IMPROVED CAPABILITIES FOR AREA ENVIRONMENTAL MONITORING AT OAK RIDGE NATIONAL LABORATORY*

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Abstract

Recent increased concern for environmental safety hazards resulting from releases of radioactivity and other hazardous materials have necessitated the installation of improved monitoring instruments and methods at Oak Ridge National Laboratory (ORNL). Over the past several years a number of important instrument projects have been initiated to improve plant monitoring systems (both inside the Laboratory and in adjacent East Tennessee areas) and to enhance operational capabilities for detecting releases of hazardous and/or radioactive materials. These measures will significantly modernize and increase the number of monitoring stations measuring activity levels in (1) plant effluent gases, (2) plant effluent liquid wastes, and (3) local streams and rivers. Monitoring instruments within the operating buildings of the Laboratory are being upgraded, and three instrumented meteorological towers are in service to provide information for calculating deposition patterns over surrounding areas. Advanced, on-line central data collection systems supply continuous information for programmable alarm-level circuits, for display at remote terminals throughout ORNL, and for scientific long-term data base purposes. When these improvements are completed in about two years, the number of environmentally derived signals will significantly exceed 750 monitored values.

Introduction

In past years the philosophy of air, water, and biological monitoring of the environment at all national laboratory sites was determined mainly through Department of Energy (DOE) or its predecessors' guidelines and directives. DOE exempted itself from local, state, and national requirements within the various Laboratory boundaries. More recently, however, DOE installations have found such legal immunities largely abrogated. Sites such as the Oak Ridge National Laboratory (ORNL) must now measure up to broadly expanded cleanliness and monitoring requirements such as those imposed by the Federal Clean Water Act, the Clean Air Act, and the State of Tennessee, and tighter orders and guidelines established by DOE.

On a day-to-day operating basis, ORNL now has four monitoring centers that collect, analyze, and record the large number of environmental and other signals generated by distant field stations and within the local plant sites. These centers become the focus for monitoring activities within ORNL and are constantly on-line to detect any releases of radioactive or other hazardous materials. Their general functions and capabilities are as follows:

- I. Waste Operations Control Center (WOCC). The WOCC is the major monitoring system to provide data for operational liquid and gaseous waste management at ORNL. Signals collected at this

center include telemetered values for radiation levels in industrial liquid and gas waste discharge systems to the environment; process equipment monitors and alarm functions in buildings where radioactive materials are handled; and other sensor-derived data vital to the control of waste/effluents in an extensive laboratory complex. Currently, more than 375 signals are being monitored round the clock at the WOCC.

- II. Environmental Monitoring Center (EMC). The EMC is responsible for maintaining a comprehensive air and water environmental monitoring network around the ORNL periphery, within DOE's Oak Ridge Reservation, and in some areas remote from the Oak Ridge complex. The system includes

- A. An air monitoring network that incorporates local (in-plant) air monitors (LAMs), perimeter air monitors (PAMs), and remote air monitors (RAMs).
- B. A water monitoring system incorporating sampling stations strategically located on all local streams to measure radioactive discharges and other effluents from both inside and outside ORNL plant sites.
- C. Stack gas effluent monitors that test discharge gases for radioactive release, with a total of seven stacks within the ORNL plant area monitored continuously via this system.
- D. A data collection system that functions to receive, record, analyze, store, and retransmit monitoring results to remote interactive terminals.

Plans are for more than 250 signals to be transmitted from the various sensors to this center.

- III. Laboratory Emergency Response Center (LERC). The LERC is a multipurpose facility for tactical control of ORNL emergency situations. It occupies a new building at ORNL, where signals from many field sensing devices, environmental and otherwise, will be monitored. A computer-based data acquisition system will provide continuous display of essential information on environmental, meteorological, utility, process-control, radiation and contamination, criticality, surveillance, safeguards, and security parameters. As presently designed, LERC will monitor more than 200 signals from the field, with expansion capabilities for as many as 2000 signals included for future use.

