Light sources for calibration

Pen-Ray line sources for wavelength calibration

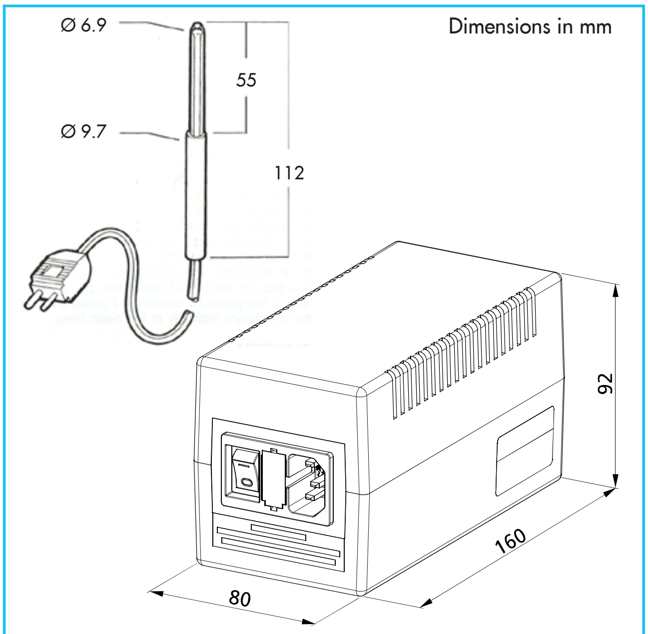
- *Narrow, discrete spectral lines*
- *Excellent stability*
- *Compact and simple to use*

The most precise and economical method for the wavelength calibration of spectroscopic instruments is using a Pen-Ray line source. Our lamps are stable, low-pressure discharge lamps (approx. 130 Pa) in the size and shape of a pencil. They produce narrow, intense lines from the excitation of various rare gas and metal vapors. As the excitation and emission processes are well understood and documented the spectral lines are also well known. Therefore these lamps are ideal for the wavelength calibration of monochromators, spectrographs and spectral radiometers.

Different gas fill

We offer six different types of lamps; use the table on the next page and the lamp spectra on the last page as a guide. The single gas lamps (Xe, Ar, Ne and Kr) have distinct lines; the Hg(Ar) and He(Ne) share the mercury lines, but also have certain differences.

The Hg(Ar) lamp is the preferred lamp for calibration. It uses a mercury line spectrum, is temperature insensitive and has a long life time of about 5000 hours.
The lamp requires a two-minute warm-up for the mercury vapor to dominate the discharge, then 30 minutes for complete stabilization.



After the thermal conditions stabilize, the average intensity is remarkably constant and reproducible. When the mercury is completely vaporized, only Hg lines are visible and the Ar lines have disappeared.

The Hg(Ne) lamp is very sensitive to lamp temperature. When run in normal lab ambient, the output is very similar to that of the Hg(Ar) lamp. The neon lines are added to the output by forced air cooling from a muffin fan.

Lamp design

The lamps are made of double-bore quartz tubing with two electrodes at one end sealed into a phenolic handle. You can hold them with simple laboratory clamps, operate them in any position, and insert them into restricted openings to illuminate enclosed areas. A 300 mm long cord with male connector is attached to the end of the handle for connection to the power supply.

Power supply

All the lamps preferably operate on an AC current. The lamps are mechanically designed for AC operation, both electrodes have the same size. The AC power supply provides the necessary ignition voltage (typ. 2000 V) for starting and the proper voltage (approx. 270 V) and current for operating the lamps. You can switch between 10 and 18 mA output current to run all six different lamps with the same power supply.

