Biweekly Airborne Sampling at Seabrook Station

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Abstract

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Seabrook Station wanted to improve REMP air sample reliability (i.e., reduce loss of sample collection due to equipment failure or heavy filter loadings), while still maintaining required sensitivity to short lived isotopes. The sampling and collection frequency recommended in NUREG 1301, "Offsite Dose Calculation Manual: Standard Radiological Controls for Pressurized Water Reactors" is weekly. The combination of the following has been addressed or implemented to meet all 3 criteria and support biweekly sampling:

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- Continuous automated real time remote monitoring of equipment status,
- Preventive maintenance and configuration of sample equipment.
- Evaluation of iodine decay (1 week vs. 2-weeks),
- Charcoal efficiency testing for 2-week duration, and
- Administrative controls for elevated on-site iodine and more frequent air sampling.

Preventive maintenance and continuous automated remote monitoring of the vital system parameters increase system / sample collection reliability, which supports an extended filter change-out cycle. Preventive maintenance is performed on the air sample equipment twice each year including calibration, pump replacement and electrical system checks. Continuous automated remote monitoring of vital system parameters is performed with telemetry that detects power outage, pump failure, filter degradation, tubing failures and excessive filter loading. The telemetry communicates by cellular transmission to a web server that communicates to a shift technician's pager when set-point thresholds are reached, providing 24/7 alert notification.

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Each environmental air sampling location consists of a 0.5-3 SCFM self-compensating vacuum pump draws air from outside atmosphere through a paper filter and charcoal cartridge in series in a filter head container. The filter head is located outside a doghouse approximately seven feet above ground level and is protected from inclement weather with a shield that deflects rain and snow. Stainless steel and polyethylene tubing connect the filter head to the suction inlet of the pump located in the adjacent doghouse that also holds a dry gas meter used to total the volume of air passing through the system.

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An iodine decay analysis compared a 1-week vs. 2-week air sampling cycle and the ability to detect iodine. For the assumption of chronic air concentrations of I-131, the longer collection time results in a higher total deposition of I-131 that remains on the

cartridge at counting time and therefore an MDA equal to or better than the 1-week cycle. The Framatome Environmental lab conducted a test on their counting system and software for an assumed one and two week collections and verified this conclusion. For potential short duration releases of I-131, a modest increase in sampler flow rate provides for a higher iodine collection factor per unit time. This higher collection factor compensates for the decay losses due to the longer turn-around time with a 2-week change-out cycle such that the effective detection capability remains about the same. With increased sampler flow rate, higher collection quantities compensate for longer decay times associated with the 2-week cycle over the 1-week collection cycle.

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Seabrook Station normally operates pump flow in the range of 1.0 to 2.0 SCFM and adjusts flow to ~1.5 SCFM for a one-week period. For the 2–week sample period, a flow rate range of 1.5 to 2.3 SCFM will be maintained with flows adjustments to approximately ~1.8 SCFM based on a need for a higher iodine collection factor during acute release conditions to compensate for longer decay times.

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Radeco CP-100 charcoal cartridges were tested for cumulative decontamination efficiency using the ASTM D3803-98 test method. Three tests were conducted at a flow rate of 2.0 SCFM, each for a 336-hour period. Test results reveal greater than or equal to 99.30% efficiency in all three tests.

For possible acute short-term releases, procedures governing effluents and in-plant air sampling provide triggers to evaluate the need to increase REMP air sampling frequency. At Seabrook, Chemistry procedures require notification to Health Physics (REMP Coordinator) if ODCM monthly and instantaneous limits are exceeded. In either case, Health Physics will evaluate the need to increase the environmental air sample collection frequency. Programmatic actions also require the need to evaluate increase environmental sampling in the event of failed fuel.

Improved reliability, remote monitoring with 24/7 alert notification, and equal to or better than 1-week MDA's support the argument that airborne sample collection up to a 2-week frequency is feasible. Savings on technician time, lab analysis, data review and sample supplies are possible while improving overall reliability.

