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Tritium Monitoring at the Sandia Tritium Research Laboratory

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TRITIUM MONITORING AT THE SANDIA TRITIUM RESEARCH LABORATORY

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ABSTRACT

Sandia Laboratories at Livermore, California, is presently beginning operation of a Tritium Research Laboratory (TRL). The laboratory incorporates containment and cleanup facilities such that any unscheduled tritium release is captured rather than vented to the atmosphere. A sophisticated tritium monitoring system is in use at the TRL to protect operating personnel and the environment, as well as ensure the safe and effective operation of the TRL decontamination systems. Each monitoring system has, in addition to a local display, a display in a centralized control room which, when coupled with the TRL control computer, automatically provides an immediate assessment of the status of the entire facility. The computer controls a complex alarm array and integrates and records all operational and unscheduled tritium releases.

ACKNOWLEDGMENTS

This system was developed under the direction of P. K. Lovell and P. D. Gildea. W. Wall was responsible for design of the system. R. Hafner was responsible for installation and calibration of the system.

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TRITIUM MONITORING AT THE
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The Tritium Research Laboratory

Sandia Laboratories Livermore is presently beginning operation of a Tritium Research Laboratory (TRL) designed for experimental work with isotopes of hydrogen and their compounds. A diverse range of experiments is possible involving gram amounts of tritium. The design basis of the facility incorporates the U. S. Department of Energy philosophy of limiting release to the environment to "as low as reasonably achievable," which is implemented through containment and recovery. This is a major departure from the established practice of using high-velocity air hoods exhausted through stacks to the environment in order to protect operating personnel.

The TRL (Figure 1) houses offices, laboratories, and containment and decontamination systems. The facility consists essentially of a central corridor with adjacent laboratories (Figure 2). Personnel protection is assured by a pressure-gradient-controlled once-through ventilation system which exhausts to a 30 meter stack. The TRL containment concept is illustrated in Figure 3. To contain any inadvertant release as well as operational leakage (due to diffusion and venting), all experiments are conducted in sealed glove boxes.

The glove boxes are constructed of welded stainless steel and are equipped with 34 glove ports, 14 viewing windows, and an air lock passthrough (Figure 4). Normally, the glove box pressure is maintained by the box pressure control system at -0.25 to -1.0 kPa with respect to the room with dry nitrogen or argon. A cooling system removes heat generated by experiments. Both tritium concentration and humidity control are maintained by connection to the decontamination system.

Decontamination of the glove box atmosphere is accomplished by two centralized systems[1], the Gas Purification System (GPS) and the Vacuum Effluent Recovery System. The systems were designed to be capable of reducing tritium concentrations to the low parts-per-billion level. Performance tests conducted on the systems show tritium removal with a concentration reduction factor (ratio of inlet to exhaust concentration) much in excess of 1000 per pass at an inlet concentration of 1 ppm (2.6 Ci/m^3 for T_2) or less for both tritium and tritiated methane.[2,3]

