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SUMMARY: The Truth about TCLP-Passing Fluorescent Lamps

Philips Lighting Company has several times raised the issue of fluorescent lamps which pass the TCLP test by using "additives". This paper addresses the issue from a scientific perspective.

Executive Summary

- The Toxic Characteristic Leaching Procedure (TCLP) is a test that is used to determine if a waste is hazardous under the Federal Resource Conservation Recovery Act.
- The TCLP is designed to simulate landfill disposal where the used product will be co-mingled with other municipal waste.
- Currently available fluorescent lamps that pass the TCLP do not do so simply by lowering the mercury dose.
- Such lamps instead rely on the properties of other unique lamp components, which vary from manufacturer to manufacturer.
- Removal of the unique components will generally cause the lamps to fail the TCLP.
- The use of "additives" to enable lamps to pass the TCLP is permissible and has the same beneficial environmental effect as the use of components that are not additives.

January 2000

The TCLP

"The Toxicity Characteristic Leaching Procedure (TCLP) is designed to simulate the leaching a waste will undergo if disposed in a sanitary landfill." During the test, a sample of lamp waste "is extracted with the appropriate buffered acetic acid solution for 18 ± 2 hours."¹ The resulting extract is analyzed for certain metals (e.g., mercury) and the concentrations are compared to specified regulatory limits. The TCLP design assumes that the potentially hazardous waste comprises at most 5% of all the material in a municipal solid waste (MSW) landfill; that is, the wastes are co-mingled with other wastes in the landfill.

All major lamp manufacturers market some types of fluorescent lamps that pass the TCLP test, i.e., yield TCLP extracts with less than 0.2 milligrams of mercury per liter.

There have been claims by one manufacturer, Philips, that its lamps pass the TCLP without the use of additives and "without sacrificing life, light output or performance." In fact, all TCLP-passing lamps contain enough mercury to fail the TCLP test if all the mercury were to dissolve during the test. It is only because of other unique components in the lamps that soluble mercury is converted to an insoluble form during the TCLP test to enable the lamps to pass the test.

Mercury in a failed fluorescent lamp is present as elemental or liquid mercury and soluble ionic mercury.

While elemental mercury, Hg^0 , is virtually insoluble in the TCLP leaching fluid, ionic mercury, Hg^{2+} , dissolves easily. As a fluorescent lamp is used, some portion of the elemental mercury is converted to soluble ionic mercury.

The mercury in solution at the end of the TCLP depends on reactions occurring during the TCLP.

During the TCLP, some of the soluble ionic mercury, Hg^{2+} , may be converted to insoluble elemental mercury, Hg^0 , by reaction with lamp parts made of reducing metals (e.g., iron) or other reducing agents present within the leaching vessel. Likewise, some of the elemental mercury, Hg^0 , may be converted to soluble ionic mercury, Hg^{2+} , through reactions with oxygen and metals within the leaching vessel.

Factors affecting the TCLP.

TCLP results on a lamp (i.e., the mercury concentration in the TCLP fluid after 18 hours of extraction) will depend on a number of factors, the most important of which are:

- Amounts of ionic and elemental mercury, Hg^{2+} and Hg^0 , in the lamp
- Metal content (type and amount) of lamp components
- Acid-base content of lamp components
- Other chemical components, e.g., cements, phosphors
- Oxygen pressure
- Lamp weight

For a given lamp type, the mercury concentration in the TCLP extract at the end of the test is determined primarily both by the amount of Hg^{2+} originally in the lamp and by the metals and other chemicals of which the lamp is constructed.

¹ EPA SW-846, "Test Methods for Evaluating Solid Waste (Physical/Chemical Methods)," Chapter 7, "Toxicity Characteristic Leaching Procedure," page SEVEN-13

TCLP-Passing Fluorescent Lamp Designs

All TCLP-passing fluorescent lamps depend on one of the following unique components to ensure passing:

- Metal parts capable of reducing ionic Hg^{2+} to elemental Hg^0 Iron, copper, etc. (Sylvania's US Pat. No. 5,229,687)
- Soluble material capable of reducing ionic Hg^{2+} to elemental Hg^0

- Material capable of enhancing the reduction of ionic Hg^{2+} by metals. Compounds of copper, other metals and chlorine

Effect of Unique Components on TCLP Results

The three large lamp manufacturers employ different unique components that ensure that their TCLP passing lamps pass the TCLP test under virtually all circumstances. The effect of the unique components on the TCLP results is illustrated in Figure 1 for a 34-watt Cool White lamp. Without the unique components, lamps with as little as 4.0 mg of soluble ionic mercury would yield a TCLP value of over 0.3 mg per liter, above the 0.2 mg/l EPA limit. In the presence of iron shields, which are used in Philips' ALTO[®] lamps, the TCLP results are below the limit for lamps containing up to about 7 mg of soluble ionic mercury. With Sylvania's ECOLOGIC[™] and General Electric's ECOLUX[®] lamps, the TCLP results are well below the limit for lamps containing 10 mg of soluble ionic mercury.

Importance of Iron Shields in Failed ALTO[®] Lamps

The unique components in Philips' ALTO[®] lamps are the two iron cathode shields. The importance of the iron shields in failed ALTO[®] lamps is demonstrated in Figures 2 and 3. These figures illustrate the TCLP results obtained by two laboratories (one independent) on 25 failed F40CW/RS/EW/ALTO and F32T8/TL741/ALTO lamps. The 11 T12's failed (i.e. no longer useable) on an industry-standard life test between 10,000 and 15,000 hours. The 14 T8's were removed from service at customer locations due to low lumen output caused by mercury depletion. Both groups of failed lamps (4 T12 & 6 T8) passed the TCLP when tested whole. However, when the iron shields were removed prior to the TCLP, all (7 T12 and 8 T8) failed the test.