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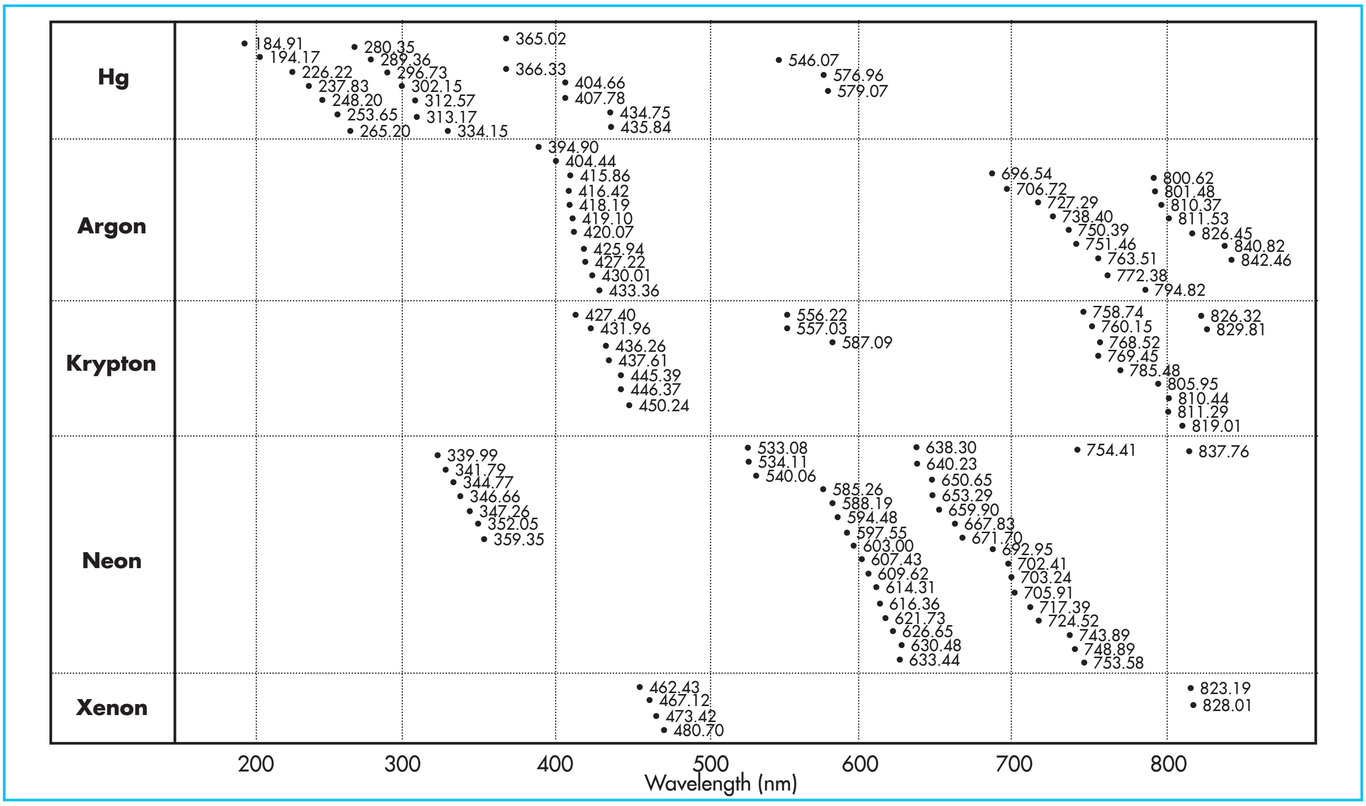
Tabulated Standard Wavelengths from literature

(Reader, et al, Wavelengths and Transition Probabilties of Atoms and Atomic Ions, NSRDS-National Bureau of Standards I168, 1980.)



Accessories

We offer 3 shields with different aperture sizes which fit over the lamp to limit the radiation area. We also offer special filters to block a specific wavelength region. The short pass filters absorb the visible lines. The long pass filters convert short-wave radiation to long-wave radiation with a peak at 366 nm.

