/OFF Button

1. Quick press of button turns unit on (0 shown on LCD).
2. Press & hold button for between 2-5 seconds for battery test (battery level shown on LCD, example: 6.8).

F. RANGE OF MEASUREMENT

1. Maximum Dose - 20,000.0 millijoules per square centimeter.
2. Maximum Irradiance -10 units per square centimeter (watts/cm² x exposure time in seconds joules/cm²).
3. Any servicing, including batteries requires re-calibration at factory (opening of compact radiometer destroys calibration and renders the unit inoperable).

G. TRAVEL DIRECTION

1. Unit is turned over for measurement and placed so that arrow points in direction of travel (input aperture end first).
2. Dotted Circle represents input aperture location on other side of unit.

NOTE: This is the recommended orientation of the unit. For optimum repeatability of readings from run to run, The Compact Radiometer should be oriented the same way in the same location. The obvious exception to this is when profile measurements are performed.

UV PROCESS SUPPLY, INC.

CON-TROL-CURE® COMPACT RADIOMETER INSTRUCTION MANUAL

PART # M007-008

The Compact Radiometer was designed to overcome the major obstacle in UV measurement inside the UV curing oven or exposure system, which is space. The unit is only 1/2 inch (12.7 mm) high. The polished aluminum housing reflects heat away to allow the Compact Radiometer to operate in the harsh measurement environment of the oven without damage. The Compact Radiometer is placed onto the oven conveyor or exposure system with the input aperture toward the light source(s). Light meters the input aperture where it is diffused and collected. After many reflections it travels through a narrow slit aperture, absorption filter and impinges on the vacuum photo-diode where it is converted to current. The current signal is amplified and converted to the final optical units of measurement, which are displayed on the LCD on the bottom panel. For best measurement repeatability, the unit should be placed in the same location each time a measurement is made.

SPECTRAL RESPONSE

Spectral response refers to how the signal out of a detector changes as the wavelength of light incident on the detector changes. Because of the wide variety of UV curable materials (photo curable monomers) each with its own relative spectral response, the only practical approach to the design of a detector of spectral sensitivity, is to cover a broad UV range, 258 to 480nm, with high relative response throughout that range. This is commonly referred to as the UV Curing Action Spectrum or the portion of the UV spectrum which the photoinitiator (absorbing dye) absorbs the UV irradiance and produces polymerization. The Compact Radiometer employs an S-5 vacuum photo-diode and glass absorption filter to produce this spectral response.

SPATIAL RESPONSE

Spatial response refers to the change in signal out of a detector as the position of a point source changes in front of the detector. The detector should view light the same way that a flat surface sees light. The relative spatial response of a flat surface is equal to the cosine of the off-axis angle of the source. In other words, if the source is not directly above but 45 degrees on-axis, then a 1 cm² surface captures only .707 cm² of light from the source. So the irradiance has fallen off to 70.7% of the on-axis value.

The narrower the spatial response of a detector, the lower and more erroneous the measurement. A special diffusing material has been designed into the Compact Radiometer that produces a very good spatial response without sacrificing sensitivity. Figure C shows the typical Compact Radiometer spatial response as compared to the absolute cosine response.

THERMAL CHARACTERISTICS

The absolute sensitivity of a detector changes with temperature. For an S-5 vacuum photo-diode used in the Compact Radiometer, a change in sensitivity of -0.2% per degree centigrade has been measured. So at a temperature that is 75° C higher than the temperature at which the device is calibrated, the measurement will be 15% lower. The temperature referred to here is that of the photodiode not the ambient temperature. With this in mind, the Compact Radiometer was engineered to keep the photo-diode temperature from increasing to a point where measurement accuracy is compromised before the actual measurement is completed.

UV PROCESS SUPPLY, INC.

CON-TROL-CURE® COMPACT RADIOMETER INSTRUCTION MANUAL

PART # M007-008

The Compact Radiometer housing is made out of aluminum, a material that opposes rapid temperature rises, and is then polished to reflect heat away. The aluminum housing is able to withstand 95% more exposure to radiation than the brass/chrome plated housing used on the older models. The Compact Radiometer is capable of short-term operation in ambient temperatures up to 538° C, for up to 30 seconds with minimum measurement error. The specified operating temperature range of the Compact Radiometer is from 10° to 43° C. this refers to the case (housing) temperature. Over 43° C, the Compact Radiometer will not be able to be held by a human hand. As a general rule, using the hand as a rough gauge, the unit should not be run again until cool to the touch.

