Preliminary

Operating Instructions for

ISSI Series

LM2xLZ-xxx LED Illumination Sources

And

LM2xLZ-DM DC/DC Pulsed Driver

LM2xLZ-DMHP High Power Driver

Caution

This LED illuminator is manufactured with very high power LEDs. Please be aware that eye damage can occur if the user stares into the LED illuminator at a close range. The same precautions should be followed with this LED illuminator as with any high intensity light source. Always use appropriate eye safety equipment

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I. Description of Water Cooled LED Illuminators

The Series LM2xLZ-xxx illuminator is a very compact, high-output, water-cooled device that is capable of operating in a constant-light-output mode (DC) or gated on and off by an external signal.

The LED illuminator is usually purchased with one of the two drive modules available. These drive modules are standardized to permit the operator who wishes to change operating modes from DC/DC pulsed to high power pulse at a later date to purchase the appropriate driver and change it in the field. The standard umbilical cable is ten (10) feet length but lengths up to twenty (20) feet can be provided.

The Series LM2xLZ-xxx illuminator consists of a LED module and one LM2xLZ-DM or LM2XLZ-DMHP drive module along with an umbilical cable to connect the drive module to the led head. The LM2xLZ-DM DC/DC Pulsed drive module allows the operator to turn the LED on and off with a TTL signal at the BNC Trig In connector. There is no duty factor limitation for this driver.

The Series LM2xLZ-DMHP drive module is a high power pulser that uses a higher voltage power supply. The LM2xLZ-DMHP drive module is capable of generating light output that is three to five times' greater peak intensity than the continuous-output drive module. To achieve that output level the duty factor must be limited to 5%, and the maximum pulse width is limited to ~1 msec. The LM2xLZ-DMHP has a built in safety circuit to protect the led head if these limits are exceeded.

II. Specifications

LM2xLZ-xxx
w/ LM2xLZ-DM Driver (DC/DC Pulsed)

Standard output wavelengths	400nm & 460 nm
Optical output power dc	> 8 W
DC pulsed -rise time	<300 nsec
-fall time	<125 nsec
Divergence-full angle	100 degrees
Power-supply voltage	22 vdc/25 A

W/LM2xLZ-DMHP Driver (High Power)

Optical output power	>4.0 watts @ 5% duty factor
Pulsed -rise time	< 600 nsec
-fall time	< 300 nsec
Maximum pulse width	1.0 milliseconds
Power- supply voltage	48 vdc/ 12 A

III. Operating Instructions

These led illuminators are extremely easy to use. There are only two parts to the led illumination source. They consist of the led module, driver module, and the umbilical cable. The umbilical cable is connected from the power supply to the led module. This cable contains the drive coaxial cables and the water lines to cool the led module.

Series LM2xLZ w/LM2xLZ-DM (DC drive)

This is the LM2xLZ-DM with the LED module attached. The same umbilical cable is used for either of the drive modules.