Fiber adapter

This fiber adapter allows the lamp to be attached to an SMA fiber or fiber bundle. The fiber is held close to the lamp to collect a portion of the light output. The adapter comes with an 11 mm hole to accept the LLZ002 threaded SMA to an 11 mm adapter or any 11 mm terminated fiber bundle. The LLZ002 needs to be ordered separately. An M6 tapped hole on the bottom of the fiber adapter allows rod mounting. As these lamps operate in any orientation, rod mounting is not necessary.

Monochromator adapter

We offer a Pen-Ray lamp housing that mounts directly on the silt assemblies to hold the calibration lamp close to the input of our monochromators. In this case the housing prevents UV output, keeps the ozone of Hg lamps inside and ensures a reproducible, stable position of the lamp to avoid wavelength shift.

Ordering information

Lamps and power supply			
	Gas	**Operating current** [mA]	**Life time** [h]
LSP035	Hg(Ar)	18 ±5	5000 @18 mA
LSP034	Hg(Ne)	18 ±5	250
LSP030	Ar	10	500
LSP031	Kr	10 ±4	1000
LSP032	Ne	10 ±4	250
LSP033	Xe	10	250
LSP060	AC power supply Output current: 10 or 18 mA, switchable Line voltage: 230 VAC ±10%, 50 Hz		
Accessories			
LSP038	Pinhole shield, aperture: 1 mm Ø		
LSP039	Small aperture shield: 8 x 9.5 mm²		
LSP040	Large aperture shield: 38 x 4.8 mm²		
LSP041	Short pass filter		
LSP042	Long pass filter		
LSZ025	UV safety spectacles		
LSZ026	UV safety spectacles, can be worn over prescription glasses		
LSP058	Fiber adapter		
LLZ002	SMA to 11 mm adapter		
MSZ135	Monochromator adapter		

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A word on safety

Even though they are considered low-power lamps, the Hg line lamps produce considerable UV intensity. We strongly recommend wearing protective eyewear when working with them.

Technical notes

While doing wavelength calibration you have to deal with different questions. Some of them might be:

- How accurate are the wavelengths for the spectral lines?
- How narrow are the lines?
- What is the variance of the relative intensities?
- Is there any structure in the lines that will distort the line shape?
- Are these lamps useful as sources for irradiance calibration?

To answer these questions several production Hg(Ar) lamps have been measured accurately under defined conditions at the National Institute of Standards and Technology (NIST). All lamps for the study were powered at 15 mA.

Wavelength accuracy

The values tabulated as standard wavelengths are usually obtained from relatively isolated atoms in lamps with low pressure and low current density. The excitation conditions in our spectral calibration lamps approach these ideal conditions very well. However, conditions in these lamps are not truly ideal as we see from signs such as a low level continuum in the Hg(Ar) lamps.

Using a Fourier Transform Spectrometer (FTS) the wavelength location of prominent Hg lines was measured. The FTS is capable of 0.001 nm or better resolution throughout the primary Hg(Ar) spectral range.

Each sample measurement was calibrated by a comparison measurement against precisely known lines from a 198 Hg standard lamp. These experimental factors were combined to provide a two sigma uncertainty in average wavelength of only ± 0.0001 nm. The following table shows the average wavelengths emitted by the Hg(Ar) lamps, as measured with the FTS, along with published values for prominent Hg lines. Observe that these lamps accurately matched published mercury spectra to within ± 0.002 nm. This accuracy is more than sufficient for the calibration of most laboratory monochromators, spectrographs, and spectroradiometers.

Line distortion effects only become a problem for spectrometers with resolving powers above 17.000 (a typical 1/4 m monochromator with 1200 l/mm gratings and 10 µm slits has an empirically determined resolving power of less than 10.000). The results appear in: "Wavelengths of spectral lines in mercury pencil lamps", Applied Optics Vol. 35, No. 1, Jan. 1996.