Remote Monitoring

Telemetry Summary

Seabrook Station uses the Telemetric T-646 MicroRTU to communicate vacuum pressure across the filter paper (see figure 1). The T646 includes an integrated two-way radio that communicates over the control channel of the cellular data network, with coverage available to all air sample station locations. Remote monitoring and status reporting are accessible from the Telemetric Intelligent Web Server or through an existing SCADA system. Operating parameters are locally programmable and remotely selectable. Communication is initiated in three ways:

- Automatic report upon status change
- Time-scheduled reports (hourly, daily, weekly, etc.)

- User requested report

A pressure transducer is connected with tygon tubing to the vacuum inlet line downstream of the filter head supply line that measures differential vacuum pressure across the sample paper (see figure 1). The pressure transducer is powered with 12 volts DC from the T-646. Output voltage of the transducer varies with vacuum changes that are sent to the T-646 analog input. When the T-646 is configured, it reads the input voltage from the transducer and assigns an equivalent 12-bit value. The 12-bit values are calibrated with the pump ∆P paper vacuum gage. Three 12-bit values are recorded at different levels of a pressure range. Next, the 12-bit values are entered into a web-based table where they are matched with display values that appear on the intelligent web server device screen via a secure Internet connection.

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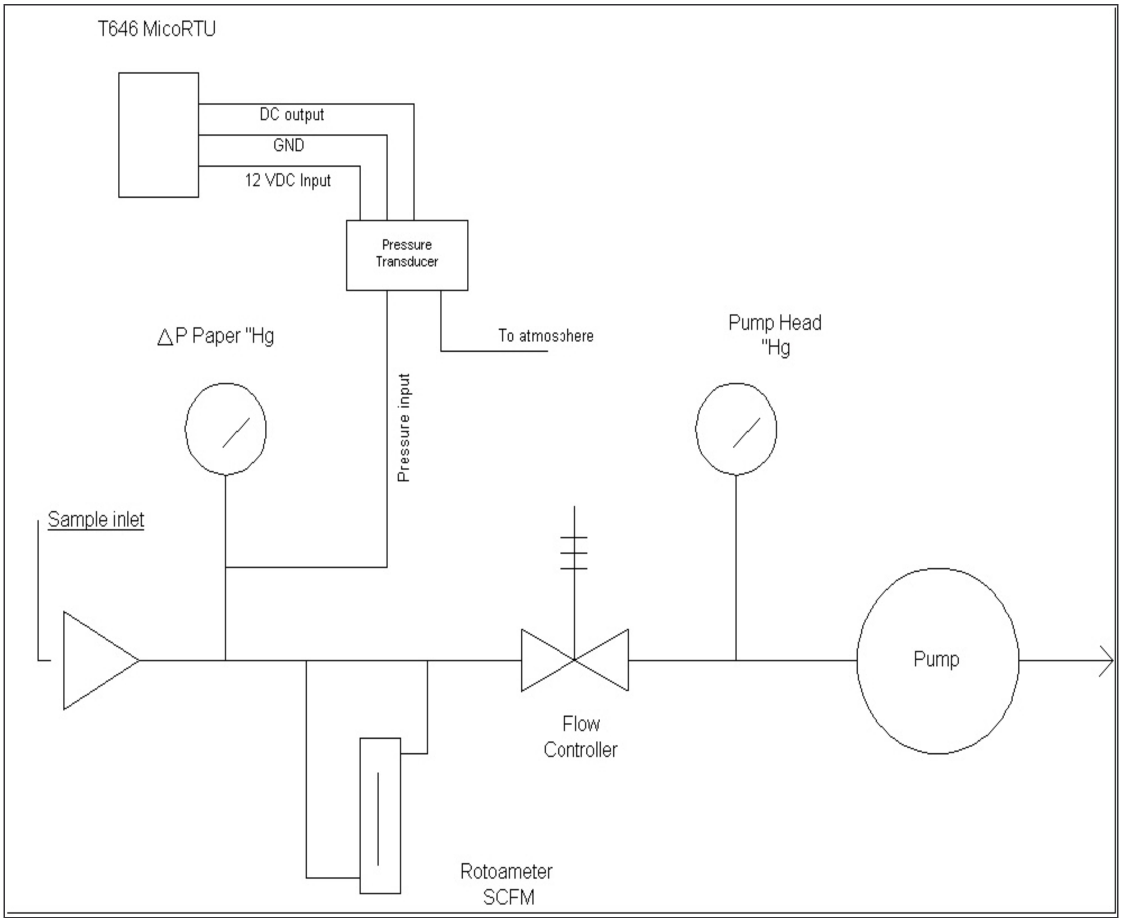
Pre-defined rule-based actions for system alert notification are established for shift technician, on duty 24/7, notification. Pager alert notifications include:

Alert	Probable Cause	Action
Low pressure	Torn filter, degraded tubing or degraded pump	Contact HP Supervision Enter alert in HP log
High pressure	Excessive filter loading	Contact HP Supervision Enter alert in HP log
A/C Power Loss	GFI breaker trip Loss of power from supply source.	Contact HP Supervision Enter alert in HP log
A/C Power Restored	A/C power restored to telemetry device and air sample pump.	None

Low and High alert pressures are based on best information available at the time they were established and may need to be adjusted as filter loading information for a biweekly frequency becomes available.

Response to a pager alert may require the call in of a technician on non-business days during daylight hours only. Field response during adverse weather conditions is not required. Alert responses normally occur within 24 hours.

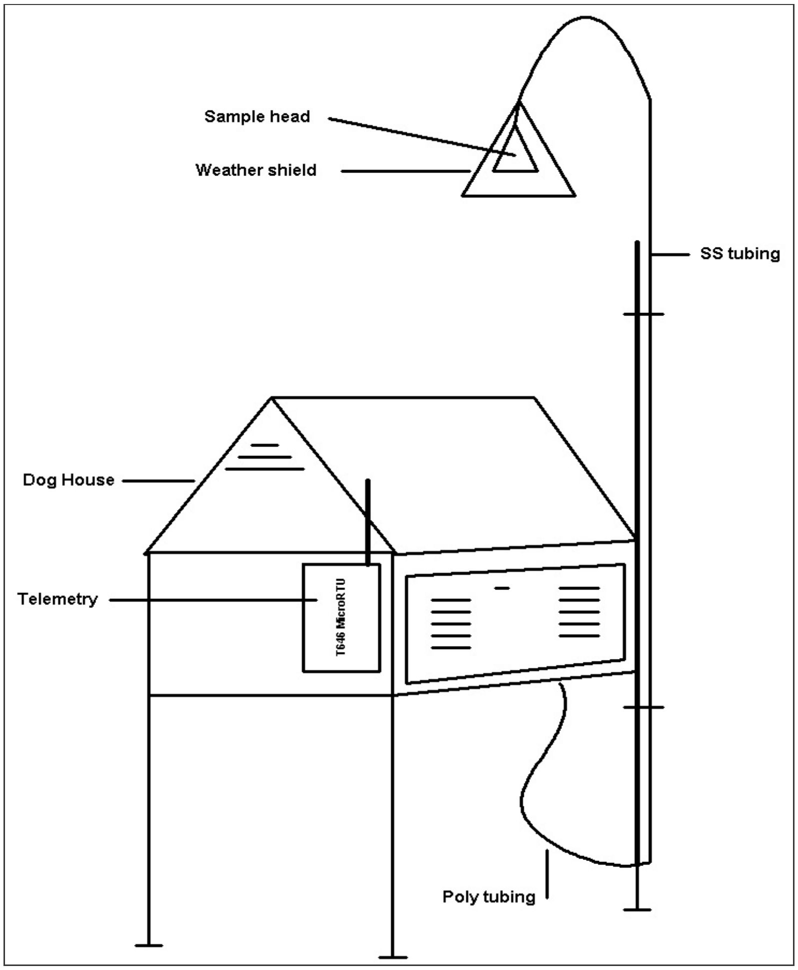
Figure 1
Air Sample Flow Diagram with Telemetry



Sample Equipment Arrangement

A 0.5-3 SCFM self-compensating vacuum pump draws air from the outside atmosphere through a paper filter and charcoal cartridge in series within a filter head container. The filter head is located outside a doghouse approximately seven feet above ground level and is protected from inclement weather with a shield that deflects rain and snow. Stainless steel and polyethylene tubing connect the filter head to the suction inlet of the pump located in the adjacent doghouse that also holds a dry gas meter used to total the volume of air passing through the system.