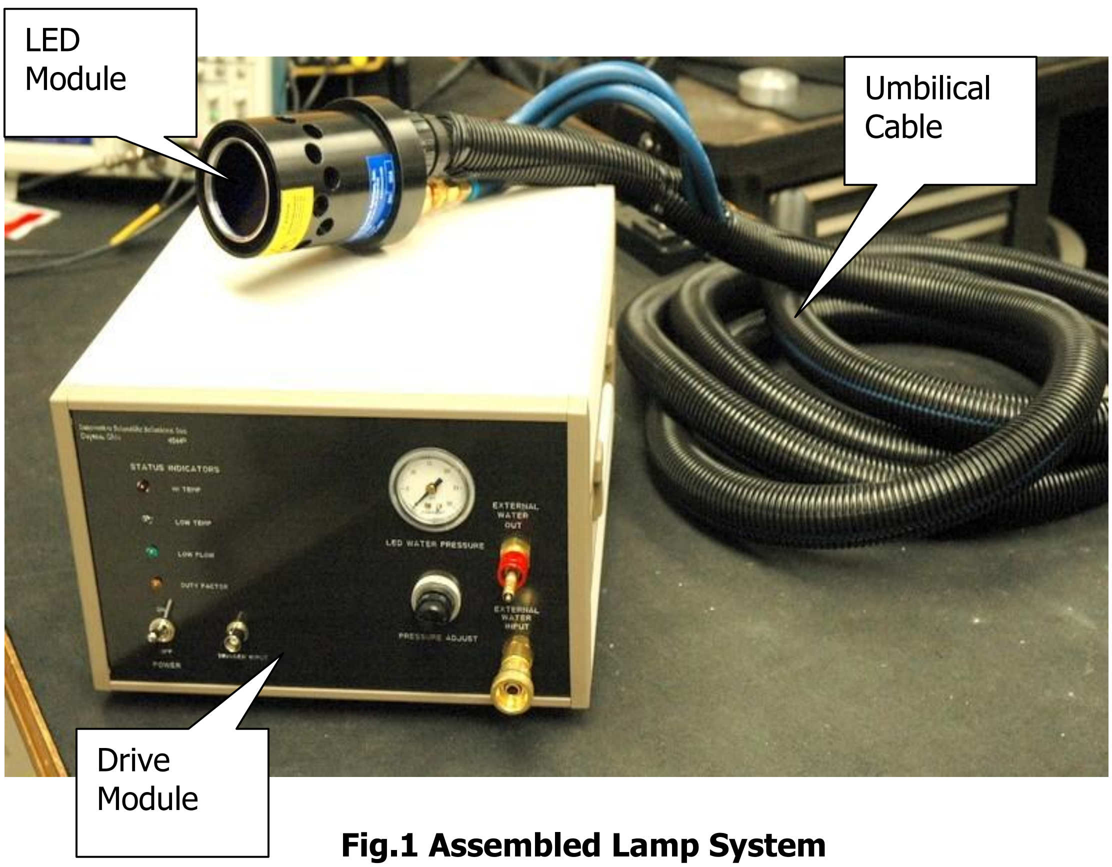

Fig.1 Assembled Lamp System

The front of the drive module has the input water connections on the right side of the panel. The input and output are marked accordingly and must be adhered to because there is a flow meter inside the drive box that needs to have the water flowing in the proper direction for correct operation. Adjacent to the water input connections are the water regulator and the water pressure gauge.

The input water pressure can be anywhere between 0 to 300 psi. When the water is applied to the input the operator should adjust the regulator to 10 to 20 psi. If the led head is placed much higher than the drive module the higher pressure will be required. Any pressure over approximately 5 psi will provide sufficient water flow to operate the led system. The output of the water port must always be at atmospheric pressure. The operator should connect all the water lines before applying water pressure to the system. When disconnecting the water lines make sure that the water flow has been stopped. The quick disconnects are not meant to be used to stop water flow but will contain any remaining water in the lines when disconnected. The water temp should be around room temperature for best led performance. If lower temperature water is used the light output of the led system will be somewhat higher. It is important that the temperature selected will not cause condensation in more humid atmospheres.

The lower left side of the panel has the power switch and the BNC trigger input connector. Above those are the led status indicators that give the operator an indication of what faults have occurred. Along with the indication, the drive module will control the output of the led lamp. If the hi temp or low flow indicators are energized the lamp will stop operating until the fault is cleared. If the low temp indicator lights because the water temperature is below the set point the water flow will be halted by a solenoid in the drive module. This will keep condensation from occurring in a humid atmosphere. The led lamp will continue to pulse with that condition. When the temperature of the led lamp gets above the low temp trip point the water flow will begin to flow.