- IV. Facility Radiation and Contamination Alarm System (FRACAS). ORNL's FRACAS is in fact many systems covering a large group of continuously monitoring instruments located in 25 operating facilities within the plant's confines. Equipment is individually tailored to meet the alarm warning needs for each facility. Important signals from 15 of these monitored buildings are retransmitted to ORNL Guard Headquarters to inform security personnel of any

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high-level contamination, evacuation, release, containment, or other emergency conditions within the plant area.

To promote compliance with new regulations from many sources, ORNL has instituted programs to provide facility upgrades and site remedial actions necessary for improving both the quality and quantity of information being received by all of the ORNL monitoring centers mentioned above. These ORNL remedial programs are divided into six major areas of emphasis or action as follows:

1. process waste water and watershed monitoring improvements,
2. ambient air monitoring station additions,
3. facility stack discharge monitoring,
4. groundwater migration analyses,
5. continuous meteorological assessments, and
6. FRACAS upgrades.

The purpose of this paper is to examine each of these areas of emphasis and their individual roles in forming an overall strategy of monitoring compliance (and accidental release safeguards) at ORNL, and to describe results of efforts to upgrade and improve field measuring capabilities in order to provide ORNL monitoring centers with the best possible area radiological monitoring information.

Process Waste Water and Watershed Monitoring Improvements

ORNL's objective in upgrading process water monitoring is to assure compliance with the Federal Clean Water Act, laws and regulations of the State of Tennessee, and more stringent orders and guidelines recently established by DOE.

Waste water from the Oak Ridge DOE Reservation drains into the Clinch River, which begins in Virginia and flows southwest to its mouth near Kingston, Tennessee, where it empties into the Tennessee River. Liquid effluents from ORNL plant operations enter the Clinch River through its tributary, White Oak Creek. Before 1986 only three stations were sampled, in compliance with the existing requirements. Under new regulations there will eventually be as many as 83 sampling points, with each plant discharge site being monitored as it enters a natural creek or branch. Parameters monitored at these stations may include such values as flow rate, alpha/beta/gamma activity, turbidity, pH, oil and grease content, total carbon, dissolved oxygen, total dissolved or suspended solids, PCBs or related chemicals, and mercury content. A program also is under way to sample sediments on the bottoms of appropriate streams, creeks, and rivers regularly for PCBs and other insoluble chemicals that tend to accumulate and settle as solids. Some of the more important water quality monitoring sites are shown on the map in Fig. 1, and a typical field installation for one such station near White Oak Dam is shown in Fig. 2.

Considerable work is in progress on the installation, testing, and calibration of the various water quality monitoring stations in the ORNL vicinity to maintain compliance with National Pollutant Discharge Elimination System (NPDES) standards. Such activities will be expanded or reduced as the factors related to the actual distribution of radioactive materials and other hazardous materials become better discerned and as uncertainties in the status of some ORNL compliance requirements are resolved.

Ambient Air Monitoring Stations

Objectives of the ambient air monitoring program at ORNL are (1) to ensure compliance with the Federal

Fig. 1. Topographical map showing major water monitoring stations south and southeast of ORNL. White Oak Creek (#6) and Melton Branch (#2) converge near #3 and #4 to fill White Oak Lake (to the right of #5). After settling and being monitored for radioactivity, waste water is released from the surface of White Oak Lake into the Clinch River (extreme lower left).

Fig. 2. Aerial view of White Oak Lake and Dam. Waste Water Monitoring Station #5 is left of the dam.

Clean Air Act and DOE orders for protecting the environment and (2) to protect the area's public health and safety.