Figure 2
Air Sample Equipment with Telemetry



Weekly vs. Biweekly Sample Collection for Detection of I-131

This evaluation involved examining the effects from both a physical as well as a theoretical standpoint. As a physical evaluation of the change in sample collection frequency, the effect on the MDA (Minimum Detectable Activity) of the counting system was examined. Two charcoal samples were analyzed for I-131 in an environmental laboratory. One sample had a sample collection period of 6 days and a decay time between end of sample collection period and beginning of sample count time of 27 hours. The second sample analyzed had a collection period of 13 days and a decay time of 99 hours between end of sample collection time and beginning of sample count period. In the case of the 1-week sample collection period, the MDA was calculated to be 3.98E-02 pCi/m^3. In the case of the 2-week sample collection period, the MDA was calculated as 3.35E-02 pCi/m^3.

These counting results show that the MDA is not negatively affected by the change in collection frequency, but is actually improved for the two-week sample collection period. In fact, the MDA remains about a factor of 1.8 to 2 times better than the required LLD of 0.07 pCi/m^3 by lab design of the counting system coupled with sample collection conditions. It should be noted that this case assumes a constant air concentration being collected for the entire sampling period (i.e., a chronic vs. a short-term release).

As part of the theoretical evaluation, an examination of the kinetics of the sampling system was performed. For a filter sample collection, the activity remaining on a filter for a given sample collection period (t) and a given release period (T_1) is defined as follows:

$$A = U*F*(1-e^{-\lambda T1})/\lambda * e^{-\lambda(t-T1)} * e^{-\lambda T2}$$

Where: U = Activity concentration in air during the release period T1 (pCi/m^3).
F = Filter collection flow rate (m^3/day).
T1 = release duration (days) assuming release starts at the beginning of sample collection.
t = Sample Collection Period (days).
λ = Decay Constant for I-131 = 8.6E-02 day^{-1}
T2 = Period (days) between end of collection period and beginning of count time.

This equation was evaluated for a 1-week sample collection period (i.e., t=7 days) versus a 2-week sample collection period (i.e., t= 14 days) for releases (T1) ranging from 1 hour to 336 hours (14 days). The evaluation reflects a range of short duration or acute releases starting at the first hour of the collection period. In each case, the period between end of sampling and beginning of sample count (T2) was assumed to be 3 days. Data was tabulated to show the comparison of the two collection periods by taking a ratio of the hourly totals over a 2-week sample collection period to the same hourly totals over the 1-week sample collection period. Results show that the loss in air concentration due to decay for a 2-week collection period would be about twice the loss for a 1-week collection period. However, by increasing the sample collection flow rate, the total activity collected per unit time would also be increased which would work to negate the loss in activity due to decay over the longer sample collection cycle.

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Conclusion

Seabrook Station in effort to reduce air sample out-of-service time and improve system reliability has made changes to environmental air sampling that support an increasing the sample cycle period. Remote monitoring, I-131 detection for 1-week vs. 2-week periods evaluation, 2-week charcoal efficiency testing and equipment preventive maintenance are elements that successfully support the frequency change. Monitoring equipment has been successful in reducing out-of-service time and sample analysis results show LLD's have been achieved.

Since the implementation (May 2004) of automated remote monitoring, the application of the real time telemetry system has already prevented three events (loss of power, tubing failure) from causing significant missed sample time. Prompt response to the alerts prevented the loss of 200 collective out-of-service hours.

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