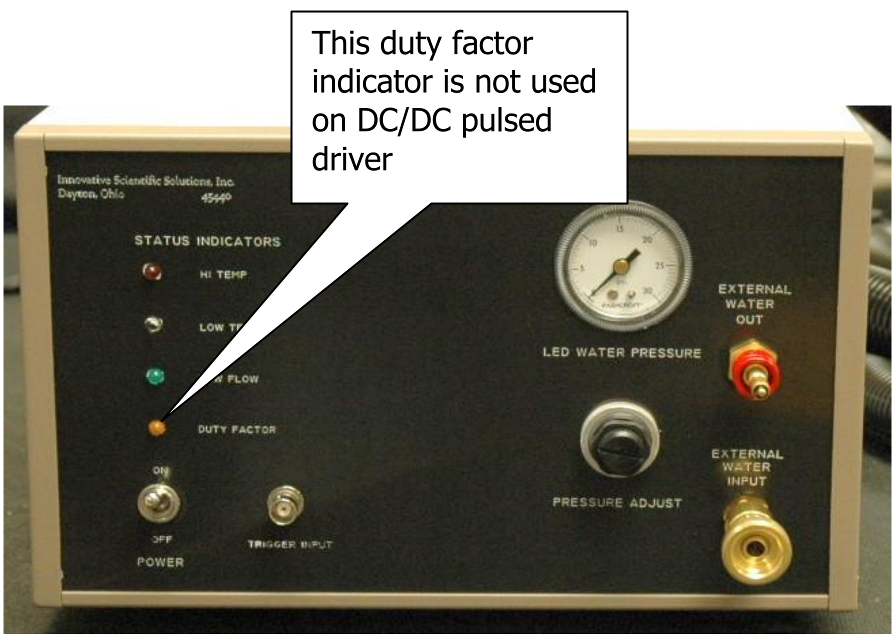

Fig.2 Front Panel of Drive Modules

The rear panel has the water connections to the led lamp head and a large connector that has the electrical connections for the head. The AC input along with the fusing for the electrical input on the rear center of the drive module. There are two fan ports on the rear that should remain clear of obstructions at all times. One draws air into the drive module while the other provides an exhaust to the atmosphere.

Fig.3 Rear Panel of Drive Modules

Series LM2xLZ-DMHP High Power Drive Module

The high power driver is basically the same as the dc driver module with the exception of the power supply which is a higher voltage power supply. This provides the higher drive currents required. There is an additional status indicator on the front panel of the high power driver. This indicator labeled Duty Factor will light if the operator exceeds the 5% duty factor or the maximum pulse width allowed. Also, the control circuits will shut off the led lamp if the temperature is above the set point or the RTD temperature sensor opens.

This block diagram is representative of both drive modules. There are differences between the two drive modules due to the different power drive requirements and the drive currents that are used.