Ambient air monitors in use at ORNL are classified into three general groups: (1) LAMs positioned relatively close to ORNL operating facilities and activities; (2) PAMs located in proximity to the three Oak Ridge plants, throughout the areas covered by the larger Oak Ridge DOE Reservation, and in the City of Oak Ridge proper; and (3) RAMs placed outside the Oak Ridge DOE Reservation at distances ranging from 19 to 121 km from the main ORNL site. Most of the RAM stations are located at TVA dam sites for convenience and physical protection. The combination of LAMs, PAMs, and RAMs constitutes a three-layered air monitoring coverage system for ORNL and its environs.

The 23 LAM stations are equipped with various combinations of moving-filter-paper continuous samplers for alpha and beta-gamma activity, rotating-disk alpha and beta-gamma particulate sensors, and sampling charcoal cartridges to detect any radioiodine. As a result of current upgrading efforts, all of these monitors will send their data to the EMC control center, which is staffed by operating personnel who monitor and respond to alarm conditions. A remote display terminal for these signals will be located at the LERC, which is manned on a 24-h basis.

Moreover, these LAM stations are also equipped to trigger high-level alarms in the WOCC and LERC promptly.

Within the past two years the capabilities of all area PAM stations have been improved significantly. The number of stations has increased from 9 to 11 to provide more uniform area coverage. Each PAM station has the capability to perform both sampling and continuous monitoring. PAM stations have monitors for five radiation parameters (gross gamma, beta particulates, alpha particulates, gaseous radioiodine, and radioactive noble gases). Each station also has an electrically signaling rain gauge and a wet/dry deposition collector. Figure 3 shows one of the new PAM monitoring stations at ORNL. The data from each PAM station are transmitted via modems to the EMC building at ORNL. A host processor collects data as 10-min averaged readings whose values are then transferred to a VAX computer for further analysis and reporting. The primary purpose is to monitor radiation levels at Oak Ridge Operations facilities for annual reporting. In three selected PAM stations, atmospheric tritium also is collected in the form of water vapor onto silica gel filters, which are assayed periodically at ORNL.

Prior to 1985, sampling data were collected from seven RAM stations and analyzed for alpha and gross beta activity in the air and in any radioparticulate fallout, with results being stored on strip-chart recorders collected by ORNL personnel and analyzed monthly. Rainfall samples were collected on a weekly basis, and the contents were analyzed for dissolved or suspended contaminants. One of these stations was decommissioned recently because its location resulted in unreliable and unstable data. The continuously recording instruments in the six remaining RAM stations are being replaced by a combination of activated-charcoal-cartridges and filter-paper holders that will be collected and analyzed monthly at ORNL. Since these stations serve mainly to provide regional baseline data (both upwind and downwind of the DOE Reservation) for the more proximal monitoring stations, this infrequent sampling schedule will serve its purpose. RAM stations also could provide more immediate information should any large release of radioactivity occur. These samples and data are collected via prompt filter-collecting trips to the affected stations as the need arises. Upgraded RAM stations will be installed in new housings and will continue to use rainwater collectors.

Since air transport is an important primary exposure pathway from any unexpected ORNL release of radioactive pollutants, all monitoring data from LAM, PAM, and RAM stations are obtained to evaluate any potential dose to the area's population. Therefore, locations for all of these monitoring stations are assigned to provide the most complete area coverage, and to detect radioactive particulates, rainfall, noble gases, absorbable gases such as radioiodine, and airborne tritium that might constitute a public hazard.

Facility Stack Discharge Monitoring

The long-term objective of ORNL's stack monitoring program is twofold: (1) to provide capabilities for reliable real-time monitoring and sampling of major operational stack discharges and (2) to provide high sensitivity measurement capabilities in order to estimate more accurately the radiological dose contribution to the environment from stack discharges. Instrumentation used to record ORNL's stack emissions often resembles the hardware used for ambient air monitoring, but because of ORNL's heavy involvement in radioactive processes and reactor development and experimentation, stack emissions are assigned to a separate monitoring category.

