# Field Test of an On-Line Real-Time Alpha Radiation Measuring Instrument for Liquid Streams

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## Abstract

The Department of Energy (DOE) has an expressed need for an on-line, real-time instrument for assaying alpha emitting radionuclides (uranium and the transuranics) in effluent waters leaving DOE sites, to assure compliance with regulatory limits. Alpha emitting radioisotopes such as $U^{238}/U^{234}$ and $Pu^{239}$ are rated by the U.S. EPA as class A carcinogens with very low regulated limits in water. Uranium also has a high chemical toxicity. The proposed EPA maximum concentration limit (MCL) for uranium in public drinking water supplies is 20 ppb (30 pCi/l, equivalent to an emission of 58 alphas per minute in 1 liter of water). For reference, the world's sea water has a uniform uranium concentration of 3.3 ppb.

Thermo Power Corporation, Tecogen division, a Thermo Electron company, is developing the Thermo Alpha monitor (TAM), a real-time, field-deployable alpha monitor based on sample preconcentration and subsequent detection with a solid-state silicon wafer semiconductor diode. The instrument will serve to monitor effluent water streams (Subsurface Contaminants and Mixed Waste Focus Areas), and will be suitable for process control of radioactive remediation and operations, such as monitoring scrubber/process/rinse water radioactivity levels (Mixed Waste, Tanks, Decontamination and Decommissioning and Plutonium Focus Areas). It will also be applicable for assaying water-borne beta emitters, or for other liquids (such as oil) or solids after proper preconditioning. Indeed, examination of the needs published by the Site Technology Coordination Groups (STCG) across the DOE Complex reveals at least eight high priority needs that can be satisfied by Thermo Alpha Monitor technology.

Due to the short range of alpha particles in water (~40 $\mu$m), it is necessary now to intermittently collect samples of water and send them to a central laboratory for analysis. A lengthy and costly procedure is used to separate and measure the radionuclides from each sample. Large variations in radionuclide concentrations in the water can go undetected due to the sporadic sampling. In addition, even when detected, the reading may not be representative of the actual stream concentration.

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In Phase 1 TAM laboratory tests, readily observable peaks were evident at very low alpha levels, to 10 parts per trillion natural uranium (15 femtocuries per liter), or 1/2000th the EPA's drinking water limit of 20 ppb, which is well under the program's goal of 30 pCi/l. In addition, the Thermo Alpha Monitor technology responded to 20 ppb natural uranium (30 pCi/l) in under a half hour, well under the program's goal of one- to twelve-hour instrument response time. Laboratory testing successfully quantified isotopically 1.5 pCi/l (2 ppb) total uranium in Carlisle, Massachusetts possible groundwater, comparing quite favorably with 0.68 pCi/l levels of soluble uranium and 1.35 pCi/l total uranium that were measured by conventional analysis methods. Laboratory testing also successfully isotopically analyzed a 600 ppb uranium sample obtained from DOE's Fernald, Ohio site. Overall, TAM technology has demonstrated a linear dynamic range over greater than six decades of concentration, from 10 parts per trillion (15 fCi/l) to 10 parts per million (15,000 pCi/l) natural uranium, including levels of national thorium between 100 parts per trillion (17 fCi/l) and 1 part per million (172 pCi/l).

Ongoing Phase II work has fully automated the laboratory system, resulting in a field-worthy computer-controlled instrument. This prototype instrument, capable of sequentially analyzing 10 samples without an operator's intervention, will be brought to Oak Ridge, Tennessee for a field test this fall. The field test will analyze waters representative of those found across the DOE complex (e.g. surface water, ground water, process water). Negotiations are ongoing with multiple Doe sites to perform a long-term demonstration. This long-term test will verify the robustness and long-term reliability of the prototype instrument, while providing DOE with a financial return on their R&D investment.

With an analysis time of minutes, depending on the concentration and statistical accuracy, this new technology represents a significant advance toward direct identification and quantitative assay of alpha emitters in aqueous streams, both on-line and in real time. In a first release product, TAM is expected to reduce the cost per analysis by a factor of 2 to a factor of 3, with a simple payback period of less than 5 months, oftentimes as short as several weeks. The estimated annual savings to DOE by adopting TAM are at minimum $36 MM/year savings (averaged over the life of the instruments, including amortization of the unit's capital cost, for market penetration to 50% of DOE samples.)

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