

APPLICATION, DESIGN AND PROJECT IMPLEMENTATION OF A PLASMA MASS SEPARATOR FOR ENHANCED HIGH LEVEL WASTE PROCESSING

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The Archimedes Technology Group has developed a partially ionized, low-temperature plasma mass separator that is ideally suited for enhancing high-level waste (HLW) processing prior to incorporation into borosilicate glass for immobilization. The plasma mass separator, referred to as the Archimedes Filter, passes light mass ions to biased electrodes at either end of the plasma chamber, but ejects heavy mass ions to the center of the chamber. A “mass cutoff” is established by adjusting the solenoidal magnetic field surrounding the plasma and biasing the concentric ring electrodes at both ends of the plasma. Material is introduced into the plasma as a vapor and ionized by RF helicon wave heating. Under steady state operation the Archimedes Filter is capable of processing 1.1 metric tons of feed material per day.

A full-scale Archimedes Filter was designed and constructed in 2002 and achieved first plasma in February 2003 at the Archimedes Development Center in San Diego. This Demonstration Filter (DEMO) has been used to demonstrate heavy and light metal mass separation in a variety of plasma conditions to support a proposed implementation plan for Hanford HLW processing. The Archimedes Filter is ideally suited for Hanford HLW because 99.9% of the radioactivity is in less than 25% of the mass that is above atomic mass 89 (⁹⁰Sr). Thus, 75% of the HLW is non-radioactive and is an unnecessary load on the very expensive vitrification process for immobilization prior to disposal in Yucca Mountain. Theoretical predictions for heavy mass elements indicated decontamination factors (DF) of >1000 would be possible and DEMO tests have confirmed DF > 100, limited only by the diagnostic detection lower limits for heavy mass elements.

A Hanford implementation plan was developed in parallel with DEMO by forming an international team of industry and national laboratory participants, including Oak Ridge National Laboratory. The team completed a conceptual design of a two-filter unit Archimedes Filter Plant (AFP) by the end of 2003. This conceptual design enabled a detailed cost estimate and a preliminary Process Hazards Analysis to establish the feasibility and safety of the plant. The AFP is highly flexible in how it could be interfaced to the Hanford Waste Treatment Plant (WTP) currently under construction. A site plan was also developed to establish infrastructure needs and to ensure no significant interferences with WTP.