NOTE: The upper limit of operating temperature is stated at 43° C for safety purposes only. Experiments have shown only a -5.72% max. Change in measurement at 50° C, on the most sensitive range (refers to input currents to the device in the range of 10 nanoamps). On the least sensitive ranges the error was -1.00% or less. At 62° C the LCD display will turn black. Please note that in most cases the LCD will return to normal state when the unit has cooled and the unit will work properly without service providing the internal temperature was not high enough to damage any of the electronic components inside the Compact Radiometer.

CALIBRATION

A. ELECTRICAL CALIBRATION

The Compact Radiometer undergoes a complete electrical test and calibration upon completion of assembly. Electrical calibration working voltage standard N/A voltage standard 4625008 which is referenced to the U.S. National Institute of Standards and Technology reference 7 was compared to transfer standard 239658. Electrical calibration working resistance standard N/A 8 was compared to transfer voltage standard 846007 which is referenced to NIST reference Standard 242008.

B. OPTICAL CALIBRATION

After electrical calibration, the Compact Radiometer is optically calibrated. This is a two-part procedure. The Compact Radiometer is first calibrated to IL Working Standard IL390 on a high pressure Mercury Vapor source then checked against the standard again on an extended source for spatial conformity, If both criteria do not meet IL specification, the unit is returned to electrical test and inspection for investigation. International Light Primary Transfer Standard(s): IL D.R.I.P. #01, #02, #05, #06 are directly traceable to primary standard NIST Detector Response and Intercomparison package (D.R.I.P.) DR#10 April 1988 - NIST Test No. 534/240436-88.

UV Process Supply recommends that the Compact Radiometer receive periodic re-calibration at a frequency dependent on usage basis. For more information on this matter, please refer to the REPAIR/SERVICE section of this manual.

BATTERY DETAILS

A. BATTERY LIFE

Two Lithium Fluoride batteries internally power the Compact Radiometer. The typical battery life of the unit is 150 hours. This figure is based on the manufacturer's specification of 750 milliamp/hour with the Compact Radiometer typically drawing 5 milliamp.

UV PROCESS SUPPLY, INC.

CON-TROL-CURE® COMPACT RADIOMETER INSTRUCTION MANUAL

PART # M007-008

B. AUTOMATIC SHUT-OFF

An automatic shutoff feature has been designed into the Compact Radiometer to conserve battery life. The unit will automatically shut itself off after approximately seven minutes after power up. For applications where auto-shutoff is not desirable, a factory custom modification to defeat the auto-shut off feature is available.

C. BATTERY TEST

The batteries are **NOT** replaceable in the field. The unit must be returned to the factory for battery replacement since the instrument calibration is destroyed when the unit is opened. If the BATTERY TEST indicates a low battery condition, contact UV Process Supply to arrange the unit's return. Refer to "BOTTOM PANEL" section of the manual for complete battery test instructions. CAUTION: The battery test should be performed only after the Compact Radiometer has been powered up for at least two full auto-shutoff cycles (approx. 14 minutes).

The Compact Radiometer batteries revert to a non-active state when the unit is not in use over an extended period of time. A battery test performed while the batteries are in this state will give a false low indication. This is an inherent trait of Lithium Fluoride type batteries, which enables a longer battery life. In most cases, due to the harshness of the environment, the Compact Radiometer will require calibration before the batteries actually indicate a low condition. This is especially true when an accident occurs such as when the instrument is dropped.

As a matter of convenience for UV Process Supply and the Customer, when the unit is returned to the factory, the batteries are replaced and the Compact Radiometer re-calibrated. This is the most cost and time effective method available to our customer. For more information refer to the REPAIR/SERVICE section of this manual.

REPAIR/SERVICE

The Compact Radiometer must be returned to the factory for any repair work, battery replacement or re-calibration. The optical calibration is destroyed when the unit is opened. There have been very few times when the Compact Radiometer is found to be damaged beyond repair. No matter what the Appearance of the unit, it can probably be fixed and subsequently operate at an optimum level.

