

## Continuous Aqueous Tritium Monitoring (U)

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by

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## CONTINUOUS AQUEOUS TRITIUM MONITORING

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### ABSTRACT

Continuous monitoring for tritium in the aqueous effluents of selected Savannah River Site (SRS) facilities is performed using a custom designed system that includes an automated water purification system and a flow-through radiation detection system optimized for tritium. Beads of plastic scintillators coupled with coincidence electronics provide adequate sensitivity ( $\approx 25 \text{ kBq/L}$ ) for tritium breakthrough detection in the aqueous discharge stream from these facilities. The tritium effluent water monitors (TEWMs) at SRS provide early warning (within 30 minutes) of an unanticipated release of tritium, supplement the routine sampling surveillances, and mitigate the impact of aqueous plant discharges of tritium releases to the environment.

### I. INTRODUCTION

The original TEWM was installed on the secondary cooling water discharge from one of the heavy water moderated production reactors at SRS. This system was installed after an unanticipated release of  $\approx 300 \text{ TBq}$  of tritium to the Savannah River via a primary-to-secondary cooling water leak in one heat exchanger. Even though this TEWM was assembled from laboratory prototype equipment, it became a prerequisite for reactor operation. The TEWM operated continuously for eight months during subsequent reactor restart activities.<sup>1</sup> Meanwhile, an improved system (TEWM-2) was designed and field tested on the aqueous discharge from another SRS production reactor over a seven-month period.<sup>2</sup> Following successful field testing, this TEWM-2 was moved to the aqueous discharge at the SRS heavy water purification plant, where it has operated since January 1994.

### II. SYSTEM DESCRIPTION

The TEWM-2 consists of a fully automated water purification system complete with performance indicating sensors, the radiation detection system, and a data acquisition and analysis system (DAAS) interfaced to plant alarms. Components in the water purification system include micro-filtration, ultra-violet sterilization, activated charcoal and ion exchange resin columns, and a phase separator. Water purification sensors interfaced to the DAAS include pressure and flow indicators, a temperature sensor, and an in-line conductivity probe.

A schematic of the TEWM-2 as it is installed in the aqueous discharge (process sewer) from the heavy water re-work facility at SRS is shown in Figure 1. Water is lifted from the process sewer with a positive displacement pump at a relatively high flow rate ( $\approx 30 \text{ Lpm}$ ). This action ensures rapid sampling of the effluent stream. A side stream is pumped through the water purification portion of the TEWM-2 at a much lower flow rate ( $\approx 100 \text{ mL/min}$ ) to permit high-quality water-purification performance. A small fraction of the purified water is then sent through the radiation detector at a lower flow rate ( $\approx 3 \text{ mL/min}$ ), which minimizes cell plugging.

Parallel to and independent of the TEWM-2 is a composite sample that removes a portion of the water in the process sewer. This sampler removes a few mL of the water every minute and collects the water for laboratory sample analysis. The composite sample is analyzed every eight hours. If the TEWM-2 is out of service for more than one hour, the process sewer sample is analyzed at one-hour intervals. As a second check, all water that passes through the TEWM-2 analysis is collected and analyzed daily. The analysis cell effluent can be collected at any time for calibration or confirmatory measurements.

