

# Tyler Research Corporation

## Ultraviolet Irradiation and Dosimetry System

The Tyler Research UV-2 ultraviolet irradiation system is intended for quantitative ultraviolet dose-response analysis in biological organisms. The irradiator consists of a stainless steel primary chamber housing a contoured bank of high-flux UV-fluorescent lights, and a large front-loaded sample carrier (Figure 1). Lamps are cascade-phosphor ultraviolet generators with a sharp 310nm peak output (65% of total UV radiation falls within 20nm half bandwidth of the peak) and 365nm peak output generators. Each wavelength is individually selectable with an indicating rocker switch mounted on the top of the cabinet.



Figure 1

The primary chamber is fully shielded and ventilated. The acrylic sample drawer may be removed for cleaning and UV-opaque ports permit observation of the interior while protecting the operator from ultraviolet radiation. Registration modules provide rapid and reproducible positioning of the test subjects (culture dishes, animal restrainers, etc) in the UV field.

The photonic dosimeter is a completely solid-state microprocessor-controlled detector/analyzer providing real-time digital output of temperature and irradiance at specified wavelengths (Figure 2). Units are user-selectable, with a choice of  $\mu\text{W}/\text{cm}^2$ ,  $\text{ergs}/\text{mm}^2/\text{sec}$ , and  $\text{Joules}/\text{m}^2/\text{sec}$ . Detector heads are small (18mm x 54mm x 35mm) and may be connected to the hand-held processor via a flexible RS-232 cable. Each detector is internally calibrated, and for this application is configured to correspond to UV-A (365nm) or UV-B (313nm) radiation. Wavelengths from 250nm to 1000nm and with virtually any bandwidth are detectable by the device. The photonic dosimeter is self-contained, and powered by a standard 9-volt battery.



Figure 2

Three animal restrainers are included with the irradiator (Figure 3). Available in a variety of sizes, these modules provide absolute restraint of the animal in the desired dorsal orientation, permitting quantitative dose delivery. The animal's sensitive eyes, ears, nose and feet are fully shielded from ultraviolet radiation, and they appear to be comfortably contained. The UV-2 can accommodate as many as 6 mouse restrainers simultaneously.

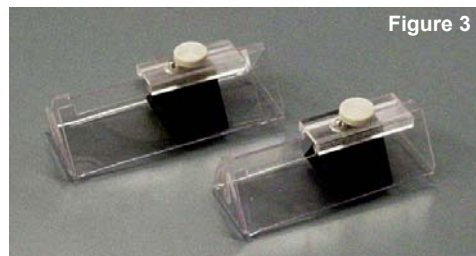


Figure 3

### Manifold Operation

Position the primary manifold on a level bench with adequate space on both ends to permit airflow, and with unencumbered room for the sample carrier to move completely in and out of the cabinet. Plug the power cord into a 120VAC 50-60Hz line (or plug into the 230VAC to 115VAC power adapter).

The main power switch is on the left rear of the cabinet. The round rocker switch beside it activates the cooling fan. It is recommended that this be left on at all times unless there is a specific reason to limit air flow (such as in the irradiation of open cell cultures and tissue cultures, for which air-borne contamination is a concern).

The stainless steel cabinet and acrylic sample carrier drawer shield the operator from ultraviolet radiation produced in the cabinet. The portholes and windows are made of UV-blocking acrylic so the interior may be observed without eye protection. Nevertheless, it is recommended that eye protection be worn at all times in working with the system, and that gloves be worn whenever opening the drawer. Although almost all safety glasses are inherently UV-opaque, the UV dosimeter should be used to confirm that safety glasses and gloves are effectively blocking all UV-B radiation specifically.

Select the desired wavelength(s) by activating the appropriate rocker switch on the top right of the cabinet (310nm, 365nm, or both simultaneously). These should be turned on approximately 10 minutes prior to introduction of an animal so that the UV flux is stabilized.