Published wavelength[1)] [nm]	Measured position[2)] [nm]	Irradiance at 25 cm[3)] [µW/cm²]	Absolute variation[4)] [%]	Relative variation[5)] [%]
253.652	253.6521	74.0	8.2	9.9
296.728	296.7283	0.65	7.3	3.0
312.567	312.5674	0.71	6.5	2.7
365.015	365.0158	1.35	5.5	1.6
404.656	404.6565	1.12	6.9	2.0
435.833	435.8335	2.55	5.8	0.0
546.074	546.0750	2.56	5.9	1.2
576.960	576.9610	0.28	9.2	3.9
579.065	579.0670	0.30	9.2	3.8

1) Per Reader, et al, „Wavelengths and Transition Probabilities of Atoms and Atomic Ions", NSRDS-National Bureau of Standards #68, 1980.
2) Wavelength uncertainty 0.0001 nm
3) Operated at 15 mA (power supply)
4) One sigma level.

Spectral irradiance

As a further experiment, a 1 m plane grating spectrometer was used to measure the irradiance from these prominent Hg(Ar) lines. Irradiance data for the spectral lamps was gathered by comparing them to a NIST standard of spectral irradiance in repeated measurements.

The table lists irradiance values for several strong lines and their one sigma variations. The low-level continuum mentioned earlier contributes little to the irradiance of each line, less than 1% for instrumental bandwidths of 1 nm or less. Last but not least, the table shows the one sigma irradiance variation for each line relative to the 435.83 nm line. Although there are wide variations (near 10%) in the absolute irradiance from each line, due to lamp-to-lamp differences and aging, the irradiance ratios of the lines in any of the lamps are remarkably consistent. With the notable exception of the 253 nm peak, these lines may be used for a relative irradiance calibration to accuracies better than 5%.

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The spectral calibration lamps are by no means a substitute for calibrated broadband sources. However, they are an inexpensive source to obtain good relative irradiance calibrations.

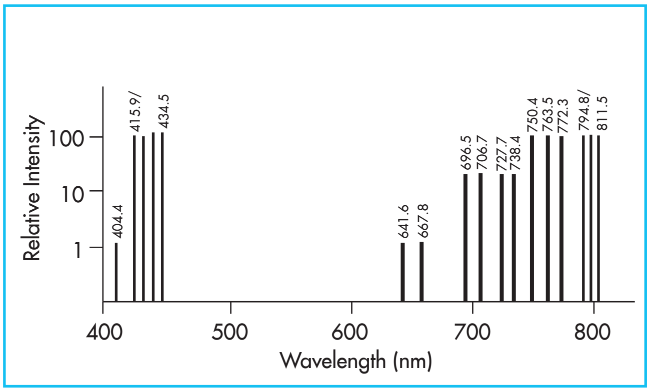
The results appear in "Irradiance of spectral lines in mercury pencil lamps", Appl. Optics, Vol. 35, No. 1, Jan. 1996.

Line width

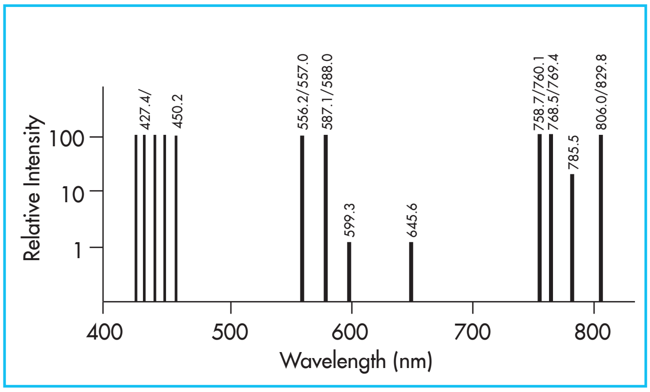
Most emission lines of these calibration lamps have a line width of less than 0,001 nm. When measuring the width of these lines with most monochromators, spectrographs or radiometers you actually measure the line width imposed by the instrument (instrumental function). Therefore, these lamps are also useful for measuring the resolution of an optical system.