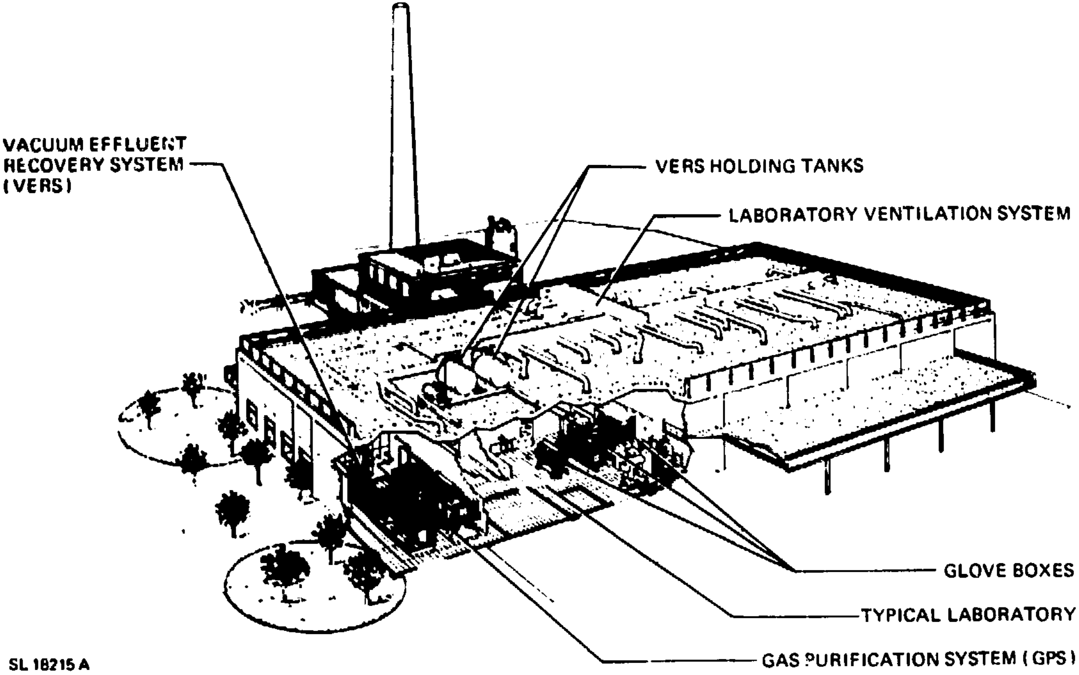


Figure 1. The TRL Building at Livermore

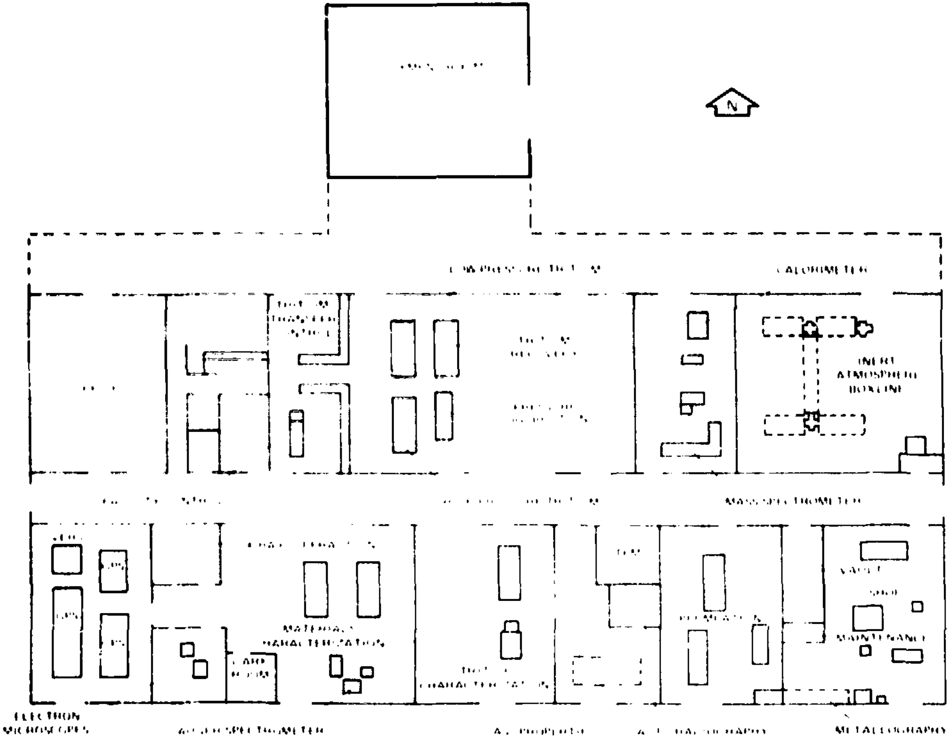


Figure 2. TRL Floor Plan

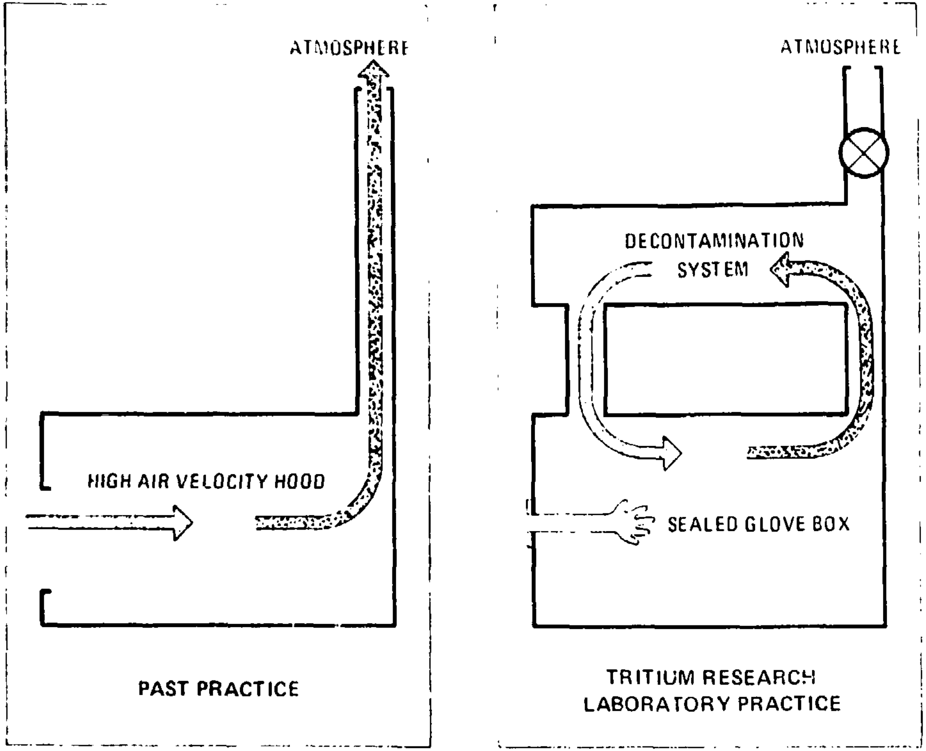


Figure 3. TRL Containment Concept

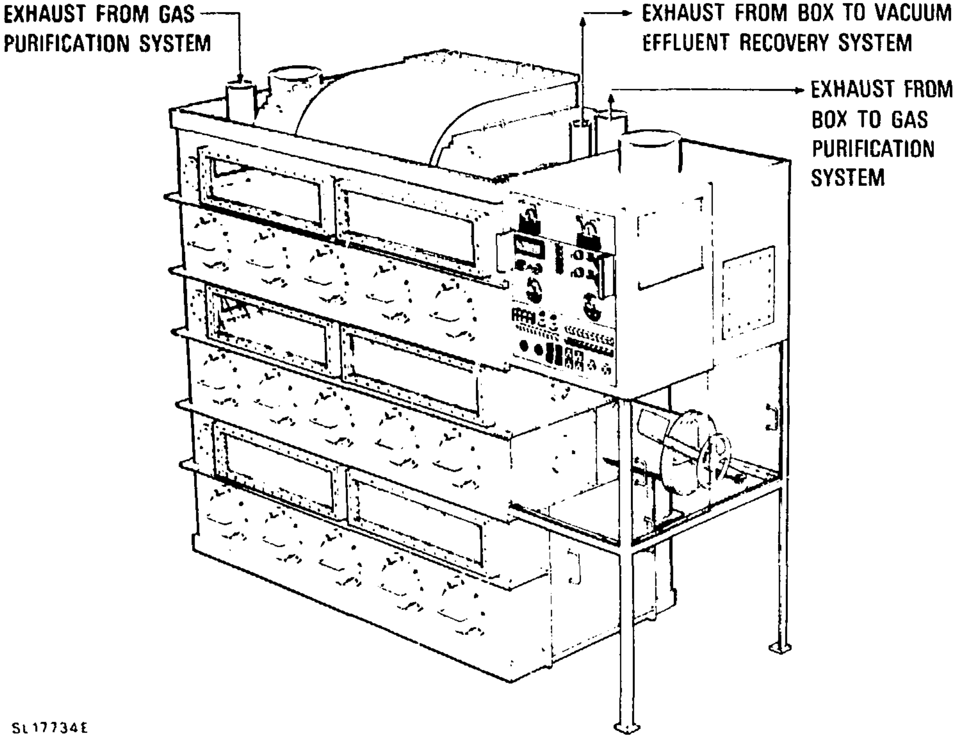


Figure 4. Sealed Glove Box

The GPS (Figure 5) protects against either an accidental release or a slow buildup of background tritium concentrations. The 340-m^3/h flow-rate system consists of a central manifold connected to each of the laboratory glove boxes, a catalytic reactor to oxidize the tritium, two molecular sieve dryers in series to collect the tritiated water, a blower to circulate the glove box atmosphere through the system, and a control and diagnostics system. The normal recirculation mode moves glove box gases through the GPS and back to the box until the contamination is reduced to an acceptable level.

The VEPS (Figure 6) decontaminates exhaust gases from the laboratory vacuum system before venting to the stack. The 17-m^3/h flow-rate system consists of a laboratory vacuum manifold and two holding tanks to collect the effluent, a catalytic reactor to oxidize the tritium, the molecular sieve dryers to collect the tritiated water, the necessary pumps to evacuate the laboratory manifold and transfer the effluent through the system, and a control and diagnostic system.

The TPL Monitoring System

The TPL monitoring system is designed to protect operating personnel and the environment, as well as to ensure the safe and effective operation of the decontamination systems. Tritium air concentrations are monitored in the room air, glove boxes, stack, GPS, and the VEPS with the use of Betatec tritium monitors. (All liquid wastes from the facility, collected in one of two 2500 gallon hold tanks, are monitored by standard liquid scintillation techniques prior to release to the sanitary waste system.) Each tritium monitor is interfaced with a central control computer, which continuously scans tritium concentrations, assesses the hazards based on the monitor readings, and automatically takes the appropriate action according to the hazard involved. Monitoring capability ranges from $\mu Ci/m^3$ to kCi/m^3 levels.