Pull out the front drawer by sliding it straight out of the cabinet until it stops. The rear of the drawer contains a baffle to prevent stray UV light from irradiating the drawer contents when it is fully open, and for this reason ***the drawer should be fully open or fully closed when the light sources are on*** - under normal circumstances the drawer should not be left in a partially open or partially closed position. In the fully open position it is safe to load mice or other samples without exposing them to ultraviolet radiation even when the lamps are turned on.



Figure 4

It is a good practice to verify the photon flux before each series of experiments. This may be done by placing one of the UV-detector modules in any position on the drawer surface and measuring the irradiance. An RS-232 connector on the front of the drawer serves as a feed-through for the dosimeter cable: plug the long serial cable into the dosimeter and the RS-232 port on the outside of the drawer, and plug the short cable into the interior RS-232 port and a detector head (Figure 4). Place the detector head in the desired spot in the sample drawer (it may be necessary to tape it in place for a specific position,

being careful not to cover the round white disk) and take a measurement with the drawer open and then with the drawer closed. The reading should be zero with the drawer fully open. The flux may vary in the cabinet due to inconsistencies in the fluorescent tubes, but the area denoted by the two rectangles of the culture plate (approximately 25cm x 10cm) will be very uniform from position to position. Calculate the times required to achieve the desired doses in each position of interest (e.g. if a dose of 0.4 Joules/cm<sup>2</sup> of UV-B radiation is required in

mouse positions 1-3, and the irradiance there has been measured at 24 Joules/m<sup>2</sup>/second, this corresponds to a dose of 0.0024 Joules/cm<sup>2</sup>/second. An exposure time of 167 seconds will deliver the desired dose).

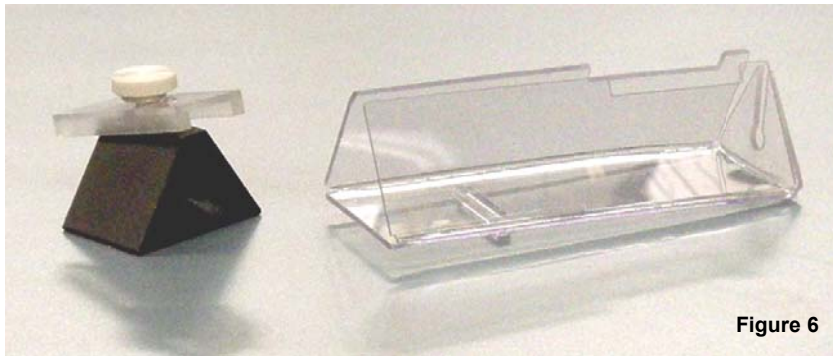
Registration sites machined into the top surface of the sample drawer assist in the correct placement of mouse restrainers and 24-well culture plates so that they receive maximum uniform UV dosages. Place loaded restrainers



into the drawer by fitting the bar on the underside of each restrainer into one of the 6 linear grooves in the drawer surface (refer to the instructions on loading mice into the restrainers in the section below). Similarly, the perimeter on the base of 24-well culture plates will lock into place on either of the radiused rectangles machined into the sample drawer. When all samples are loaded, slide the drawer fully closed and begin timing the exposure. Open the drawer fully when the desired exposure has been reached.

### Mouse Restrainers

These unique three-sided modules are simple to load and provide absolute restraint of the animal in the desired dorsal orientation, permitting quantitative dose delivery (Figure 6). The animal's sensitive eyes, ears, nose and feet are fully shielded from ultraviolet radiation, and the mice appear to be comfortably contained.



