Application Bulletin
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UVP, Inc. 2066 W. 11th Street
Upland, CA 91786
(800) 452-6788 / (909) 946-3197
Fax: (909) 946-3597 / E-Mail: uvp@uvp.com

Internet: www.uvp.com

Ultra-Violet Product Ltd., Trinity Hall Farm Estate
Unit 1, Nuffield Rd, Cambridge CB1 1TG UK
+44(0)1223-420022 / Fax: +44(0)1223-420561
E-Mail: uvp@uvp.co.uk

Noice Factors in Pen-Ray® Lamps

The Mercury, Zinc, and Cadmium Pen-Ray® lamps manufactured by UVP, Inc. all belong to the general class of devices known as low-pressure metal vapor discharge lamps. Probably the most significant characteristics of such devices is that their radioactive emissions are dominated (usually by orders of magnitude) by the resonance transitions of the corresponding metal vapor. This attribute has made them extremely useful in numerous instrument applications requiring intense radiation at an isolated wavelength. For most such applications it is desirable that the emission of the source be uniform and constant in time, with variations from the ideal falling into the general classification of "noise".

External Noise Factors

The intensity of the spectral output from such discharge lamps depends most sensitively upon two interrelated factors which are largely controllable from outside the lamp: The pressure of the metallic vapor within the discharge vessel, and the electrical power dissipation per unit length along the discharge. These two factors are controlled externally by the lamp current and operating temperature. In the normal state, the excess metal within the lamp (the metal "reservoir") is condensed at the coldest interior surface of the discharge vessel with the pressure of the metal vapor determined by the temperature of this reservoir. The externally variable quantities are interrelated in that the lamp operating temperature is determined by the balance between the ambient temperature and the power dissipation; the power dissipation, in turn, depends upon the lamp current and voltage with the latter dependent upon the metal vapor pressure and hence the lamp operating temperature. As a result, the proper operating current of the lamp must be matched to the particular thermal environment in which the lamp is to be operated.

The published operating specification for Pen-Ray lamps are nominal values for an average laboratory environment with the lamp mounted so as to be free from extraordinary heat sources or sinks and protected from air currents. For this particular operating condition, the specified current maximizes the output at the resonance lines and therefor minimizes the sensitivity of the output to external fluctuations. With careful attention to the control of lamp current and thermal environment, extremely high stability of output is attainable.

Internal Noise Factors

Even under ideal conditions, some fluctuations in lamp output remain. Some of these are attributable to basic physical laws which specify lower limits for the noise in a system, while others are presumably attributable to specific internal conditions within the lamp. Among the latter are included hydrodynamic plasma instabilities, current driven plasma oscillations, thermal instabilities driven by radiation transport, fluctuations in emissivity of electrode surfaces, and variations in transmission of the lamp envelope. All of these effects (as well as others which have yet to be identified) contribute to the noise in such discharge lamps. Their relative importance varies greatly with the specific characteristics of the power supply (impedance, frequency, waveform, etc.) as well as length and conditions of previous use, including number of starts. Furthermore, their practical importance in an actual instrument depends upon which spectral line is to be utilized, the frequency selectivity of the detector, and the spatial response of the optical system.

Given the number of relevant factors and the complexity of their interrelationship, it is not in general possible to predict the performance with respect to noise in a particular system. Even extrapolations of experimental results to similar systems will often give erroneous results. From the design engineer's point of view therefore, the most important consideration is product uniformity to insure that an instrument will reproduce established from a prototype version with a representative sample of lamps.

Empirically, the most important consideration in manufacturing lamps with uniform noise characteristics is the control of impurities within the lamp. To control these effects, UVP, Inc. utilizes the purest materials which are available in the construction of the lamps. Strict controls of the processes insure that any contaminants introduced during shipping, handling, or fabrication are reduced to the lowest possible level. Spectra of sample lamps are run periodically to establish that these controls are effective. The lamps are serially numbered to trace individual lamps to particular production batches and test data. Additionally, every lamp is operated for a specified number of hours by Quality Control to insure stabilized operation prior to testing, inspection, and shipment.

Testing Specifications

Because of the number and complexity of the different noise manifestations and the lack of a generalized test procedure which will adequately represent performance in typical application, UVP, Inc. makes no claims with regards to noise specifications of the lamps. Each lamp is tested after the burn-in period at the factory for starting voltage, operating voltage, and output intensity at a specified resonance line while visually observing for unstable conditions in the arc. Experience has shown that these are the most easily observable and most reliable indicators of the overall lamp performance. The conditions of the tests and the range of values allowed vary with the individual lamps and may be obtained from our Engineering Department. Note that shipping, rough handling or previous improper operation in hostile thermal environments can disrupt normal Equilibrium conditions in the lamp. Normally these will reverse themselves within a few hours of operation in a proper environment. If a lamp is suspected to be defective, it should be turned off (if operating) and allowed to cool for one hour, and then run steadily for 24 hours in a protective environment. This will normally correct abnormal conditions in the lamp which have been caused by external perturbations.