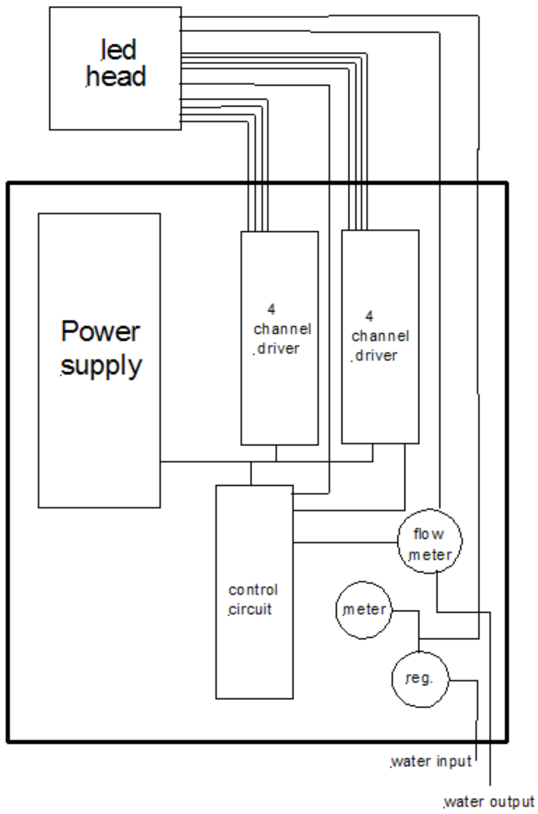

Fig.4 Basic Block Diagram of Driver Modules

IV. Typical Waveforms

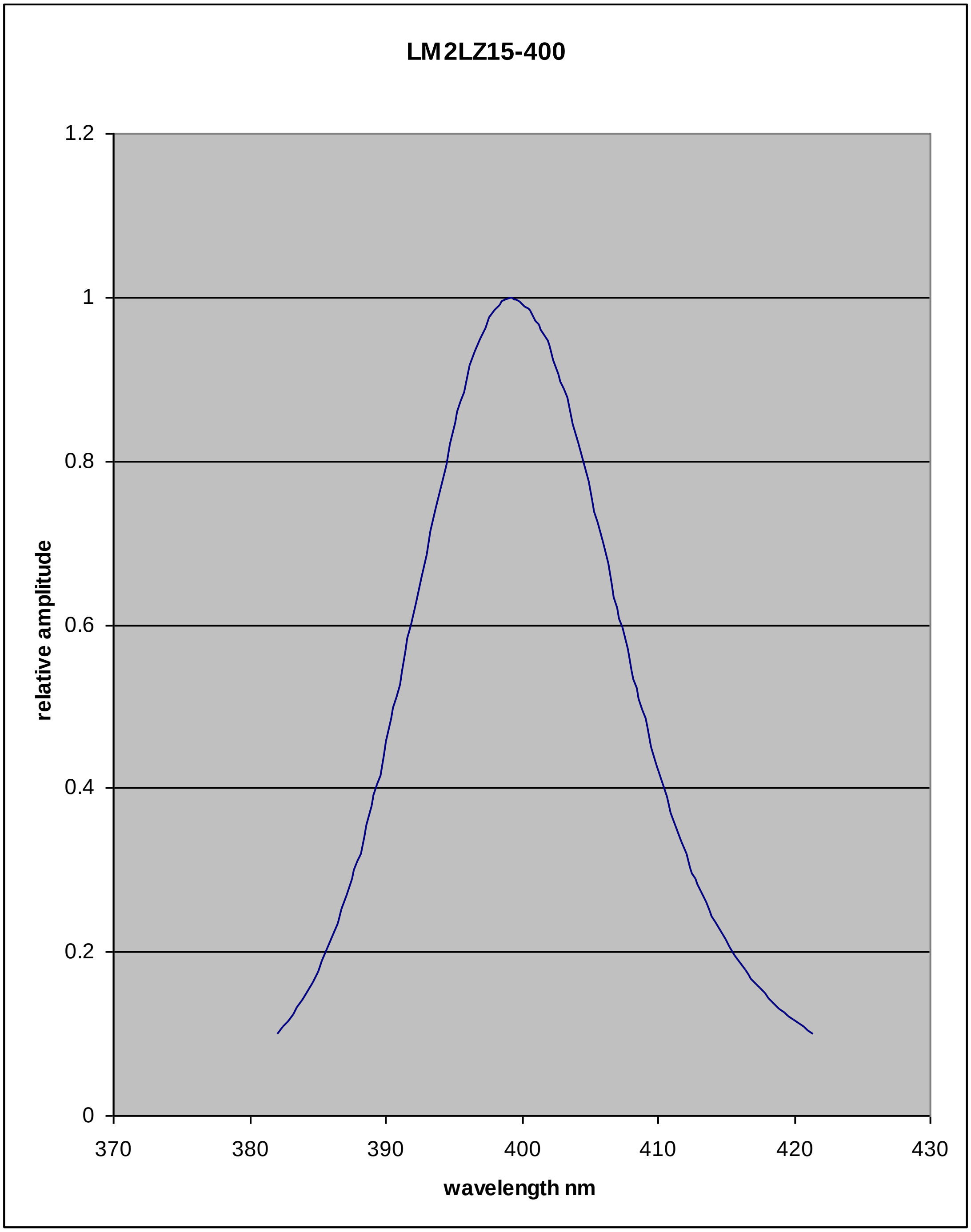

Fig.4 Typical waveform of an LM2xLZ15-400

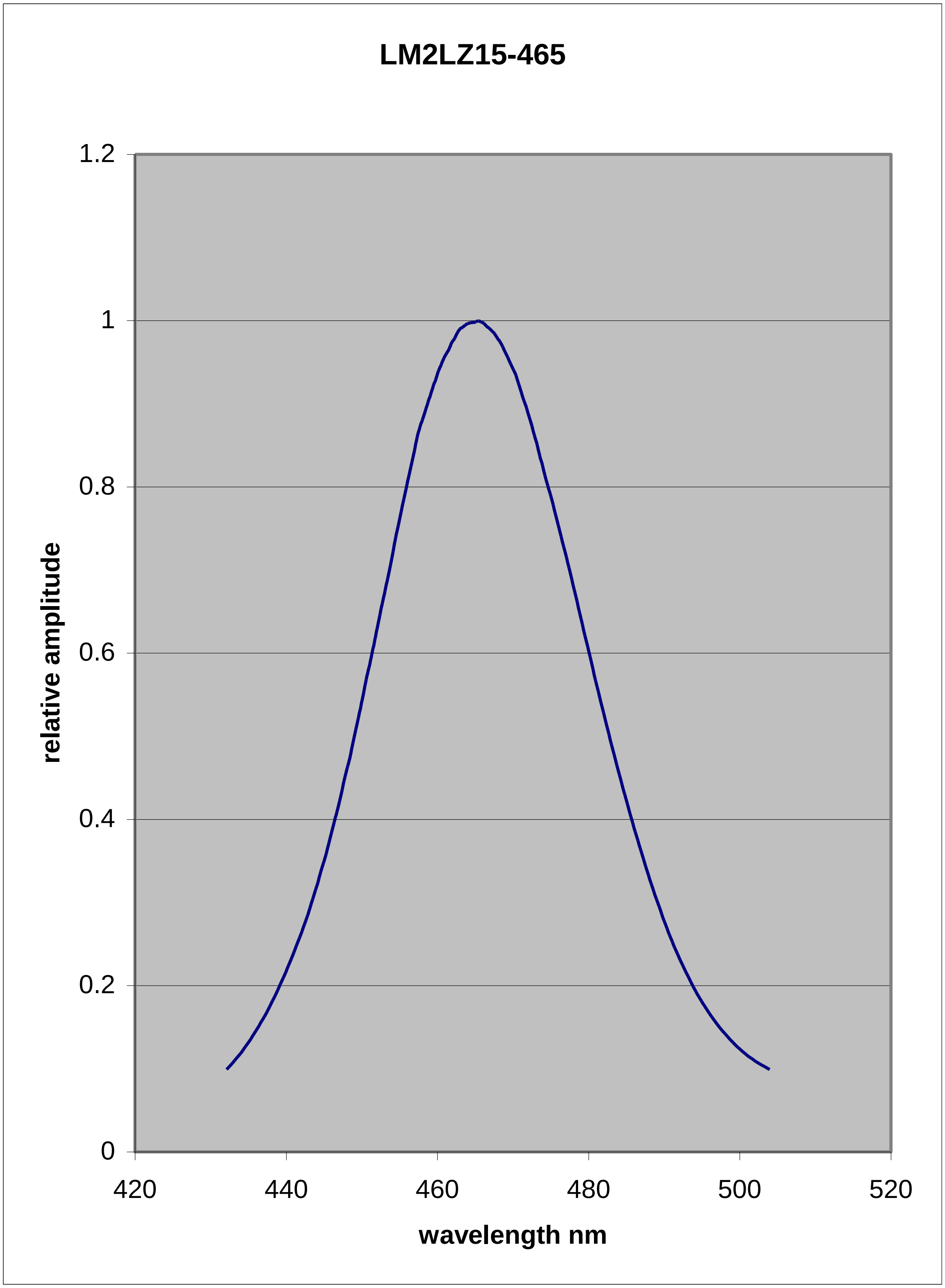

Fig.5

Typical waveform of an LM2xLZ15-465

V. Safety Notices

Safe Operating Procedures for the LM2X-400

The data and recommendations contained in this document are based on "Recommended Practice for Photobiological Safety for Lamps & Lamp Systems – General Requirements", published by the American National Standard and prepared by the IESNA Committee. (ANSI/IESNA RP-27.1-96) This document is a general guide; the user of the LM2X-400 LED assumes all responsibility for the safe use and operation of the device. **The overall recommendation is that the use of safety goggles is recommended to prevent the possibility of damage to the eyes.** The safe working distance, defined as the distance at which continuous exposure to the lamp will not exceed the recommended danger level, for a singe lamp is 13-cm. Note that the use of multiple lamps will increase this distance.

Exposure Limits for LM2X-400 LED

Personnel working with or in the vicinity of the LM2X-400 LED should not be exposed to levels exceeding the following limits.

Ultraviolet Exposure Limits

Exposure limits for ultraviolet extend from 200-nm to 400-nm, just on the boundary of the operation of this lamp. The peak region for UV hazard is centered near 270-nm, a region where this lamp has no content. The spectral content of a LM2X-400 LED is shown in Figure 1. The peak wavelength is near 397-nm and the FWHM is approximately 20-nm. The distribution of radiation at a distance of 76-cm (30-inches) is shown in Figure 2 and the radiation along the centerline as a function of distance is shown in Figure 3. The Effective Ultraviolet Irradiance is calculated using the spectra in Figure 1 and:

(1)
$$E_S = \sum_{200}^{400} E_\lambda \bullet S(\lambda) \bullet \Delta\lambda$$

E_S is the Effective Ultraviolet Irradiance in W•cm^{-2}
E_λ is the Spectral Irradiance in W•cm^{-2}•nm^{-1}
S (λ) is the hazard weighting function (Table 2, ANSI/IESNA RP-27.1-96)
Δλ is the bandwidth in nm

