

PROCESS MONITORS FOR ¹³⁷CESIUM COLUMN BREAKTHROUGH

TECHNOLOGY NEED

Before liquid wastes that are currently contained in holding tanks can be solidified/immobilized, it will be necessary to remove certain high specific activity or potentially dangerous long-lived radionuclides. For example, in the case of high-level radioactive liquid wastes, it will be necessary to remove most of the cesium-137 (¹³⁷Cs) to ensure that the final waste product is in compliance with the radioactivity limits for disposal. The current plan is to selectively remove ¹³⁷Cs from the waste feed stream on an ion exchange column. To determine the ¹³⁷Cs removal efficiency factors of the column, and to determine the breakthrough of ¹³⁷Cs when the column has reached its holding capacity for cesium, it is necessary to measure cesium in the effluent in real time with respect to the process response time required to divert the effluent stream from the immobilization stage back to feedstock.

The baseline monitoring technique in this case is to sample and allow the ¹³⁷Cs present in the effluent to come into equilibrium with its daughter nuclide barium-137m (^{137m}Ba) such that the measurement of its 662-keV gamma ray reflects the actual ¹³⁷Cs present. The amount of time, effort, and expense that is required for this procedure is completely unacceptable in a high throughput operation.

TECHNOLOGY DESCRIPTION

A matched pair of gamma radiation detectors will be used to monitor the ^{137m}Ba activity in the effluent stream at two locations separated by a short distance. Alternatively, a single detector can be used to make two separate measurements on the same sample volume. The deviation of the two measured activities from the ratio expected based on the decay of pure ^{137m}Ba represents the concentration of ¹³⁷Cs in the effluent. High precision measurements can be repeated every few seconds, and ¹³⁷Cs concentrations of only 10 percent of the ^{137m}Ba concentration can be determined in a few tens of seconds.

BENEFITS

This monitoring scenario for the ¹³⁷Cs column breakthrough offers significant advantages over any other technique:

- It relies on completely proven and extremely reliable technology.
- It provides extremely sensitive and accurate measurements in very short, on-line time periods (tens of seconds) and can make the intended measurements at the desired sensitivity levels within practical process buffer times, thus ensuring timely diversion of unacceptably high ¹³⁷Cs concentrations.
- No routine process samples are required.
- No alterations to process engineering designs are required.
- No secondary wastes are generated.
- Costs are as low or lower than any other detection technology--even if the most expensive radiation detectors are required.
- The technique is independent of process chemistry, temperature, concentration, matrix, or other variables since the measurements are made on the same sample volume.

CAPABILITIES/LIMITATIONS

Both high-resolution, germanium gamma-ray spectrometers and sodium iodide thallium-doped (NaI(Tl)) spectrometers are capable of making the necessary radiation measurements within the time and accuracy required. Therefore, the reason for selecting a detector for any particular installation will depend on other considerations. The two major disadvantages of germanium spectrometers are initial cost and the need for liquid nitrogen cooling. The cost for a single suitable germanium spectrometer is on

the order of \$15K while a suitable NaI(Tl) spectrometer can be obtained for \$1K. However, by the time sufficient electronics for signal processing and data acquisition are added, along with the cost of software for data reduction, the differential becomes nearly insignificant. A more likely consideration is based on the need to operate high-resolution semiconductor detectors at about 90 °K, where liquid nitrogen is a commonly used coolant. This practice requires a supply of liquid nitrogen, which is not normally a problem in industrialized countries, and the need to fill a reservoir typically on a weekly basis. If the detectors are located in a sector of the process facility that is difficult to access, filling the liquid nitrogen reservoirs could be problematic. Similarly, if the area is acoustically and/or vibrationally unstable, germanium spectrometers could be adversely affected. Alternative cooling using electrical power is available, however, this results in an additional expense beyond the nominal liquid nitrogen technology. Scintillation detectors, such as NaI(Tl), operate at ambient temperatures and are less susceptible to microphonic noise.