Figure 2 shows a schematic of the individual compo-

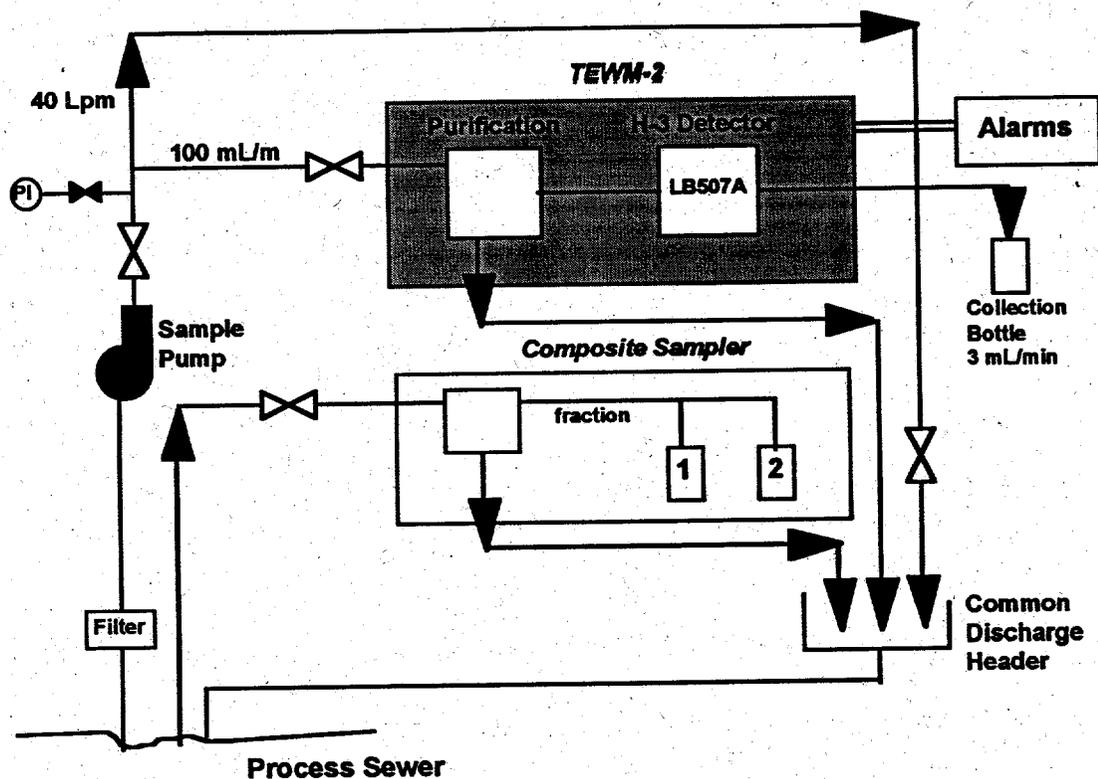


Figure 1. Schematic of the tritium effluent water monitor installed in the aqueous discharge from the SRS heavy water purification facility.

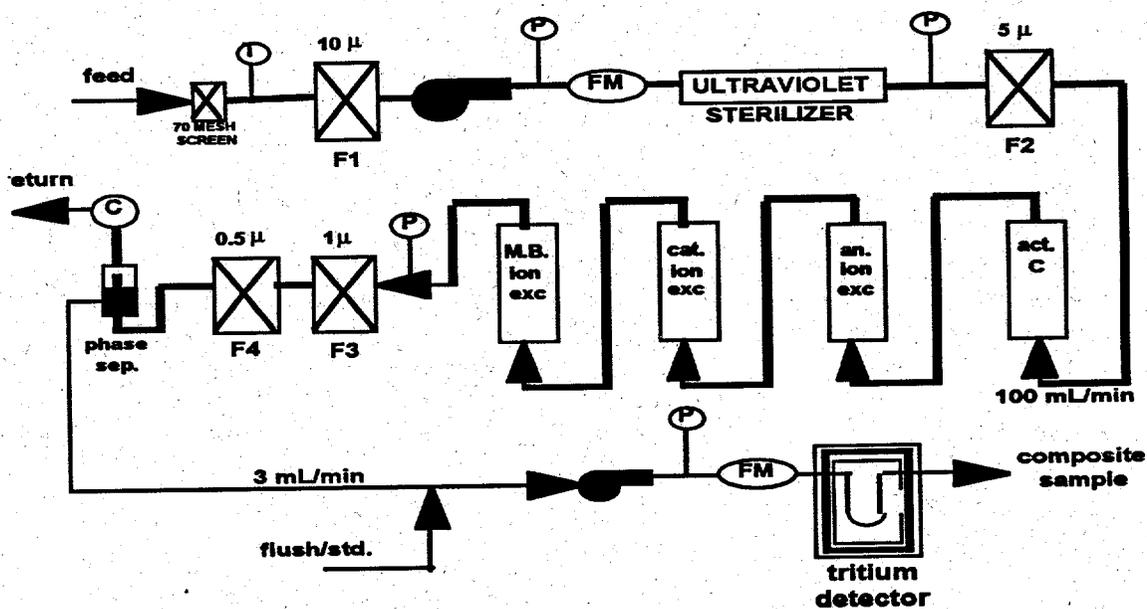


Figure 2. A schematic of the TEWM-2 showing the water purification system and radiation detector system.

nents in the TEWM-2. The side stream of water is pulled from the sampling stream and passes through a mesh screen before entering the 10-mm (nominal) pre-filter which protects the metering pump and all downstream components. The temperature sensor ensures that the ion exchange resins do not exceed the 90°F limit, the pressure sensors monitor any pressure buildup in the ultra-violet (UV) sterilizer and the F2 filter, rated at 5 mm. The flow monitor ensures design flow through the water purification system. The UV sterilizer destroys any organisms while the F2 filter removes suspended debris. The water then passes through a series of absorbent beds, beginning with an activated charcoal bed to remove dissolved organics. The next bed contains anion exchange resin to remove anions and trace organics. That is followed by a strong base cation exchange resin column to remove hardness minerals /the final step is a polishing bed of mixed cation/anion resin. Any fine debris (including resin fines) is then filtered by a pair of polishing filters rated at 1 and 0.5 mm, respectively. The water then passes through a phase separator to remove any dissolved gases and then is discharged back to the process sewer. An in-line conductivity probe monitors the quality of the water produced by the water purification system.