Room Air Monitoring

The ambient air in each room of the TPL is constantly monitored for tritium with a range of 1 $\mu Ci/m^3$ to 20 Ci/m^3. Each room air monitoring system (Figure 7) consists of remotely selectable multiple inlet lines, a metal bellows air mover, flow gage, dual 2-liter ionization chambers (Figure 8) with vibrating reed electrometer, and several digital displays. The five-decade autoranging digital displays are located in the rooms themselves (Figure 9), in the central corridor at the doorways to each room (Figure 10), and in the control room (Figure 11). The meter module[4] provides direct digital readout of the tritium concentration and independent, fully adjustable low- and high-level audible/visual alarms. Console displays are similar to the meter module, but in addition are the interface between

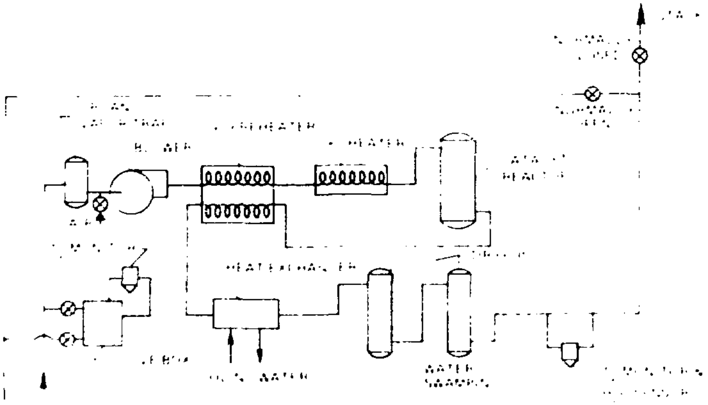


Figure 5. GPS Schematic

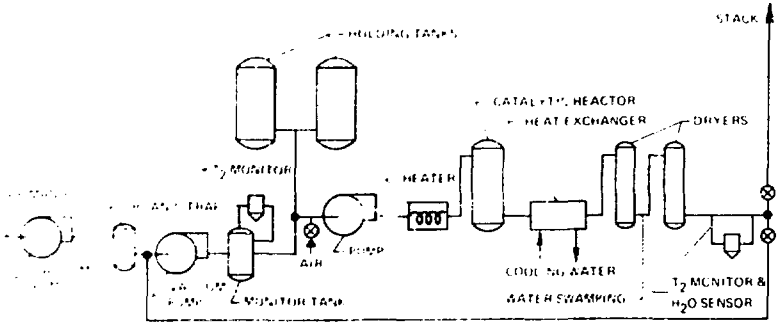


Figure 6. VERS Schematic

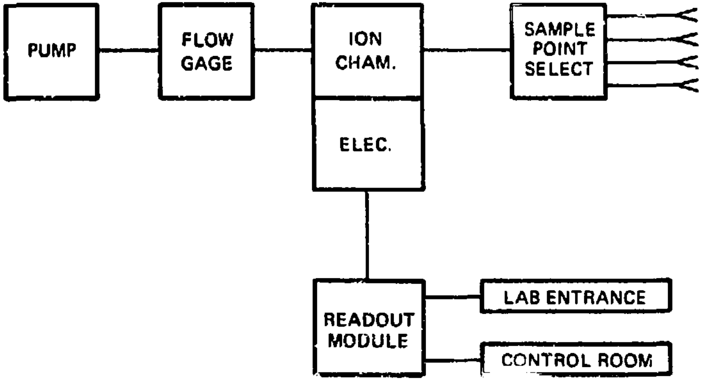


Figure 7. TRL Monitoring System Schematic

