

quantitative recoveries between 84% and 109%. Thus, there is no evidence of a problem with the analysis of mercury in the leachates. We believe this is because the mercury was in solution, and therefore, available for analysis.

All reviewers said that the study was conducted properly. Reviewers were then asked whether the stated objectives were adequately met. All reviewers agreed that the studies met the objectives of: (1) Evaluating the ability of alternative treatment technologies to achieve a goal of 0.025 mg/L or less for the stabilization of mercury over a range of pH levels from 2 to 12; and, (2) to compare constant pH leaching protocol results to standard TCLP results.

The reviewers all agreed that the results of the bulk elemental mercury study supported the conclusion that the presence of chloride ions in a given disposal environment may significantly impact the release from a treated waste form (mercury selenide).

4. What Additional Studies Are Recommended?

When asked if further studies were recommended for other factors that impact solubility, one reviewer recommended additional extractions up to at least pH 12.5. Again, as described above, we do not agree that additional studies are warranted for this pH range, as few landfills have been shown to maintain pH conditions in excess of pH 12. This reviewer also recommended that mercuric selenide waste should be evaluated over the range of pH 2 to 12.5, with varied chloride content in the leachate. We agree that if additional studies were planned, it would be useful to further investigate mercuric selenide or elemental mercury treated to a mercuric selenide composition across a wider range of pH values than the 2 pH conditions in our study. We also believe that varying chloride content and other potentially significant variables across the pH range for all waste forms would be a useful study, and would provide additional information on the potential effects of chloride content in landfill leachate.

5. Must Site-Specific Disposal Conditions Be Considered Along With Appropriate Treatment Technology as Decisions Are Made About Disposal of Mercury Wastes?

Peer reviewer opinions were mixed as to whether the studies supported the assertion that site-specific disposal conditions must be considered along with appropriate treatment technology as decisions are made about disposal of mercury wastes. One reviewer stated that the studies provide useful data on

pH and chlorides, but do not provide adequate support for an absolute requirement. The reviewer also stated that, "For any disposal of hazardous wastes, treated or untreated, it is scientifically preferable to use site-specific information." This reviewer maintained, however, that requiring the factoring of site-specific conditions into decision making is not always feasible. Another reviewer's comments countered that these research results do support the assertion, because they demonstrate that leaching fluids, which vary greatly in pH under different disposal conditions, can have an important impact on the amount of mercury leached from the treated wastes. The third reviewer suggested that if several actual wastes have been tested and are shown to be stable at all pH values, then selection of stabilization technology would not require any site-specific considerations. We do not agree with this reviewer's comment, because we believe that there are other factors (redox conditions, presence of chlorides, *etc.*) besides pH, which would likely impact the solubility of the treated waste form.

The complete results of the peer review are provided in Docket Number: RCRA-2002-0029, along with EPA's responses to the peer review comments.

J. What Conclusions Do We Reach From the Treatability Studies?

For wastes containing a wide range of mercury compounds, treatment can result in a residual of reduced solubility under certain pH conditions. Our treatability studies showed that the leaching of mercury out of the stabilized waste form varied with pH. We saw that some of the vendor's treatment of surrogate waste performed better in certain pH ranges. For example, Vendor A performed best (*i.e.*, achieved levels less than 0.025 mg/L) except in very alkaline conditions (*i.e.*, when the pH was greater than 10), whereas Vendor B's treatment performed best only under very alkaline conditions. Because the pH in a hazardous waste landfill can vary anywhere from near pH 2 to over pH 12, it appears that none of the treatment processes tested in the studies presented here are effective for the entire range of pH levels that could exist.

We find that the evaluated processes are effective to a degree for the treatment of elemental mercury wastes. Several have been demonstrated to achieve 0.025 mg/L or better under certain pH conditions. However, vapor

pressure measurements¹⁸ and observation of small droplets of mercury in some samples of the treated wastes lead us to believe that some treatment processes did not result in complete treatment of all the elemental mercury in every test sample. We also believe that the testing conditions cannot be considered to be worst-case, because the additional presence of sulfide and chloride ions in leachates can promote formation of soluble mercury complexes.

The physical properties of elemental mercury present significant challenges to its long-term management. Mercury cannot be destroyed. Elemental mercury is easily vaporized due to its vapor pressure at ambient temperatures. Also, elemental mercury is not significantly soluble¹⁹ and therefore not readily detected by short term leachate tests, such as the TCLP. Disposal of large amounts of elemental mercury require control of both volatilization losses and any subsequent solubilization in leachates. Thus, for protective long-term management in a disposal environment, elemental mercury first has to be treated to convert it to a form with reduced volatility and solubility, and then measures must be put into place to prevent these treatments from being degraded once the properties of the treatment residual have been determined.

The physical properties of mercury also present treatment challenges. At ambient conditions, mercury is an extremely dense liquid with high surface tension. It does not appreciably dissolve into, or adhere to, wastes or environmental media, and because of its density and surface tension, it is extremely difficult to distribute homogeneously through the treatment reagents. Consequently, large volumes of treatment reagents are needed to contact and react with the elemental mercury, resulting in low waste loadings and large volume increases.

The current treatment standard for high mercury and elemental mercury wastes is recovery of mercury followed by land disposal of any treatment residuals that pass a leaching standard.²⁰ The results of the treatability studies outlined in this notice lead us to conclude that, at this time, we cannot

¹⁸ C.H. Mattus, "Measurements of Mercury Released from Solidified/Stabilized Waste Forms," Oak Ridge National Laboratory, ORNL/TM-2001/17, April 2001. Available at <http://osti.gov/bridge>.

¹⁹ The solubility of elemental mercury is 0.056 mg/L at 25°C (MERCK Index).

²⁰ Residuals that do not pass the leaching standard would require additional treatment to meet the standard for the applicable subcategory of mercury waste.