Fig. 3. Perimeter Air Monitoring (PAM) Station. A gross gamma monitor, rain gauge, and wet/dry deposition collector are within the fenced area; other air-sampling and radioactivity monitoring instruments are inside the building for protection.

Gaseous process effluents are disposed of at ORNL through a system of seven tall smokestacks. (Some are shown in Fig. 4.) waste effluents consist of off-gases from process vessels and experiments, ventilator discharges from cells in which radioisotopes are handled, and some other special processing buildings. Gaseous effluents that are likely to contain excess radioactivity are passed through filters and/or scrubbers before being discharged through the stacks. Such effluents are monitored for one or more of the following contaminants before being discharged to the atmosphere: beta-gamma emitting particulates, alpha-emitting particulates, radioiodine, and inert radioactive gases. In-stack samplers are used for inventory-type sampling. Data obtained from analysis of the inventory samples, combined with sampling time and effluent-flow rate data, are used to approximate total particulate and radioiodine discharges.

Samplers positioned within stacks are used to remove small amounts of effluent gas for testing. The samples are taken as isokinetically as possible (i.e., sampling velocity in the probe is equivalent to the stack's average gas velocity). Sample gas is pumped through a sampling cartridge that collects particulates and radioiodine components; the remaining stripped gas is returned to the main stack flow. Sampling cartridges are removed and analyzed routinely. Sampling intervals depend on operational commitments and anticipated amounts of radioactivity flowing up a stack. Two smaller sampling probes are used to transport test portions of gas to continuously operating alpha and beta-gamma particulate and iodine-trapping charcoal cartridges that are actively counted. Results from on-line instruments are fed via data concentrators to the recorders at the WOCC, where they are monitored on a round-the-clock basis. (ORNL's new WOCC monitoring center, where results from the stack-monitoring instruments are observed and recorded, is shown in Fig. 5.)

This kind of stack monitoring equipment has been in operation at ORNL for more than 20 years. Although the equipment has been maintained in good working condition, it now marginally meets the current Environmental Protection Agency (EPA)- and DOE-referenced ANSI specifications for sensitivity and accuracy. Over the past two years a two-phase project has been established to upgrade all stack activity monitoring instruments, and to establish a state-of-the-art data acquisition system for

Fig. 4. Main ORNL plant area, showing some of the process waste stacks for releasing monitored gaseous effluents (left center).

Fig. 5. Interior view of the Waste Operations Control Center (WUCC), showing the data-collecting computer, magnetic tape recorders, and 24-h monitoring operation.

archiving, reporting, and retransmitting data and presetting alarm limits for ORNL stack installations. The first phase of this upgrading activity, transmitting signals to the EMC and LERC operators--incorporating real-time particulate alpha/beta, iodine, noble-gas, tritium, and flow-rate instrumentation on two important stacks--is nearing completion. Phase II changes, aimed at bringing the other five plant stacks into regulatory and operational compliance, will begin sometime in the near future as Phase I objectives are completed.

Groundwater Migration Analyses

Certain areas of the Oak Ridge DOE Reservation have been used in the past and at present as radioactive waste burial sites for low-level radioactive materials. Wastes are placed in man-made trenches or in natural depressions and are later covered. Studies are under way to determine the direction and extent of migration patterns for these radioactive materials through local

groundwater systems. ORNL plant operations are located on complex hydrogeologic sites covering primarily two contiguous valley areas separated by one ridge. In some of these areas a strong interaction has been discerned between the local groundwater and surface drainage systems.

Reservation-wide hydrogeologic studies are a multiyear undertaking and will involve a variety of different approaches. One initial goal will be to acquire accurate geologic information on the lithologic and structural aspects of strata that underlie the Reservation and its environs. This information is fundamental to the study since groundwater (and to some degree surface water) flows are controlled largely by fractures in the various levels of bedrock. The present level of understanding of Reservation geology lacks adequate detail to support adequate hydrogeologic studies, although detailed geologic maps of surface features are available.