The permissible time per day for exposure to ultraviolet radiation upon the unprotected eye or skin is computed using:

(2)
$$t(\max) = \frac{0.003}{E_S}$$

The spectral irradiance at the exit plane of the LM2X was measured as 32-mW•cm^{-2}. To simplify the analysis, all radiation from the lamp is assumed to be at 395-nm and therefore, the value of S (λ) at 395-nm (from Table 2

ANSI/IESNA RP-27.1-96) is 0.000036. Using this information and equation 1, a value for E_S of ($1.2\ 10^{-6}$) is computed. Using this result and equation 2, the maximum exposure time per day is ~43 minutes. Note that this assumes the user has placed his/her skin or eye at the exit plane of the lamp. To determine safe operation, the peak irradiance as a function of working distance is plotted in Figure 3. This plot was converted to maximum exposure time as a function of distance as demonstrated above using, equation 1, and equation 2. The maximum exposure time for a single lamp as a function of distance is plotted in Figure 4 (black circles). From this figure, **the recommended safe operating distance for ultraviolet exposure for the LM2X-400 lamp is 13-cm.** Note that the use of multiple lamps will increase the spectral irradiance at a given distance and thus decrease the maximum allowable exposure time at that distance. Plots of the maximum exposure time as a function of distance for multiple lamps are also included in Figure 4. **Regardless of the operating conditions, the use of UV safety glasses is recommended.**

Light and Near Infrared Radiation Exposure Limits

Exposure limits for ultraviolet extend from 400-nm to 1400-nm. These limits apply for exposure within any 8-hour period.

Retinal Thermal Hazard Exposure Limit

To protect against retinal thermal injury, the integrated spectral radiance of the light source, L_R, weighted by the burn hazard weighting function R(λ) (From Table 3, ANSI/IESNA Rp-27.1-96) should not exceed levels defined by:

(4) $$L_R = \sum_{400}^{1400} L_\lambda \bullet R(\lambda) \bullet \Delta\lambda \le \frac{5}{\alpha\, t^{0.25}}$$

L_R is the burn hazard weighted radiance of the light source in $W \bullet cm^{-2} \bullet sr^{-1}$.
L_λ is the spectral radiance in $W \bullet cm^{-2} \bullet sr^{-1} \bullet nm^{-1}$.
R(λ) is the burn hazard weighting function (Table 3, ANSI/IESNA RP-27.1-96)
Δλ is the bandwidth in nm.
α is the angular subtense of the source in radians defined b the 50 percent peak radiance points.

If the calculation of α exceeds 0.1 radian, use 0.1 radian in equation 4. No criteria for thermal hazard are relevant for exposure durations longer than 10 seconds, because while thermal injury is the dominant injury mechanism to 10 seconds, photochemical mechanisms predominate for exposure durations longer than 10 s. Finally, note that the burn hazard is minimal at 400-nm and peaks near 440-nm.

For this calculation we have used the *worst case* model of an exposure of 10 seconds and α of 0.1 radian. The half maximum in Figure 1 is near 415-nm, we will simply use a burn hazard function of 10 for all wavelengths to predict the maximum burn hazard. With these assumptions, LR equals 1.9 while the lower limit on LR is 28.1. From this we conclude that **the LM2X poses no burn hazard**.

Retinal Blue Light Hazard Exposure Limit

To protect against retinal photochemical injury from chronic blue-light exposure, the integrated spectral radiance of the light source weighted against the blue-light hazard function (Table 3, ANSI/IESNA RP-27.1-96) should not exceed levels defined by:

(5a) $$(L_B \bullet t) = \sum_{400}^{700} L_\lambda \bullet B(\lambda) \bullet t \bullet \Delta\lambda \leq 100 \qquad (\text{for } t \leq 10^4)$$

(5b) $$L_B = \sum_{400}^{700} L_\lambda \bullet B(\lambda) \bullet \Delta\lambda \leq 0.1 \qquad (\text{for } t \geq 10^4)$$

L_B is the blue light weighted radiance in $W \bullet cm^{-2} \bullet sr^{-1}$.
L_λ is the spectral radiance in $W \bullet cm^{-2} \bullet sr^{-1} \bullet nm^{-1}$.
$B(\lambda)$ is the blue light hazard weighting function (Table 3, ANSI/IESNA RP-27.1-96)
$\Delta\lambda$ is the bandwidth in nm.
t is the exposure duration in seconds.