Additives or Not

Iron shields are a functional design feature of Philips ALTO[®] lamps sold in the US. *They are not, however, essential to lamp operation and are not in fact used in Sylvania or General Electric lamps.* The presence of these components ensures that ALTO[®] lamps are TCLP-passing. Even if the iron shields are construed to be additives, *it is perfectly permissible for a manufacturer to design a product to pass the TCLP test*, and it is environmentally responsible to design products to minimize soluble mercury. To suggest otherwise is wrong and irresponsible.

Furthermore, in a landfill situation, there is an equal likelihood of the mercury reacting with unique components, whether they are additives or not. In reality, the mercury is far more likely to react with the abundance of other materials contained in adjacent wastes.

Figure 1. Effect of Lamp Components on TCLP Results F40T12 CW Lamps Containing TCLP-Soluble Mercury

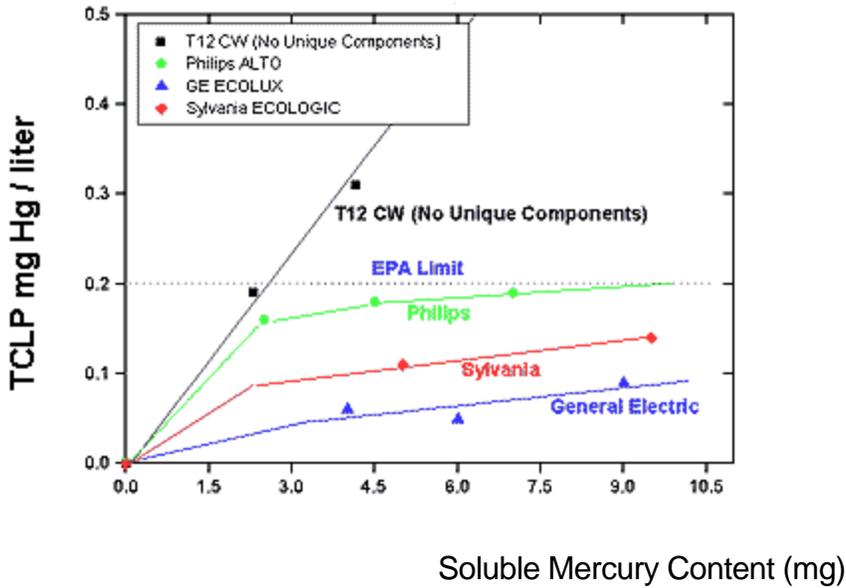


Figure 2. TCLP Results for Failed (Burned-Out) T12 ALTO Lamps 1995/1996 F40CW/RS/EW/ALTO

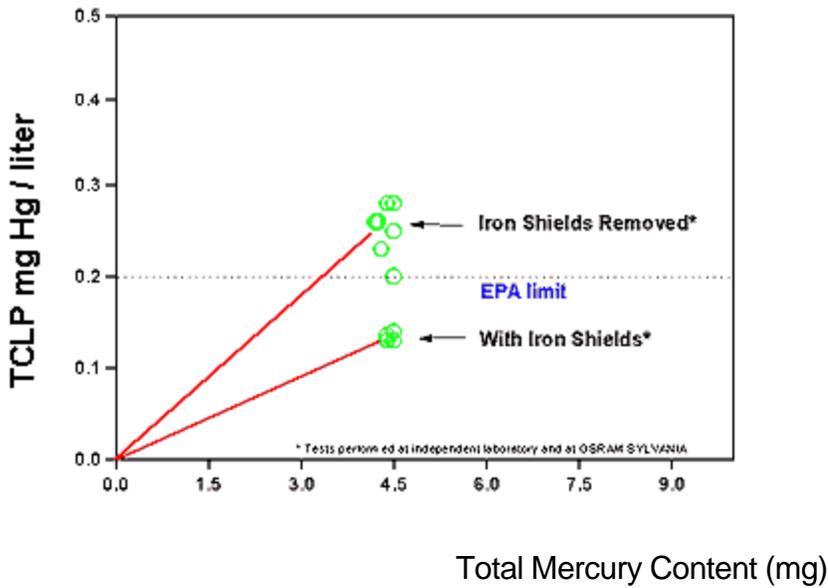
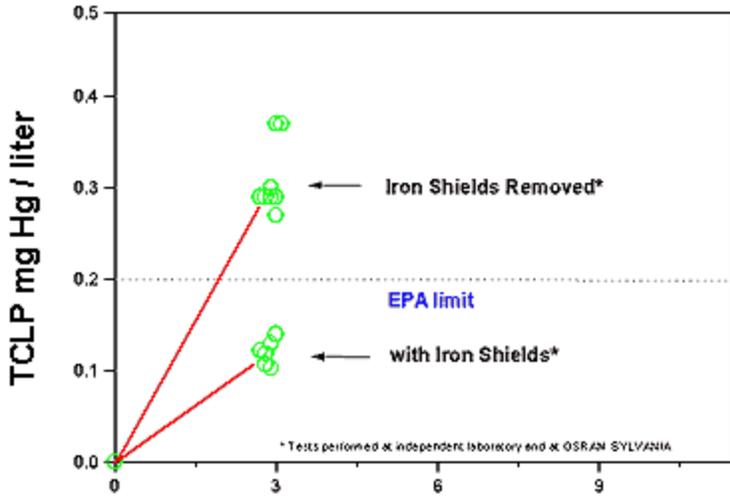


Figure 3. TCLP Results for Mercury-Depleted T8 ALTO Lamps 1998 F32T8/TL741/ALTO Lamps from Field



Total Mercury Content (mg)