Loosen the thumbscrew on the sliding nosecone/shield by unscrewing approximately two full turns and slide the assembly off the end of the triangular polycarbonate tube. Holding the tube in one hand, grasp a mouse firmly by the base of the tail and position it at the open end of the tube with its dorsal surface up (against the gap between the sides of the triangular tube). Pull the mouse backwards into the

tube by drawing the tail toward the closed end through the gap between the sides. It may be necessary to gently dislodge the rear and front feet from the open edge as you pull the animal rearward. Continue to pull the mouse back until the tail can be pulled through the slot in the closed end. Hold the tail in this position, bracing your fingers against the end to prevent the animal from moving forward in the tube. With the shield of the nosecone tipped upward by the captive spring, slide the nosecone into the tube, taking care to straddle the sides of the triangular tube with the downturned edges of the shield. When the nosecone is fully inside the tube the shield will flatten into position on the top of the tube. Gently continue pushing the nosecone assembly rearward until it covers the nose and eyes of the mouse and the mouse is contained firmly between the nosecone and the end plate through which its tail is protruding. Tighten the thumbscrew to prevent the mouse from moving it forward. If the animal has been properly positioned and constrained, it will be unable to turn around or rotate in the triangular space, and its back will be properly positioned for irradiation.

## Access Ports

The linear window in the front of the sample drawer and the two round viewports in the front of the UV-2 cabinet are normally used for viewing the interior of the cabinet during irradiation procedures. A similar rectangular port at the



right rear of the cabinet is provided if direct access to the interior should be necessary (Figure 7). If required, the six screws surrounding this port may be removed and the lens taken out. This will permit the feed-through of tubes or electrical cables to the irradiation zone, for example. One or both of the circular lenses in the front of the cabinet may also be removed, although we recommend that these be left simply as observation ports. In the event any window is removed it is imperative that the opening(s) be shielded by filling or draping with UV-opaque material to prevent radiation exposure outside the cabinet when the UV lamps are activated.

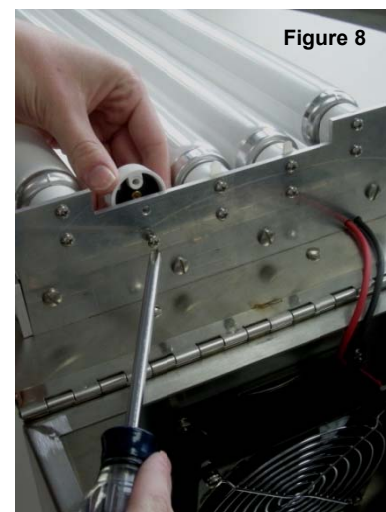
## Maintenance

Little is required in the way of maintenance other than ensuring that the fan and lamps continue to operate properly. It will probably be necessary to clean mouse restrainers frequently and the sample drawer from time to time. The triangular mouse restrainer housings may be cleaned in detergent and water as required. If it becomes necessary to clean the nosecone/shield assembly, we recommend that it be disassembled, cleaned and thoroughly dried before reassembling for storage or returning it to active use.

The drawer is supported by two ball-bearing tracks underneath the sample platform. To remove the drawer, open it fully and locate the two black plastic levers in the steel tracks approximately 15cm from the front on the underside of the drawer rails. While pushing both levers fully to the left, gently pull the drawer forward a few centimeters. It will disengage from the tracks and can be removed completely for cleaning in detergent and water. To re-install the drawer, ensure that the tracks in the cabinet are fully extended forward. Line up the interior tracks on the underside rear of the drawer with the black plastic ends of the tracks on the cabinet floor and gently push the drawer into the cabinet. The drawer should move easily until it is a couple of centimeters from being fully closed. While supporting the back of the cabinet to prevent it from sliding, push firmly on the front of the drawer *in line with the platform and slightly below the level of the handle* until the drawer moves completely into the cabinet. It is now re-engaged with the ball bearing track and can be opened and closed easily.

## Changing Lamps

UV-generating fluorescent tubes may lose intensity over time so that exposures must increase, eventually reaching the point where it becomes desirable to replace the tube. If it is necessary to change one or more of the UV generating tubes, unplug the power cord and remove the 9 phillips-drive screws along the perimeter of the cabinet's top surface. Grasp the handle on the right side and open the top by lifting up – it is hinged on the left side. Continue swinging the top up and over until the handle opposite the hinge is resting on the bench. The center three lamps in the frame are 310nm generators and the two peripheral lamps are 365nm generators. Remove the two Phillips-drive screws holding the white plastic lamp fixture of the lamp requiring replacement at the hinge end of the assembly (Figure 8). Gently slide the white fixture up approximately 2cm, at which point it will be possible to disengage the pins in the lamp from the fixture. Pull the lamp away from the fixture on the other end of the lamp holder. To replace a lamp, reverse this procedure. Carefully insert the pins on one end of the new lamp into the fixed holder, engage the pins on the other end of the lamp in the free floating fixture and gently slide this fixture back into position in the frame. Line up the holes in the back of the fixture with those in the aluminum frame and re-install the screws. Close the cover and install the 9 retaining screws to secure the cover to the cabinet. Plug the power cord into the power module and test the newly installed lamp(s).