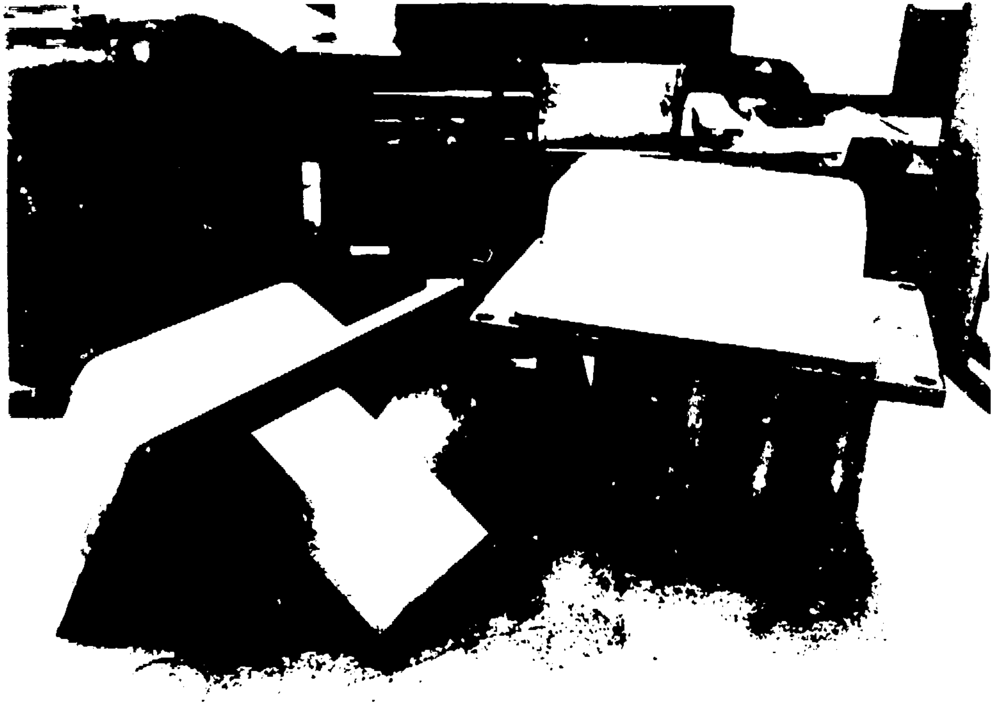


Figure 8. Dual 2-Liter and 20-cm^3 Ion Chambers

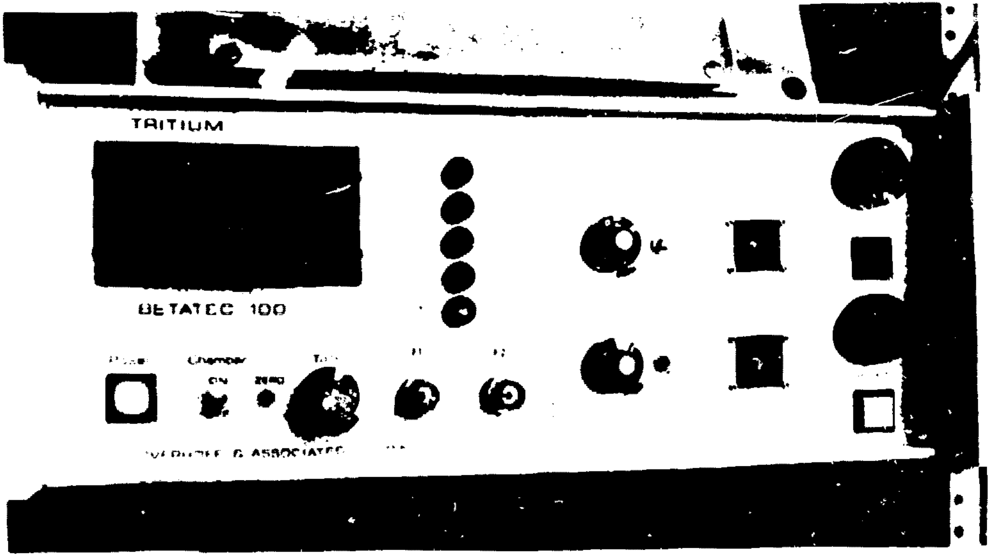


Figure 9. A Meter Module

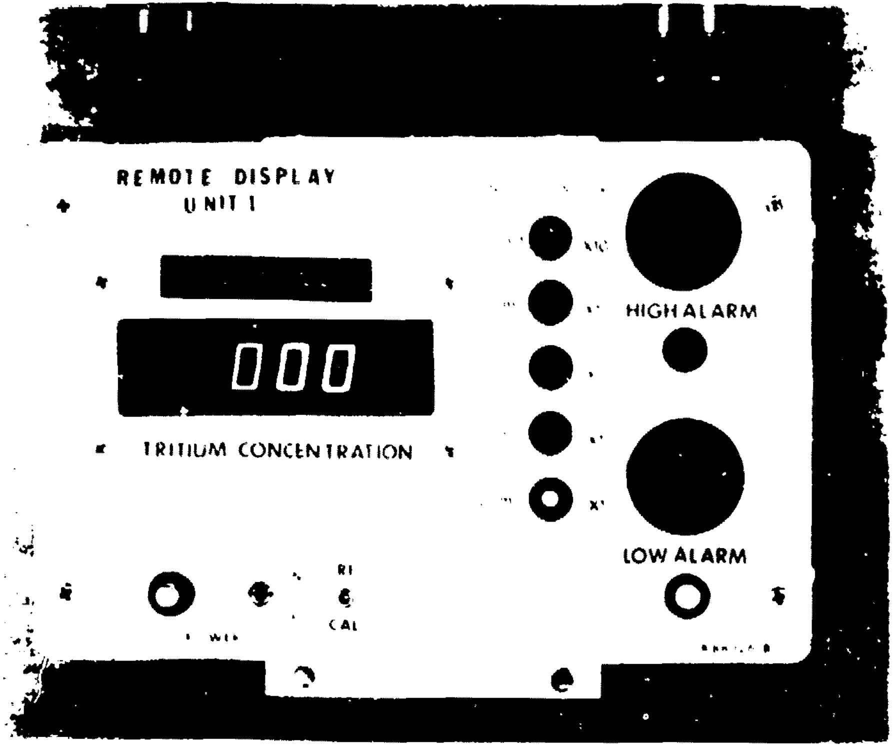


Figure 10 A Remote Display Module

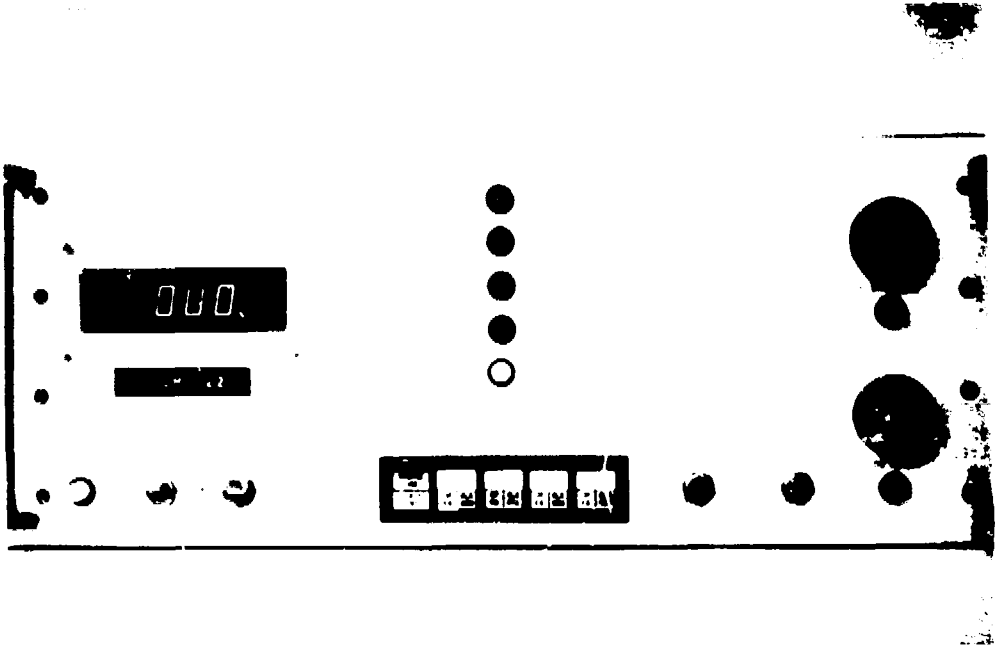


Figure 11. A Console Display Module

[illegible] located in the [illegible].

A [illegible] feature of the room-air monitoring system is the room-air [illegible] manifold. The [illegible] manifold allows localized monitoring in each room. Each manifold [illegible] of a remotely selectable, four-way inlet system and is [illegible] with [illegible] and normally open solenoid valve. The [illegible] are selected [illegible] likely release of tritium [illegible] the working face of a glove box. In the normal [illegible] all the valves are open such that the average [illegible] particular area of the room [illegible] the valves [illegible] only closed from the appropriate [illegible].

[illegible]

The [illegible] glove box [illegible] continuously monitored with [illegible] with a sensitivity of [illegible]. This range was selected to monitor glove box tritium [illegible]. The glove box monitor provides a control [illegible] when a glove box tritium concentration exceeds a [illegible] level, the box is connected to the [illegible] for decontamination. [illegible] building [illegible] glove box. A [illegible] display is located on each glove [illegible] as well as in the control room. The control room console display also controls a backup glove box [illegible] calibration line.

[illegible] Effluent Monitoring System

There are no scheduled releases of tritium to the 30-m stack. However, some low-level tritium is released to the laboratory areas and glove boxes, [illegible] the use of maintenance procedures. Tritium is released either as elemental gas or in chemical combinations such as tritiated water or methane. Ultimate operating-personnel protection is assured by the pressure-gradient-controlled once-through ventilation system exhausting to the stack.

