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TITLE: A COMPUTERIZED PLUTONIUM LABORATORY-STACK MONITORING SYSTEM

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A COMPUTERIZED PLUTONIUM LABORATORY-STACK MONITORING SYSTEM

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ABSTRACT

The Los Alamos Scientific Laboratory has recently designed and constructed a Plutonium Research and Development Facility to meet design criteria imposed by the United States Energy Research and Development Administration. A primary objective of the design criteria is to assure environmental protection and to reliably monitor plutonium effluent via the ventilation exhaust systems.

A state-of-the-art facility exhaust air monitoring system is described which establishes near ideal conditions for evaluating plutonium activity in the stack effluent. Total and static pressure sensing manifolds are incorporated to measure average velocity and integrated total discharge air volume. These data are logged at a computer which receives instrument data through a multiplex scanning system.

A multipoint isokinetic sampling assembly with associated instrumentation is described. Continuous air monitors have been designed to sample from the isokinetic sampling assembly and transmit both instantaneous and integrated stack effluent concentration data to the computer and various cathode ray tube displays. The continuous air monitors also serve as room air monitors in the plutonium facility with the primary objective of timely evacuation of personnel if an above tolerance airborne plutonium concentration is detected. Several continuous air monitors are incorporated in the ventilation system to assist in identification of release problem areas.

INTRODUCTION

The Los Alamos Scientific Laboratory (LASL) Plutonium Research and Development Facility has been designed and constructed to meet the United States Energy

Research and Development Administration criteria for new facilities handling kilogram quantities of plutonium.[1] The operational facility consists of a single structure containing plutonium research laboratory areas constructed to meet requirements for containment under design accident conditions.

To meet the basic requirements for monitoring exhaust flow and concentration of radioactive materials discharged to the environment from the plutonium process areas, a state of the art flow monitoring and isokinetic stack sampling system is incorporated within the exhaust air stacks. All process exhaust from the glovebox lines and air bleed off from laboratory and mechanical areas is discharged through two essentially identical exhaust air plenums and stacks.

The stack air sampling system consists of flow conditioning equipment, velocity sensing probes, isokinetic air sampling probes, plutonium continuous air monitors, and computer transmitter devices.

SYSTEM AND FACILITY DESCRIPTION

The LASL Plutonium Research and Development Facility consists primarily of an Administration Building, Cold Support Building, and Plutonium Operations Building. The Plutonium Operations Building is approximately 81 meters by 86 meters with ground and basement levels. Plutonium laboratories are located in the ground level complex and ventilation equipment in the basement. Three ventilation zones are incorporated. Zone 3 is the basement area and is free of radioactive contamination. Zone 3 is 0.25 cm of water negative to the outside. Zone 2 is 0.25 cm of water more negative than Zone 3 and is comprised of the main laboratories on the ground level floor. Gloveboxes are used within the plutonium laboratories to handle plutonium materials associated with research and development activities. Glovebox atmospheres are identified as Zone 1 and are 1.5 cm of water negative with respect to the laboratory rooms. Each ventilation zone has its own ventilation exhaust system; however, before air is discharged to the atmosphere, all ventilation systems are combined in a common plenum and stack for each half of the building.

Each exhaust stack incorporates air processing elements designed to establish a flat velocity profile at the flow measurement and isokinetic sample withdrawal cross-sectional plane. The development of this flat velocity profile simplifies obtaining representative air samples from a multipoint sampler as required in American National Standard Guide to Sampling Airborne Radioactive Material in Nuclear Facilities, N13.1-1969[2] since all points in the sample withdrawal plane are at the same velocity.

Stack air flow conditioning is provided by three assemblies (Figure 1) which produce sequentially air flow straightening, a parabolic velocity profile, and finally, flat velocity profile. The air flow straightening section consists

[1] UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, General Design Criteria for Plutonium Facilities, ERDA Manual Chapter 6301, Part II. September 17, 1974.

[2] ANSI Standard N13.1-1969, American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

of stainless steel honeycomb parallel cells mounted in a heavy gauge duct casing. This section reduces turbulent air flow without attempting to correct velocity variations.

The velocity profile suppression is produced by a similar stainless steel honeycomb cell section mounted in the duct casing stream of the straightening section. The ratio of the honeycomb cell wall to cell cross sectional area is approximately 32 to 1, thus higher velocities are suppressed more than lower velocities since the velocity frictional losses are a function of the square of the velocity.

The final air processing station is the flat velocity profile section which developes an ideal, nearly flat, non-rotating velocity profile for isokinetic sampling. The honeycomb cell depth for this section is greater at the center than the outer periphery so that higher centerline velocities are further suppressed into a profile which is of uniform velocity parallel to the sample plane. Pressure drop through the three sections of honeycomb is approximately 1.9 cm of water at a stack velocity of 14.22 m sec^{-1}.