## Specifications

- Cabinet Dimensions: 70cm wide x 26cm deep x 18cm high
  - Stainless Steel with Aluminum Subbase and Nylon Feet
- Drawer Dimensions: 40cm wide x 24cm deep x 6cm top surface clearance
  - Acrylic with Stainless Steel Fixtures
- Cabinet Weight: 20kg
- Power: 115VAC / 1.5 Amps / 50-60 Hz
  - Optional: 230VAC to 115VAC Converter
- Ventilation: 1600 liters/minute, switched
- Irradiance:
  - 2400 $\mu$ W/cm<sup>2</sup> nominal at 310nm from (3) FS20T12/UVB/HO AU tubes
  - 650 $\mu$ W/cm<sup>2</sup> nominal at 365nm from (2) F20T12/BL GE tubes
- Dosimeter: Solid State Digital High Frequency Sampling
  - UVA 365FS25-12.5 Interference
  - UVB 310FS25-12.5 Interference
- Data connections:
  - RS232 in Drawer
  - RS232 in Cabinet
  - Serial Cables (2)
- Mouse Restraints:
  - Polycarbonate Shell with ABS Nosecone and Acrylic Shield

## Photonic Dosimeter Operation

The detector heads supplied with the photonic dosimeter are calibrated when delivered. Each detector head is assigned a unique identifier, which is read by the microprocessor unit when it is plugged into the RS-232 port. The program matches the identifier to a calibration matrix stored in e<sup>2</sup> memory, and automatically displays the correct UV flux in the hand-held display. The detectors may be identified by numbers corresponding to the peak detection wavelength engraved into the housings.

Only two buttons are marked on the photonic dosimeter: **Power** and **Units** (Figure 2). The **Power** button is used in normal mode to turn the system on and off. The **Units** button is used to select among the three comparable units display options. Units may be displayed in  $\mu$ W/cm<sup>2</sup>, ergs/mm<sup>2</sup>/sec, and Joules/m<sup>2</sup>/sec.

When first powered on, the display will provide readout of the firmware version number and a code corresponding to the date on which this version was compiled. After a few seconds, the display will revert to normal mode, giving readout of photon flux, the peak wavelength of the detector, and the temperature. To conserve battery life, the dosimeter is programmed to turn off after a prolonged period during which no buttons are pushed. The value is set at 10 minutes when delivered, but this may be changed by the user in calibration mode.

### *Calibration Mode:*

The detector heads are calibrated at Tyler Research before delivery, and in most cases there is no need to adjust this calibration at any point in the life of the dosimeter. However, in the event that recalibration is desired, the following procedure should be followed. **Do not enter into this mode lightly!** If an error is made in calibration, all subsequent dosimetry measurements will be inaccurate. If it is essential that the device be recalibrated, be certain that a calibrated light source and/or a second accurately calibrated dosimeter is available to re-establish calibration in the Tyler Research photonic dosimeter at each of the wavelengths required.

There are actually four buttons on the hand-held dosimeter. Two of these are marked as discussed above, and two others are unmarked. They lie in a straight line directly between the two marked buttons. By running a finger along the face of the label between the two marked buttons it is possible to feel the hidden buttons as they are depressed.

To access calibration mode:

1. Turn the dosimeter **OFF**
2. With three fingers, depress the **Units** button and the two **hidden buttons** simultaneously.
3. *While keeping these three buttons depressed*, push the **Power** button once and release it.
4. The display will turn on.
5. Simultaneously release the three buttons that were depressed in step 2.
6. Following the initial screen, the first of the calibration screens will appear.