Table 1 summarizes the water quality parameters routinely measured on the influent and the effluent from the TEWM-2 for the initial seven months of operation on the SRS heavy water rework facility discharge. These data are measured on daily grab samples taken from the system. Flow rates through the water purification portion of the system during this period were  $87 \pm 25$  mL/min while the flow through the radiation detector was  $3.1 \pm 0.4$  mL/min.

Table 1: Water Quality Parameters for Initial Seven Months of Operation

| Parameter              | Influent            | Effluent            |
|------------------------|---------------------|---------------------|
| Parameter              | $5.6 \pm 0.7$       | $6.0 \pm 0.5$       |
| pH                     | $91 \pm 14$ mS      | $2.7 \pm 3.0$ mS    |
| Total dissolved solids | $46 \pm 10$ ppm     | $1.3 \pm 2.2$ ppm   |
| Turbidity              | $12 \pm 9$ NTU      | $2.8 \pm 4.0$ NTU   |
| Tritium concentration  | $0.5 \pm 0.8$ kBq/L | $0.5 \pm 0.5$ kBq/L |

The radiation detectors provides tritium and gross-beta signals to the DAAS to continuously evaluate the count rate data. The lower-level discriminator is set just above the tritium counting window for the gross-beta counting channel. All sensor and count rate data are evaluated by the custom software for operation within preselected limits. A local hardcopy and visual readout are provided along with disk storage of all data and interfaces to plant alarm relays. The system is programmed to shut down all internal pumps when high differential pressure, low flow, or high conductivity conditions are sensed (see Figure 3). Count rates in the tritium channel are evaluated at ten-minute and one-hour counting intervals.

### III. RESULTS

The TEWM-2 is set to alarm at tritium concentrations of 75 kBq/L in a ten-minute interval and about 40 kBq/L for the one-hour interval. These limits are based on a twice-background count rate limit for the short time interval and 4.66 standard deviation limit for the long count time interval. These sensitivities are routinely verified by injecting a known tritium solution standard of the appropriate specific activity into the counting cell through the flushing/standard connection (see Figure 2). These alarms limits permit the detection of a tritium release of about 0.04 TBq/hour to the environment from the SRS heavy water facility through the process sewer pathway based on the discharge flow rate. Figure 4 displays the analyzed results of hourly count rates in the tritium and gross-beta counting channels for one month of operation. These data are printed out hourly on the line printer and stored on the system disk. All abnormal conditions are recorded on the line printer and disk, an out-of-specification status condition is displayed on the local system display, and a TEWM trouble or high-activity alarm is sent to a local alarm panel and echoes in the SRS heavy water facility control room. Operations personnel diagnose the problem from the records and conditions and take corrective actions.

The count rate data shown in Figure 4 are typical for the TEWM-2. For example, during May 1994, the average count rate per hour observed in the tritium channel was  $322 \pm 46$  cph ( $5.4 \pm 0.6$  cpm) while the gross-beta count was observed during period. The tritium count rate limit for the ten-minute counting interval was set at 100 cpm (600 cph) while the one-hour count rate limit was set at 420 cph (7 cpm), these limits are shown in Figure 4. Limits are not typically set on the gross-beta count rate channel because all other radionuclides are removed on the filters or ion exchange columns.

The operation of TEWM-2 requires routine surveillance and maintenance. The TEWM-2 is taken out of service when these activities are performed or when there are hydraulic problems. During the eight months of operation of TEWM in the outfall of the K Reactor, the in-service time reached 90% in the latter months. We have experienced