An extensive system of approximately 800 shallow-to-deep groundwater wells is being drilled in appropriate locations to help characterize the local geology and the movement of active materials from waste-burial sites through groundwater interactions. Drilling of numerous sampling wells is under way at ORNL as part of this investigative program.

Continuous Meteorological Assessments

Information gained from the Windscale, Three Mile Island, and Chernobyl accidents has shown just how capricious fallout-laden winds can be and has demonstrated the importance of having reliable meteorological data associated with any unanticipated releases of windborne radioactivity. Needed information should be updated frequently and archived for use in calculating annual flow patterns and for needed emergency model projections.

A meteorological monitoring network installed at ORNL in 1982 consists of two instrumented 30-m towers installed to characterize accurately the meteorology of Bethel and Melton valleys and a third 100-m tower located in a southwesterly direction to supply upwind data. The two shorter towers have arrays of weather sensors at the 10- and 30-m levels, while the taller structure has sensors at 10-, 30-, and 100-m elevations (Fig. 6). Data from the sensors are acquired, stored, edited, and formatted by a data collection system consisting of a central processor and remote data loggers. Current and stored information is used in modeling environmental conditions for both normal and emergency operating conditions. A key element in the successful modeling of discharges from stacks and other facilities at ORNL is the ability to assess the actual and potential consequences of an accident. For this reason, ORNL is in the process of compiling meteorological and radiological monitoring programs to assess the types of radioactive materials released; outline any possible areas of affected population; and give dimensions, travel time, and continuous probable location for any possible plume. In the Oak Ridge area, dispersion processes are strongly influenced by meteorological phenomena such as wind (speed and direction), turbulence, atmospheric stability, and conditions resulting from the very hilly, wooded terrain surrounding ORNL areas.

The three meteorological towers constructed in 1982 are still in good operating condition. All towers undergo quarterly maintenance and calibration. To date, reliability and measurement accuracies have been excellent. Information on local meteorological data from these three towers is combined with other supplementary data received from similar installations at the other two DOE plants located on the Oak Ridge Reservation.

Fig. 6. ORNL 100-m meteorological monitoring tower. Weather monitoring instrument arrays are mounted at 10, 30, and 100 m.

Fig. 7. A FRACAS Constant Alpha Air Monitor (CAAM) air-sampling instrument located in a processing facility. Upon a coincidence alarm with another instrument of this type, the two nitrogen bottles activate and blow the two-tone air whistle to signal evacuation of all personnel from the building.

Facility Radiation and Contamination Alarm System (FRACAS) Upgrades

ORNL's FRACAS alarm systems cover a large group of monitoring instruments located in 25 operating buildings within the plant areas. These instruments signal to operating personnel within each facility the presence of unusual levels of radiation and/or airborne radioactive contaminants. Individually tailored systems meet the needs of each monitored building, including combinations of such detecting equipment as beta-gamma air monitors, alpha air monitors, criticality neutron monitors, and "Monitron" instruments for detecting abnormal increases in gamma dose levels. One of the constantly operating air monitors is illustrated in Fig. 7. These units provide signals indicating "High-level," "Caution," "Inoperative," "Containment," or "Evacuation" for the protection of each building's operating personnel and facilities. Figure 8 shows one of the central control panels used for receiving and displaying signals from many individual monitoring instruments in one operating ORNL facility. Two or more monitoring instruments simultaneously registering "high-level" alarms will result in action to evacuate the personnel of some buildings, signaled by multiple nitrogen-driven clarion whistle horns whose two-tone, high-dB blasts are difficult to ignore.

Radiation alarm signals from 15 of the 25 FRACAS-monitored buildings are currently retransmitted to ORNL's Guard Headquarters, thereby alerting security personnel on a 24-h basis to any important, out-of-limit radiation conditions and their locations within the plant.