Although NaI(Tl) spectrometers can easily measure the 662-keV gamma rays from ^{137m}Ba , they cannot resolve the small quantities of other isotopes, as can germanium spectrometers. Therefore, if it is desirable to quantify all the radioisotopes present in the process stream, it will be necessary to use germanium spectrometers. The use of cadmium-tellurium (Cd-Te) or cadmium zinc tellurium (Cd-Zn-Te) detectors for this application is not recommended because of the inordinately long data acquisition times required to obtain sufficient statistical accuracy.

COLLABORATION/TECHNOLOGY TRANSFER

The initial installation and field utilization of this technology is planned at ORNL in 1998.

ACCOMPLISHMENTS

Development of the generic technology will be completed by June 1998. The technology is ready for transfer or installation at any other site or in any other situation requiring the real-time monitoring of ^{137}Cs or other radionuclides in a process stream.

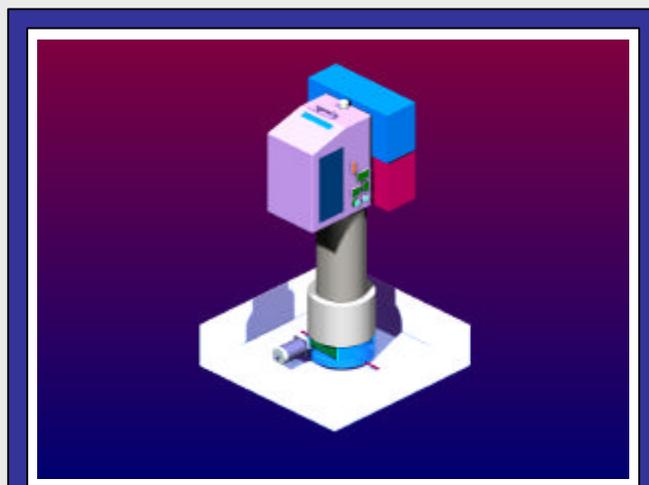
TECHNICAL TASK PLAN (TTP) INFORMATION

TTP No./Title: OR17C231 - Pipeline Testing of Pipeline Slurry Monitors

CONTACTS

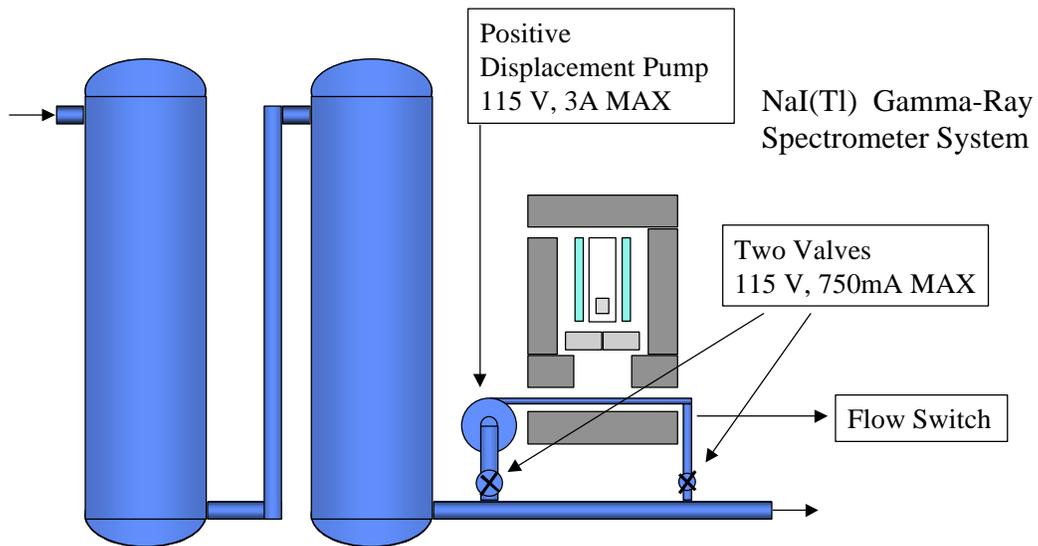
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Artist's Rendering of Cesium-137 Monitor

On-line ^{137}Cs Process Monitoring and Control System



Gamma ray spectral activity is measured at two locations in an ion exchange loop by a matched pair of radiation detectors. The deviation of the two measured activities is calculated and compared to the expected decay concentration of barium-137m to determine the cesium-137 concentration.