Relative intensities

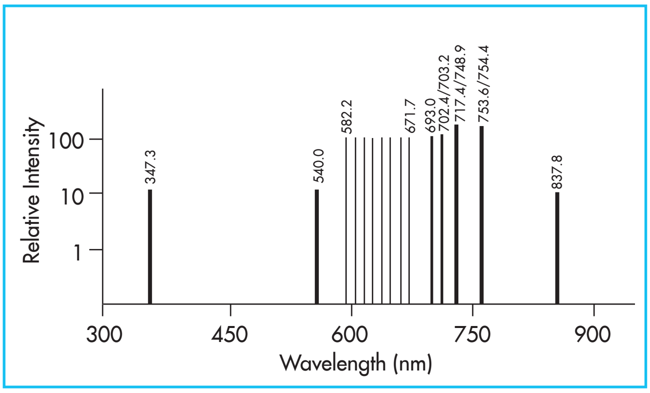
The following spectra show the typical relatve intensities or our Pen-Ray line sources.



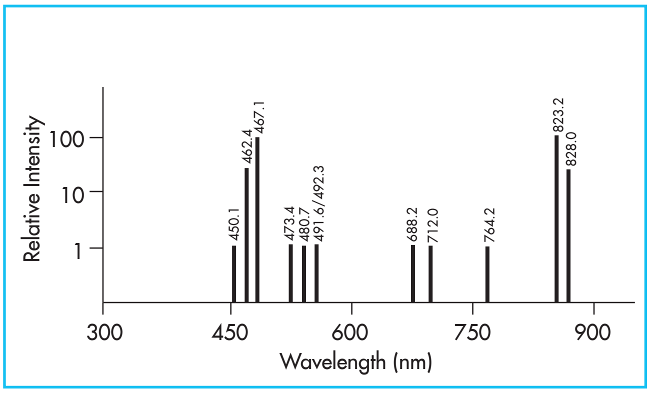
Argon



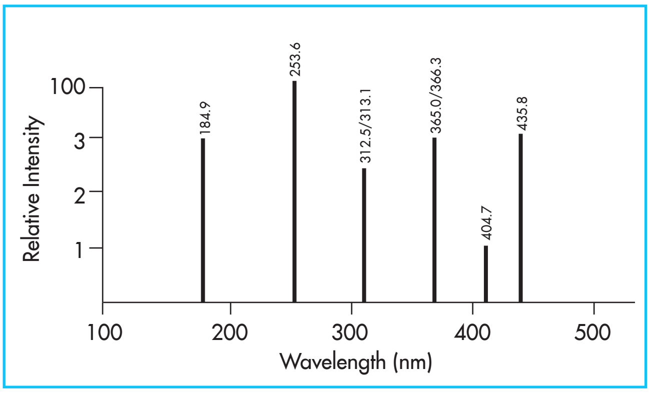
Krypton



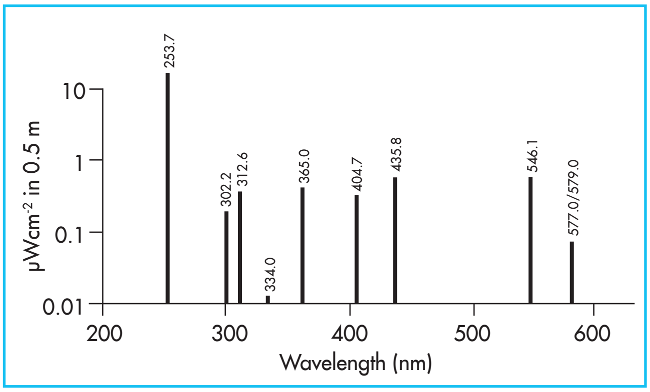
Neon



Xenon



Mercury



Hg(Ar)

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