Air exhausted from the facility is collected in a central duct and is drawn through an air equalizing and straightening section, past the stack tritium monitoring sampling array, through the exhaust fans, and up the stack (Figure 12). The sampling array features an expanded aluminum honeycomb straightening section (Figure 13) which reduces variances in the velocity profile of the air flow leaving the section. All air rotation (turbulence) is eliminated and uniform laminar air flow is delivered to the sensor sections. The air flow is thus fully processed, and directionalized air flow is delivered to the sensor sections for accurate measurement. The sensor sections function on the principle of a pitot tube. The system includes separate static and total pressure sensing and averaging manifolds, and the stack tritium monitor sampling array.

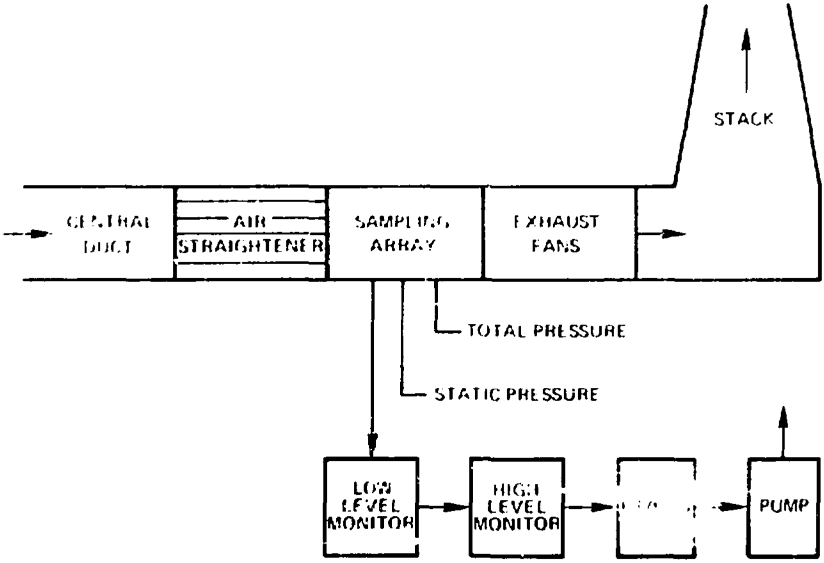


Figure 12. Schematic of the TRL Stack Tritium Monitoring System

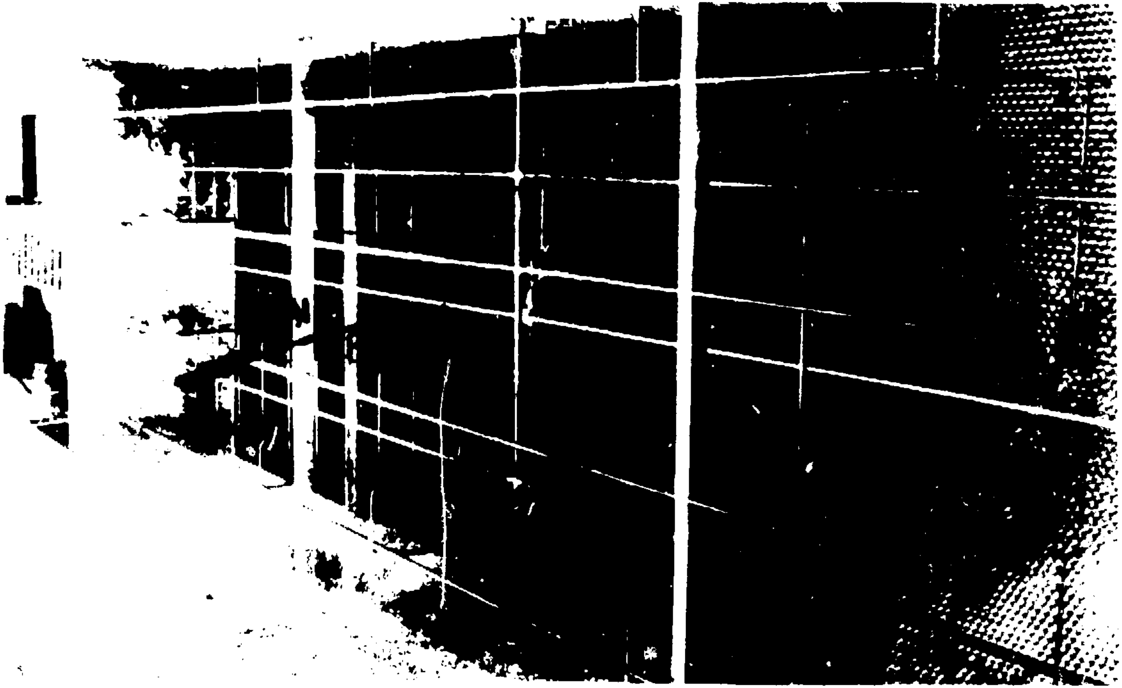


Figure 13. The Stack Effluent Sample Array

[illegible] located in the control room [illegible] interfaces directly with the control computer, [illegible] drives a totalizer.