Active FRACAS instruments being operated within the system at ORNL are

Beta-gamma constant air monitors (CAMs)	105
Alpha constant air monitors (ACAMs)	49
Gamma "Monitrons" (dose level only)	113
Neutron monitors (dose and burst levels)	27

Total continuously active FRACAS instruments at ORNL

294

Fig. 8. A central alarm panel displays signals from 18 FRACAS instruments operating within one ORNL process building. Signals indicating "Caution," "Hi-level," "Evacuation," "Inoperative," or "Containment" are retransmitted from this panel to ORNL Guard Headquarters to inform Laboratory supervisory personnel 24 hours a day.

Many FRACAS instruments still operating adequately were built using designs and electronic components available 20 or 30 years ago. The longevity of this equipment attests to the ruggedness of its original design. Recently, however, ORNL has begun a program to upgrade these instruments by replacing them with units of recent, state-of-the-art design. Especially useful are those monitoring instruments having

microprocessor-based capabilities with response characteristics that can be changed to accommodate the different monitoring demands of individual sites, and having electronic counting-rate limits that can be altered as required by varying the software commands.

Summary

Projects currently are under way to improve environmental monitoring capabilities at ORNL. These actions will significantly modernize many existing gaseous and liquid environmental monitoring stations, will add more stations to help provide more thorough coverage of the surrounding areas, and will furnish new and more flexible environmental data-handling capabilities.

At ORNL, air quality monitoring for releases of radioactivity is conducted using three separate layers of coverage. First, within the fenced plant areas are local air monitors (LAMs) that use air sampling devices and associated detector/counters, producing readings that are immediately telemetered to an environmental monitoring center (EMC).

Next in outward progression are the perimeter air monitors (PAMs), located throughout the Oak Ridge Reservation area and the City of Oak Ridge. The PAMs have been the object of extensive recent modifications and additions. These include capabilities for (1) measuring area gross gamma activity, (2) particulate sensing for detecting alpha/beta-emitting nuclides, (3) absorbing radioactive iodine gas within charcoal cartridges, (4) sensing any radioactive noble gases released by plant or reactor operations, (5) collecting wet and dry particulate samples for subsequent laboratory analyses, and (6) making rainfall measurements that include bottled sample collections. Important PAM data are also continuously transmitted back to the EMC via dedicated telephone lines.

More distant monitoring data are collected by remote air monitors (RAMs) located up to 121 km from the ORNL site. These stations, which are located in line with the prevailing winds both downwind and upwind of the plant, serve mainly to collect regional baseline data for the on-site monitoring systems. The RAMs can also provide distant measurement information should any large release of radioactivity occur. Activity recordings from each RAM station are collected manually by field personnel once each month or whenever necessary to meet special needs.

Additional monitoring equipment has been provided to supply real-time measurements of gaseous effluents from ORNL's tall process and reactor stacks, as well as from intermediate manholes and outlets of the plant's liquid waste discharge system. Some monitoring instruments have been augmented recently with discharge air flow and water flow measuring devices so that amounts of background-level gas and liquid radioactivity released into the environment can be determined more accurately.

Proportional sampling stations are now in operation on all area streams taking water samples discharged from ORNL in order to assure that all liquids released conform to National Pollutant Discharge Elimination System (NPDES) constraints as mandated by the Clean Water Act. Moreover, similar proportional monitoring stations are in operation on the Clinch and Tennessee rivers downstream of ORNL to verify NPDES compliance at greater distances from the plant site.

An existing ORNL environmental and effluent monitoring control panel is being replaced with a two-tiered, multicomputer-based collection center and reporting system. Data will be telemetered from all reporting stations to the computer monitoring system host computers through data concentrators. Routine functions such as communications with monitors, data unit conversions, and alarm determinations will be handled by this set of distributed computers. Communication control, data displays, alarm annunciations, and data-archiving functions also are handled by these monitoring host computers. Data reduction, event modeling, and other higher level functions are performed by a larger ORNL computer, to which all field monitoring systems and the host computers are networked.

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