The velocity measuring and isokinetic sampling probes are located at a plane immediately downstream of the flat profile development section. Stack air velocity and volume is measured by an array of independent multipoint total and static pressure sensors.

A differential pressure transmitter relays velocity pressure through a multiplex system to a Data General Eclipse S/200 Computer. Average air velocity, volume, and integrated discharge volume is logged by the computer and displayed on four cathode ray tube (CRT) or remote display locations in the facility.

A sixteen point sample withdrawal unit (Figure 2) is incorporated in the velocity pressure sensing section and is comprised of a series of stainless steel isokinetic probes arranged to extract equal sample volumes. Since non-uniform particle size distribution and activity concentration through the cross section of the stack could occur, a multipoint sample withdrawal system is incorporated to represent the average composition of the stack effluent.

A multiprobe sampling system is designed in accordance with standards of the American National Standards Institute and, in fact, incorporate more sampling points than recommended in the Standard. Withdrawal of a representative sample from a stack requires proper placement of a sufficient number of sampling probes with adequate design of sample entry tubes. Prior to installation, the velocity at each isokinetic nozzle was measured while the header was subjected to the design sample rates. Variations between individual nozzle flow rates with the average header flow of 4.72 X $10^{-4}m^3sec^{-1}$ were less than $\pm$ 5%. Aerosol studies to characterize material loss in this sampling system as a function of particle size at the designed sampling rates are presently under investigation.

A total of 4.72 X $10^{-3}m^3sec^{-1}$ is continuously sampled through the isokinetic sampling unit with 3.78 X $10^{-3}m^3sec^{-1}$ to a fixed head air sampler for subsequent analysis and 9.44 X $10^{-4}m^3sec^{-1}$ to the continuous air monitor (CAM). An emergency single probe battery operated sampler is installed and will automatically operate for eight hours, if any portion of the primary sampling system fails. The battery operated emergency sampling system will operate at a flow rate of 2.36 X $10^{-4} m^3 sec^{-1}$.

The CAM (Figure 3) consists of an air sample head which utilizes a 25 mm diameter membrane filter, a solid state silicon diffused junction type detector with a face surface area of 490 mm^2 and two single channel pulse height analyzers. Resolution of the continuous air monitor is highly dependent upon the type of filter medium used to collect the air sample. Millipore Type SM filter medium (5.0 μm pore size) has proven effective for alpha continuous air monitors due to its high collection efficiency and surface deposition characteristics.[3]

One pulse height analyzer is specific for plutonium alpha energies and the other for natural radon-thoron daughter alpha energies. The lower plutonium window threshold is set at 4.8 MeV with a window width of 1 MeV allowing simultaneous detection of Pu-238 and Pu-239. The upper window is adjustable to allow detection of 5.99 MeV radium-A alpha particles. Investigations reveal that approximately two percent of the radium-A alpha particles undergo energy degradation sufficient to result in detection in the lower plutonium window; therefore, this detection allows automatic background radon-thoron subtraction. Each CAM has local analysis capabilities through two log circuits associated with the single channel analyzers. The local analysis capability is used to sound a local alarm and notify the computer of this alarm by a switch closure output channel from the instrument to the computer. The CAM is provided with two pulse output channels relayed through a multiplex scanner to the central computer.

During normal operations, the computer will calculate the corrected counts per minute every 30 seconds. This data is available for display at remote CRT units at any time. If a local alarm is generated at the instrument, a switch closure notifies the computer which initiates interrogation of the associated pulse channels every 15 seconds and performs the necessary computations to display plutonium airborne concentration in disentigrations per minute per cubic meter.

There are approximately 125 continuous air monitors in the new Plutonium Facility, all of which are connected to the computer. Continuous air monitors serve two distinct purposes in the facility; first to detect above normal room air plutonium concentrations which require evacuation of personnel from the immediate area, and second, to provide information concerning ventilation system and stack plutonium concentrations. Figure 4 shows the plutonium facility laboratories and associated room air continuous air monitors. A continuous air monitor is located at every laboratory exhaust register in the plutonium facility. Again, the primary purpose of these instruments is to notify personnel of high airborne plutonium concentrations; however, they also are helpful in early notification of high ventilation system plutonium concentrations which could result in stack releases from the facility.

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[3]Alpha Air Monitor, Technical Manual, Eberline Instrument Corporation, Santa Fe, New Mexico.

