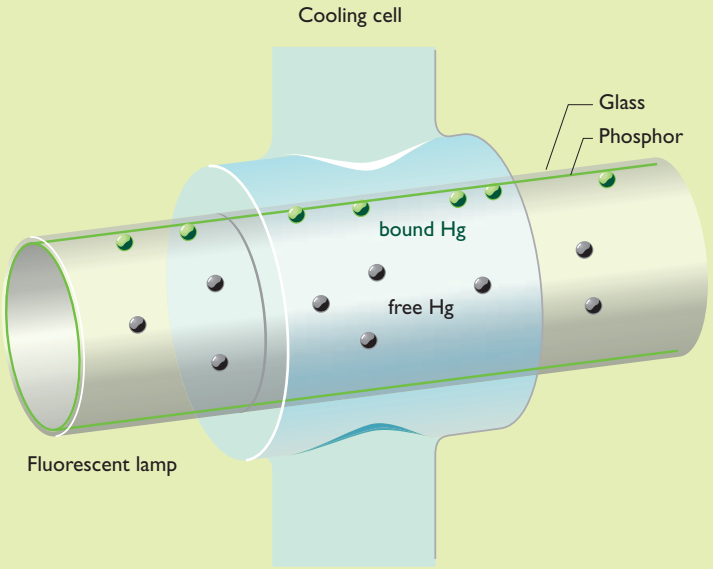

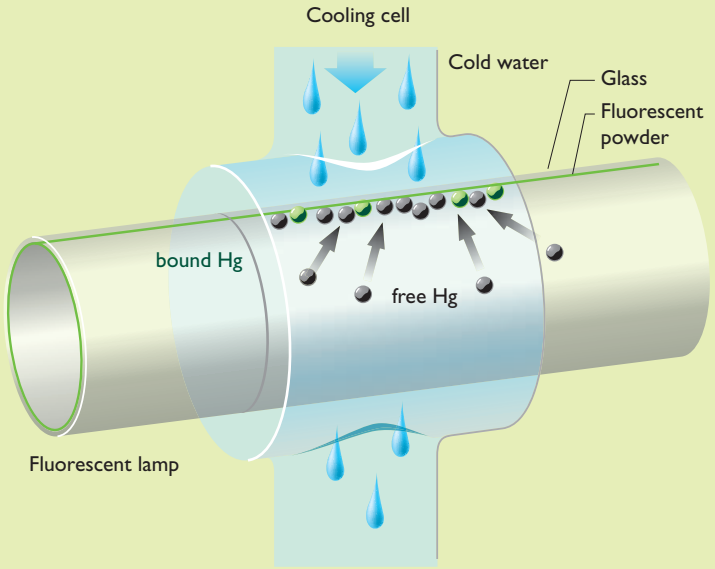

Mercury determination in fluorescent lamps

Sustainability and lifetime tests

Fluorescent lamps cannot work properly and reach high energy efficiency without a small amount of mercury. The mercury must be accurately dosed in the lamp during the manufacturing process. Legislation stipulates that the amount of mercury in the lamps is precisely known and that it does not exceed the limits set by the EU Directive on Restriction of Hazardous Substances. Philips Innovation Services draws on extensive experience in accurately determining mercury using the specially developed cold spot method in combination with Cold Vapor Atomic Absorption Spectrometry (CV-AAS). This method is very suitable for quantitatively analyzing the mercury content in all kinds of fluorescent lamps.

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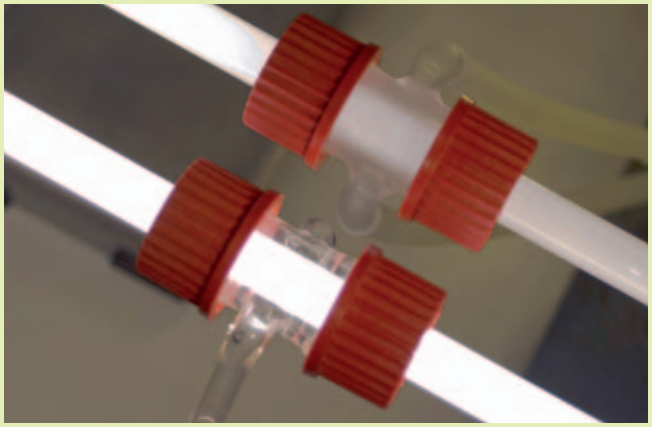

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Figure 1: A cold spot is created on a fluorescent lamp by allowing cooling water to flow through a cell that is connected to a lamp. In the images, only the upper lamp is connected to the cooling water. In the left image, the mercury from the right side of the cooled lamp has sublimated on the cold spot (recognizable by the darker appearance), whereas in the right image also the mercury from the left side has sublimated on the cold spot. Apparently, the left side of the cooled lamp has the highest mercury concentration. Therefore it takes longer to sublimate all the mercury from the left side on the cold spot. The uncooled lamp stays equally bright along its entire length.

The role of mercury

When a lamp is turned on, a low pressure mercury discharge is established inside the lamp, which generates UV radiation. The UV is subsequently transformed into desired visible light by the fluorescent powder layer on the inner lamp surface. During operation of the lamp, mercury is slowly absorbed into glass, fluorescent powder, and tube electrodes, hereby losing its functionality in the long term. This is called ‘bound mercury’. The mercury that is left available for discharging is called ‘free mercury’.

RoHS

The Restriction of Hazardous Substances (RoHS) is a directive on the use of certain hazardous substances in electronic equipment. This directive requires the limitation of mercury present in a fluorescent lamp. Depending on the lamp type, the mercury limit should be between 3-5 mg per lamp. The lighting industry is rapidly complying with this directive, and accurate analysis is required to verify the total amount of mercury being dosed in these fluorescent lamps.

The cold spot method

In order to quantitatively measure the total amount of mercury in a lamp at any time during lifetime, both bound and free mercury amounts have to be determined. In order to prevent losing the free mercury while opening the lamp, a forced cold spot is created on a burning lamp. All free mercury will sublimate on this cold spot (see figure 1). After removal of this glass part from the rest of the lamp, both free mercury and bound mercury can be analyzed separately using CVAAS.

Lifetime studies

The amount of free (i.e active) mercury slowly decreases as a function of the number of burning hours. To ensure long lifetime despite the limited amount of mercury that can be dosed in the lamps, thorough understanding of mercury consumption in the lamp is desired. By analyzing mercury in different segments of a lamp, a difference in mercury consumption between electrode region, stem and cold spot can be analyzed. Using the cold spot method, also the ratio of bound versus free mercury is obtained. In this way, quantitative lifetime tests can be performed, leading to an optimized lamp design.