For a weighted source exceeding 10-$mW \bullet cm^{-2} \bullet sr^{-1}$, the maximum possible exposure duration, t(max), is

(6) $$t(\max) = \frac{100}{L_B}$$

The spectral radiance at the exit plane of the LM2X was measured to be 32-$mW \bullet cm^{-2} \bullet sr^{-1}$. Since this exceeds the 10-$mW \bullet cm^{-2} \bullet sr^{-1}$ limit equation 6 is used to compute t(max). Again, a *worst case* estimate is made by assuming that all radiation form the LM2X is at 435-nm, the peak sensitivity for blue light hazard (Note from Figure 6 that the LM2X has little content beyond 415-nm). Making these assumptions yields a maximum exposure duration of 3125 seconds (52 min.). Again, this estimate assumes that the user has placed his/her eye at the exit plane of the lamp. A careful integration of equation 5b using Figure 1 and the data from Table 3 of ANSI/IESNA RP-27.1-96 yields a limit on the maximum exposure time of 4 hours. Finally, using the peak radiance as a function of distance from Figure 3, a curve for the maximum exposure time for blue light hazard as a function of distance is produced. These curves are very similar to Figure 4 however; the limits are less restrictive than those for UV hazard. The recommended safe operating distance for Blue Light Hazard for the LM2X-400 lamp is 5-cm. Note that the limit for UV exposure in the preceding section is more restrictive and therefore this limit is followed. **The recommended safe operating distance for Blue Light Hazard for the LM2X-400 lamp is 13-cm.**

Infrared Radiation Hazard Exposure Limit

To avoid thermal injury of the cornea and possible delayed effects upon the lens of the eye, ocular exposure to infrared radiation, E_{IR}, over the range 770-nm to 3000-nm should be limited to 0.01 $W \bullet cm^{-2}$ for periods exceeding 1000 seconds. This can be expressed as:

(9a) $$E_{IR} = \sum_{770}^{3000} E_\lambda \bullet \Delta\lambda \leq 0.01 \qquad (\text{for } t > 1000)$$

For exposures of less than 1000 seconds the irradiance limit should be:

(9b) $$E_{IR} = \sum_{770}^{3000} E_\lambda \bullet \Delta\lambda \leq 1.8 \bullet t^{-0.75} \qquad (\text{for } t < 1000)$$

E_{IR} is the ocular exposure to infrared radiation in $W\bullet cm^{-2}$.
$\Delta\lambda$ is the bandwidth in nm.
t is the exposure duration in seconds.
The LM2X-400 has no significant content beyond 450-nm and therefore, **the LM2X-400 does not present an infrared radiation hazard**.

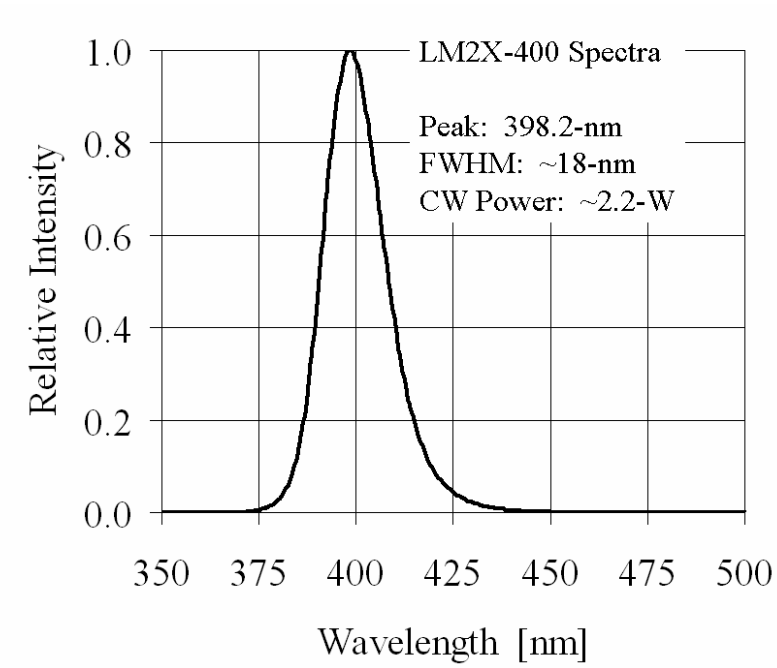

Figure 6: Spectral content of a LM2X-400.