In calibration mode, each of the four buttons assumes a new function. These are, reading left to right,

**Escape    Decrement    Increment    Enter**

When in calibration mode it is always possible to revert to standard mode by pressing the **Escape** (Units) button. However, if a sampling sequence has been initiated (see below), reversion to standard mode will not occur until the sampling sequence is complete and the new value automatically entered into the calibration matrix.

There are six calibration functions. In order of appearance, these are:

- Dark Cal
- Light Cal
- Low Temp Cal
- High Temp Cal
- Filter Wavelength
- Configuration

Using the Increment and Decrement (hidden) keys it is possible to cycle through these six screens to access the desired calibration mode. The desired mode is selected by pressing the **Enter** (Power) button.

**Dark Calibration:** When Dark Cal is on the display, pressing **Enter** will initiate a dark calibration. The microprocessor will begin a sampling sequence to measure the photon flux at the detector. This takes about 4 seconds, after which the value is entered into the calibration matrix. For this reason, it is essential that the detector be protected from ultraviolet light during this procedure (by placing a thumb over the white detector window, for example). After dark current measurement, the screen returns to Dark Cal.

**Light Calibration:** When Light Cal is on the display, pressing Enter will initiate a light calibration. The next screen that appears shows a value (in  $\mu\text{W}/\text{cm}^2$ ) for the photon flux that will be used to calibrate the detector. It is important to use a photon flux in calibration that is in the range expected during normal operation. At Tyler Research, a photon flux of  $3000 \mu\text{W}/\text{cm}^2$  is used for light calibration of the 310nm detector, and  $1000 \mu\text{W}/\text{cm}^2$  is used for light calibration of the 365nm detector.] Using the **Increment** and **Decrement** buttons, move to the appropriate value. Pressing **Enter** will initiate sampling, after which the new value is entered into the calibration matrix. After light current measurement, the screen returns to Light Cal.

**Low Temperature Calibration:** When Low Temp Cal is on the display, pressing **Enter** will initiate a low temperature calibration. The next screen shows a value (in  $^{\circ}\text{C}$ ) for the low calibration temperature. We recommend placing the detector in a non-lubricated condom and immersing it in ice water. Allow the detector to become equilibrated, type in the exact temperature of the water, and press the **Enter** button. The microprocessor will initiate a sampling sequence to measure the temperature at the detector, after which the new value is stored in the calibration matrix. After low temperature measurement, the screen returns to Low Temp Cal.

**High Temperature Calibration:** When High Temp Cal is on the display, pressing **Enter** will initiate a high temperature calibration. The next screen shows a value (in  $^{\circ}\text{C}$ ) for the high calibration temperature. We recommend placing the detector in a non-lubricated condom and immersing it in warm water (usually about  $37^{\circ}\text{C}$  and above  $25.1^{\circ}\text{C}$  in any case). Allow the detector to become equilibrated, type in the exact temperature of the water, and press the **Enter** button. The microprocessor will initiate a sampling sequence to measure the temperature at the detector, after which the new value is stored in the calibration matrix. After high temperature measurement, the screen returns to High Temp Cal.

**Filter Wavelength:** When Filter Wavelength is on the display, pressing **Enter** will bring up a screen with the set wavelength of the detector. This should be set to the filter array of the detector (in most cases, either 310nm or

365nm) by using the **Increment** and **Decrement** buttons. Note that this is for recording purposes only, and changing this value will not change the value of the detector. Instead, the typed value should always match the value engraved on the detector housing.

**Configuration:** When Configuration is on the display, Pressing **Enter** will bring up a screen reading:

Power Off: 10 Min.

Using the Increment and Decrement buttons will change this value. Any value between 1 minute and 30 minutes is valid. Pressing **Enter** will store the value in the configuration matrix.

Calibration mode is exited by pressing the **Escape** (Units) button once when in any of the main calibration screens.