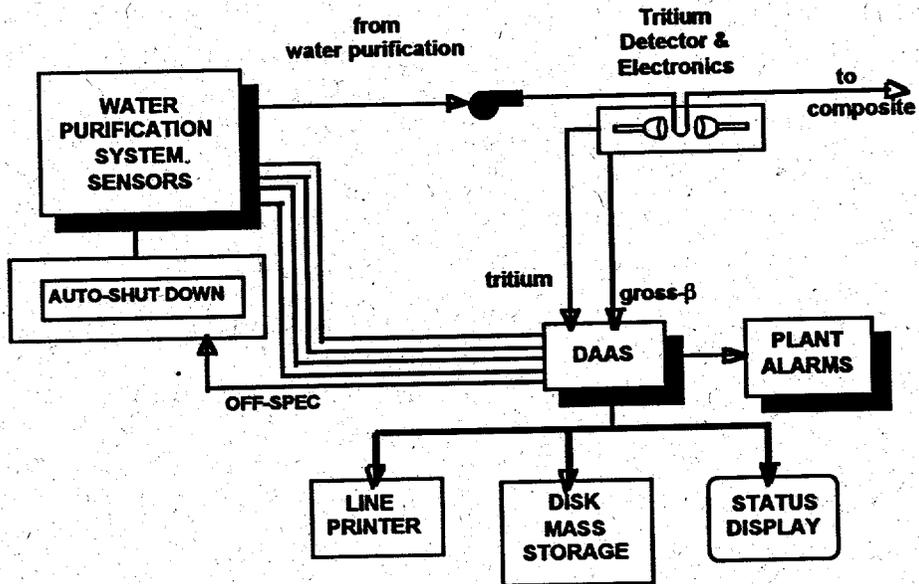


Figure 3. Logic and interface diagram for the TEWM-2

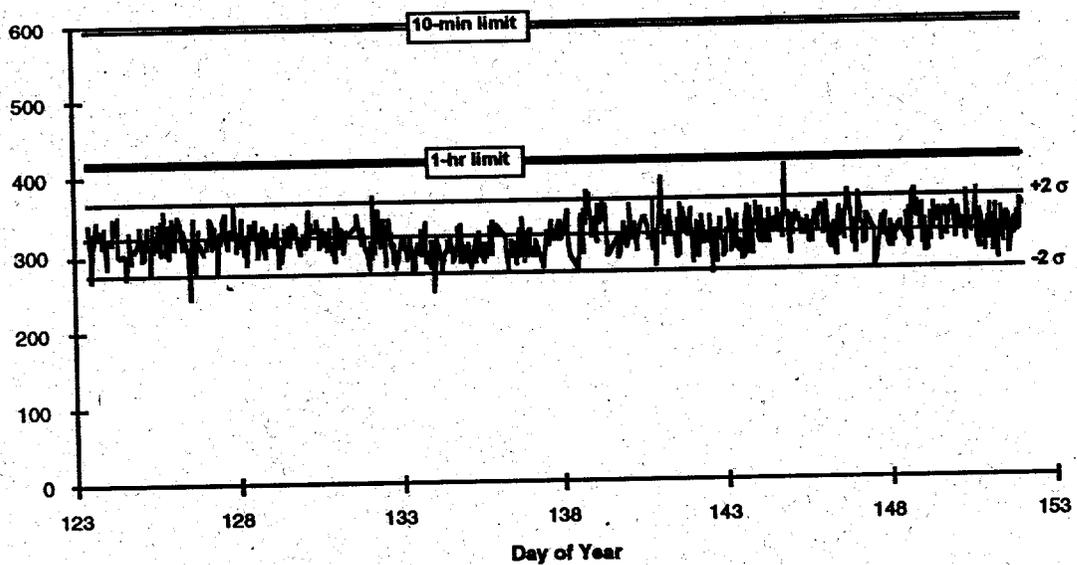


Figure 4. Tritium count rates recorded by the TEWM-2 for May 1994

similar duty cycles for the TEWM-2 after it was installed in heavy water rework facility. Preventive maintenance includes weekly filter changes, biweekly analysis cell flushing, and monthly resin column changeouts. Most of the remaining problems are from algae buildup (especially in the spring) in the process sewer, which plugs the prefilters.

#### IV. CONCLUSIONS

The installation of TEWMs on selected effluent streams at SRS is part of the active program to reduce the quantity of tritium released to the environment. The TEWMs supplement the standard sampling surveillances and supply additional control over unplanned releases. Solid scintillators provide limited detection sensitivity and are the basis for a simple counting system. Evaluation of improved tritium detection sensitivity with solid scintillators is underway using large surface area detectors, brighter scintillators, and alternate electronics. The automation of liquid scintillation counting techniques to reach environmental tritium concentrations is also under study with some successes reported.<sup>3</sup> Another project supported by SRS is to evaluate improved pulse-shape discrimination techniques using bismuth germanate windows in a liquid scintillation-flow cell counter and has shown promising results.<sup>4</sup> All these studies will demonstrate the SRS commitment to reducing tritium releases in the aqueous discharges.

#### ACKNOWLEDGMENTS

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