11-5 Determination of Small Amounts of Plutonium in Highly Radioactive Liquid Waste
—Development of a Simple Inspection Technique Using Spectrophotometry—

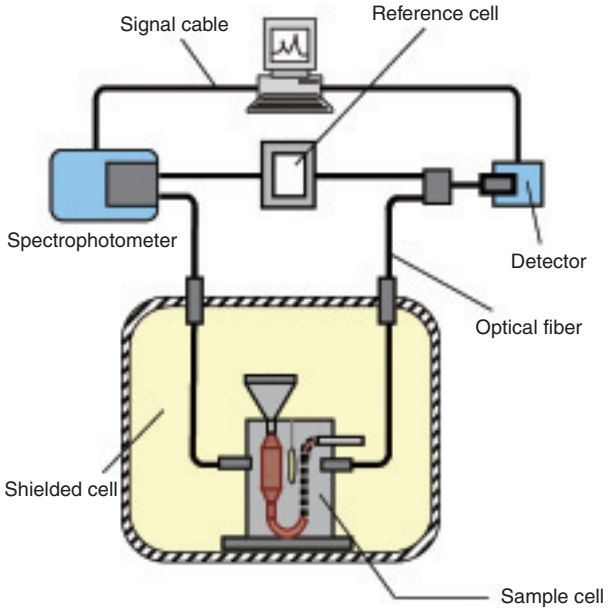

Fig.11-10 Schematic diagram of spectrophotometer using optical fiber
The sample preparation is carried out by remote control in a shielded cell because HALW sample, which contains fission products, is highly radioactive. The sample cell was designed to be easily remote controlled. The sample cell was made of materials which are highly radiation resistant. The sample cell installed in a shielded cell was connected to a spectrophotometer by a set of optical fibers.

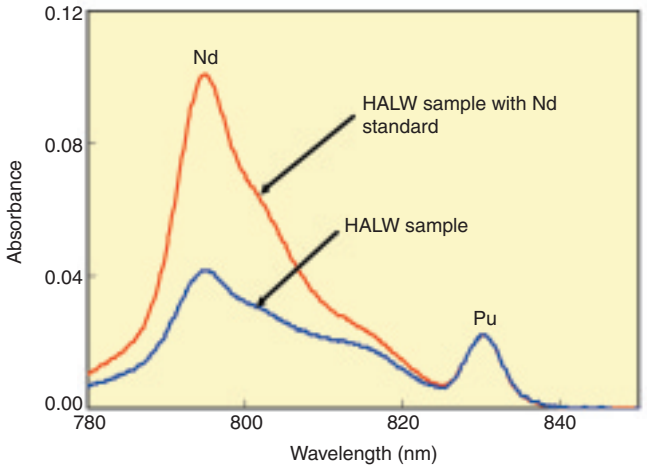

Fig.11-11 Absorption spectra of HALW and HALW with neodymium standard
A known amount of non-radioactive neodymium was added to the sample aliquot. From the absorbance ratio of the neodymium standard and plutonium, the plutonium concentration was calculated. The neodymium initially contained in HALW as one of the fission products was corrected for by measuring the absorbance ratio of plutonium and neodymium.

Spent nuclear fuel from a nuclear power plant is reprocessed to recover residual uranium and newly produced plutonium. Highly radioactive liquid waste (HALW) is produced in this process. It contains small amounts of plutonium at low concentration, but it is necessary to be controlled because it is the material which must be most safeguarded. The HALW samples are transported to IAEA's Safeguards Analytical Laboratory (IAEA-SAL) for independent measurement. Therefore, it takes a few months for IAEA to obtain analytical results. Isotope dilution mass spectrometry (IDMS) has been applied to safeguards analysis to determine the plutonium in the HALW. IDMS involves a complicated procedure and requires highly skilled operators. A rapid safeguards analysis of plutonium in HALW using conventional spectrophotometry is proposed to achieve on-site safeguard measurements and overcome these disadvantages.

A schematic diagram of UV-VIS spectrophotometry system used in this work is shown in Fig.11-10. A known amount of neodymium standard was added to the sample aliquot as an internal standard. Fig.11-11 shows the absorption spectra for HALW as well as HALW with the neodymium standard. Plutonium concentration is calculated from the absorbance ratio of the neodymium and plutonium.

Validation of the proposed method was carried out with an actual HALW sample, comparing results with IDMS. The plutonium concentration ratio of values of this method and IDMS was 0.91 to 1.10. The analytical results using this method agreed well with those obtained using IDMS. The time required for an analysis was about 4 hours.

This method offers easy and rapid determination of plutonium in HALW, requiring neither complicated analytical procedures nor skilled operators. The method greatly simplifies the process of inspection, eliminating the necessity for transport of nuclear materials for off-site analyses. After a performance test carried out with inspectors from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and IAEA, the proposed method was successfully applied for rapid and independent safeguards analysis of plutonium in HALW at Tokai Reprocessing Plant, achieving the timely attainment of inspection goal.

This work was performed as a part of a support program for IAEA.

Reference

Taguchi, S. et al., Determination of Plutonium in Highly Radioactive Liquid Waste by Spectrophotometry Using Neodymium as an Internal Standard for Safeguards Analysis, 2006, JAEA-Technology 2006-041, 58p.