. . . ates . ne half of the building ventilation system with associated continuous air monitors. Outside make-up air enters the facility through . . . . ency . arti ulate Air (HEPA) filter to the building corridors and infiltrates through doors i . o individual laboratories. Air is then exhausted from the laboratories through two banks of HEPA filters where 90% of the air is recirculated back to the laboratories and 10% bled off . . . . here thro gh two additional banks of HEPA filters. A small quantity (approximately .94 m^3sec^{-1}) is also removed and dried to supply air to gloveboxes where plutonium is handled. Air exhausted from Pu-239 glove-boxes is . . . ered through three stages of HEPA filters and four stages for Pu-238 glovebox exhaust. Process or glovebox air is not recirculated prior to being exhausted. All effluent air from each half of the building is combined into a common plenum before being released to the atmosphere. Continuous Air Monitors are supplied in ventilation system duct work at strategic locations to provide information which can define the source of plutonium release. All laboratory and exhaust duct continuous air monitors transmit data to the computer for interro . . . . cal alarm is identified, the computer begins interrogating the asso . iat . . . . . channels every 15 seconds, computes the change in concentration for each 15 second period, logs the information in a disk file, and displays the new data at all CRT's. If the alarm lasts for less than four 15 second scans, the computer identifies this data as a calibration run and stores the information in a disk file for subsequent retrieval. The computer also deletes the local alarm if a calibration has been identified. If the alarm is maintained for four or more 15 second scans, the computer accepts the data as a valid local alarm and transmits an alarm signal to the Health Physics Office, Control Room, and Management Office. It will then calculate and log the change in airborne concentration (in $\mu Ci\ ml^{-1}$) as a function of time. After the change in concentration for subsequent scans returns to zero, the computer will log the total integrated activity (in µCi) collected on the continuous air monitor filter and will then return to normal 30 second scans. A continuous air monitor is considered as a non-functional unit if the computer receives less than three counts from the upper background window during a one minute period. An instrument failure is identified by an alarm condition at all CRT terminals. The alarm condition persists until the unit is either repaired or removed from the system.

Release of plutonium to the environment from either stack is detected either by a local logarithmic circuit at the continuous air monitor instrument relaying an alarm condition to the computer, or by the detection of above tolerance plutonium as determined by the pulse output analyzed at the computer. Plutonium effluent alarm conditions are presently set at 3.6×10^{-5} µCi of plutonium collected on the membrane filter as determined by the computer. This activity represents a plutonium concentration of 4.4×10^{-13} $\mu Ci\ ml^{-1}$ averaged over 24 hours. After an alarm condition is registered by the computer, an update mode switches the data scanning intervals from 30 seconds to 15 seconds. Information supplied in the update mode allows computer determination of the actual airborne concentration (in disintegrations per minute per cubic meter) as a function of time. The integrated concentration is then continuously graphed and displayed on CRT units as concentration released to the atmosphere in $\mu Ci\ ml^{-1}$ as a function of time. This available data provides information for management decisions leading to complete building ventilation shut down to avoid unacceptable atmospheric releases.

Stack continuous air monitor filters are changed each morning at 8:15 a.m.

At 8:10 a.m., the computer averages the previous ten scans and computes the average effluent plutonium concentration for the previous 24 hours. This data is stored and accumulated in a disk file for subsequent retrieval and reporting. A print out may be received at any time from the computer terminal.

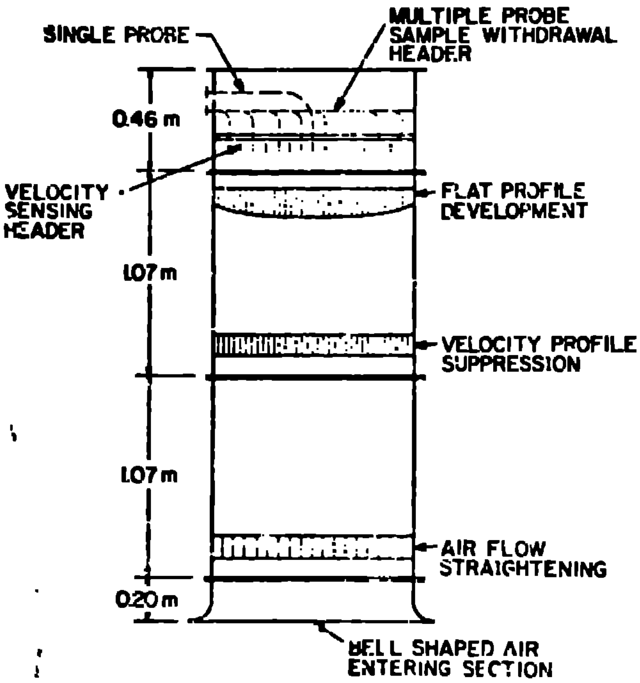
REFERENCES

[1] UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, General Design Criteria for Plutonium Facilities, ERDA Manual Chapter 6301, Part II. September 17, 1974.