A. RETURN AUTHORIZATION NUMBER

To arrange the return of the Compact Radiometer to the factory, please contact us at **(773) 248-0099** or **(800) 621-1296** to obtain a **RETURN AUTHORIZATION NUMBER**. This will enable us to expedite your return order quickly. Compact Radiometers require calibration every 12-18 months depending on use. Typically, the intensity of the UV light in the curing processor eventually degrades or deteriorates the lamps and reflector materials and will also affect the components of a frequently used radiometer. This is why calibration is suggested every year. When re-calibrating your Compact Radiometer, we completely overhaul it with new optics and a new battery. Re-calibration of the Compact Radiometer is normally completed after 1-2 weeks from the time we receive it.

In order that you will not be without a radiometer while we are in the process of re-calibrating it, we have created the Compact Radiometer Loaner Program. We can ship you an immediate replacement from our "pool" of recently calibrated radiometers. Once your Compact Radiometer is recalibrated, we will ship you your original unit back upon receipt of the loaner. How do you go about the Loaner Program?

UV PROCESS SUPPLY, INC.

CON-TROL-CURE® COMPACT RADIOMETER INSTRUCTION MANUAL

PART # M007-008

First, call UV Process Supply for a Return Authorization Number (RA#) before returning your radiometer. Mark on the return package the Return Authorization number assigned to you. Upon receipt of an order for the exchange, the replacement radiometer will be shipped and billed for the current quoted price. Upon receipt of your radiometer, a credit is issued for all costs except \$375.00 for the replacement radiometer. Your original radiometer will be repaired or re-calibrated and returned to the Loaner Program. If your Compact Radiometer only needed recalibration, the order is completed. If the repair was major, you will be billed \$375.00 plus any additional charges that exceed a normal calibration. If you have any questions, call us at (773) 248-0099.

B. IER CALIBRATION

By specifying IER CALIBRATION the Compact Radiometer will be internally re-calibrated which includes both electrical and optical calibrations and new batteries will be installed. If any repairs are required you will be notified of the problem with an estimate of the costs for the repair work. As a reminder, be sure the Compact Radiometer has been on for at least 14 minutes or has been in regular use before performing battery test or a false low battery condition may be indicated.

C. CALIBRATION CYCLE

UV Process Supply recommends a yearly recalibration. Where, the Compact Radiometer is used approximately 30 minutes a day after twelve months the batteries are due for replacement and due to the rough environment recalibration is essential. In some cases UVPS customers will have two or more Compact Radiometers in use which will be returned to UV Process Supply on a 3-month cyclic basis. It all depends on the frequency of usage and how the unit is handled in use. Whenever possible, a second Compact Radiometer should be purchased and kept as a non-working standard to compare readings with the working unit on line to maintain the optimum level of measurement accuracy and process control. Obviously, we favor this method of calibration check.

MEASUREMENT

In a UV curing oven it is most important to know the total exposure the product receives so that the process can be evaluated, adjusted or controlled and repeated from run to run. To know the effect of UV on a target, the appropriate unit of measurement is energy per unit area (joules/cm²). In some cases power per unit area (watts/cm²) must be known and is directly related to energy per unit area by this formula: 1 joule/cm² - 1 watt/cm² x exposure time (seconds)

Briefly, energy is measured in joules. Energy is what does work. Next is the rate at which work is done i.e. energy per unit time. A work rate of one joule per second is defined as one watt. The units of Joules or watts are familiar electrical parameters and are also used when measuring lasers. They are not used when measuring extended light sources normally found in UV Curing applications. As mentioned above, either energy or power per unit area units is used since the product to be cured acts as an extended receiver.

The Compact Radiometer collects all the light (watts) incident upon it and divides by the detector area (cm²) then integrates this over the exposure time (seconds) which equals energy per unit area (Joules/cm²).

Typically, this will be in the range from .5 to 5 joules/cm². The Compact Radiometer measures directly in millijoules/cm² to enable better resolution in readings on the LCD. To convert the reading in the displayed unit to milliwatts/cm², divide the reading shown by the exposure time in seconds. Compact Radiometer range of measurement: 0.1 to 20,000 millijoules/cm² .001 to 10 watts/cm². Since the integration times are considered long, 30 seconds to 3 minutes, there is no problem with radiometer response time, therefore temporal response error is less than one percent.