[2] ANSI Standard N13.1-1969, American National Standards Institute, Inc. 1430 Broadway, New York, NY 10018.

[3] Alpha Air Monitor, Technical Manual, Eberline Instrument Coporation, Santa Fe, New Mexico.

FIGURE 1

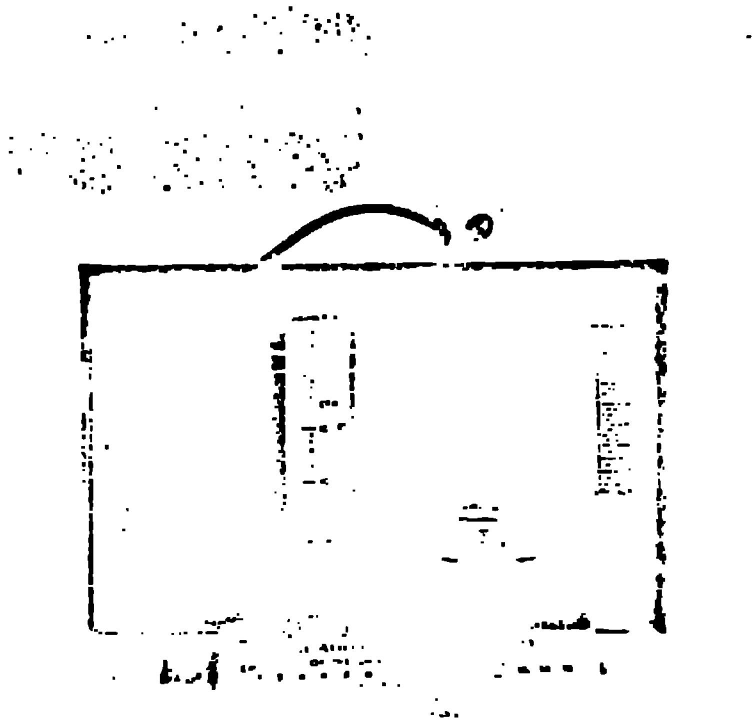


ISOKINETIC STACK SAMPLING UNIT

FIGURE 2

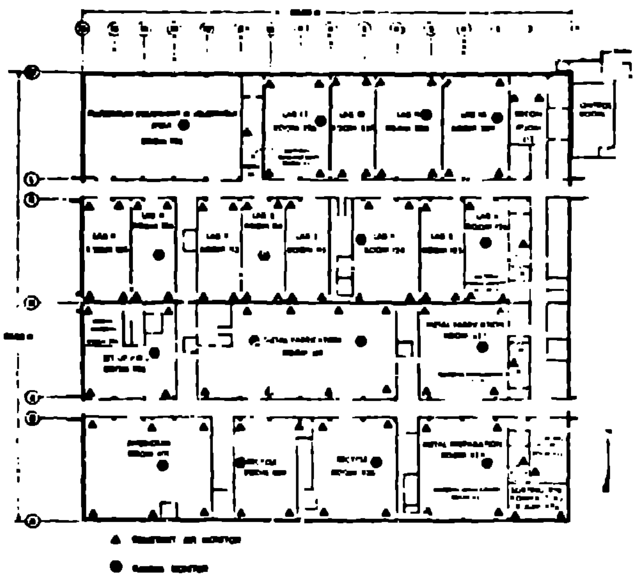
ISOKINETIC SAMPLING PROBE ASSEMBLY

FIGURE 3



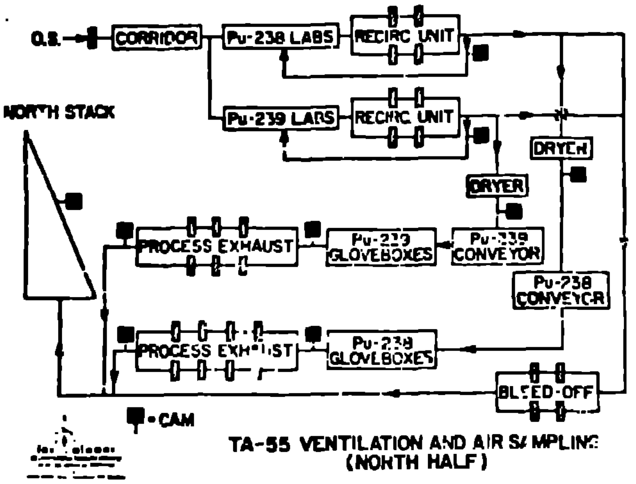
CONTINUOUS AIR MONITOR

FIGURE 4



PLUTON[illegible] FACILITY GAMMA AND CONTINUOUS AIR MONITORS

FIGURE 5



TA-55 VENTILATION AND AIR SAMPLING
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