The totalizer integrates the total amount of tritium released to the stack for a preset integration interval. An accumulated readout is [illegible] the total tritium released to the stack since the totalizer was [illegible] reset to zero. At the end of each integration interval, the results [illegible]. The totalizer is provided with a low- and a [illegible] alarm, which are activated if the tritium totals exceed their [illegible] preset levels during the integration interval. The stack [illegible] is also integrated by the control computer, which samples and stores [illegible] every ten seconds.

[illegible] conditions, [illegible] tritiated hydrocarbons [illegible] in the stack gases. [illegible] and tested [illegible] between the [illegible] indicate a sensitivity [illegible] the μCi/m³ [illegible].

[illegible]—Although the individual components of the stack monitoring system had been tested prior to assembly, the complete system had not been tested with tritium. Therefore general tests were performed involving releases of [illegible] of tritium to the ventilation system (Ref 5). Known amounts of tritium were released under continuous and instantaneous release conditions. [illegible] stack concentration and the totalizer readings agreed with the calculated values within 5%, assuring reliability of the stack monitoring system.

[illegible] Monitors

The GPS, through which the glove box atmospheres are circulated, has inlet, internal, and exhaust tritium monitors with sensitivities from 1 μCi/m³ to [illegible] kCi/m³, depending on the desired level of each. For example, the inlet monitor is identical to a glove box monitor, with a range from 1 μCi/m³ to 20 kCi/m³. This monitor also drives a totalizer which records the total amount of tritium processed by the GPS.

The VERS, which collects the effluent from all of the vacuum systems in the TRL, has internal and exhaust monitors with sensitivities from 10 μCi/m³ to 200 Ci/m³. Display modules for the VERS, as well as the GPS, are located at the entrance to the systems' equipment room and in the control room at the appropriate control station (Figures 15 and 16).

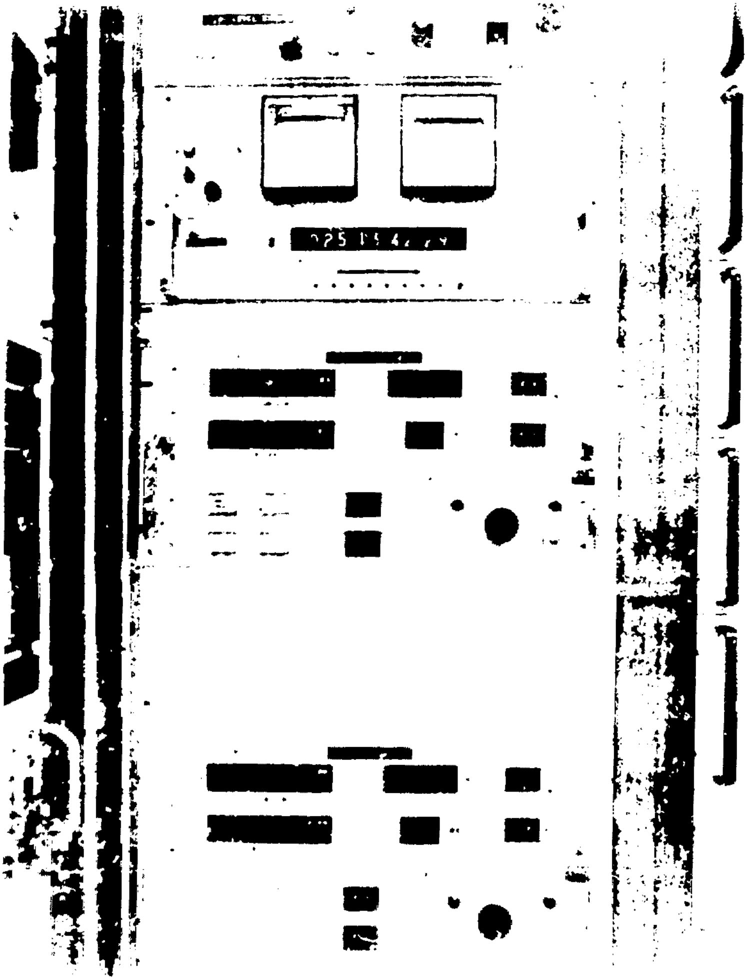


Figure [illegible] The Installed System

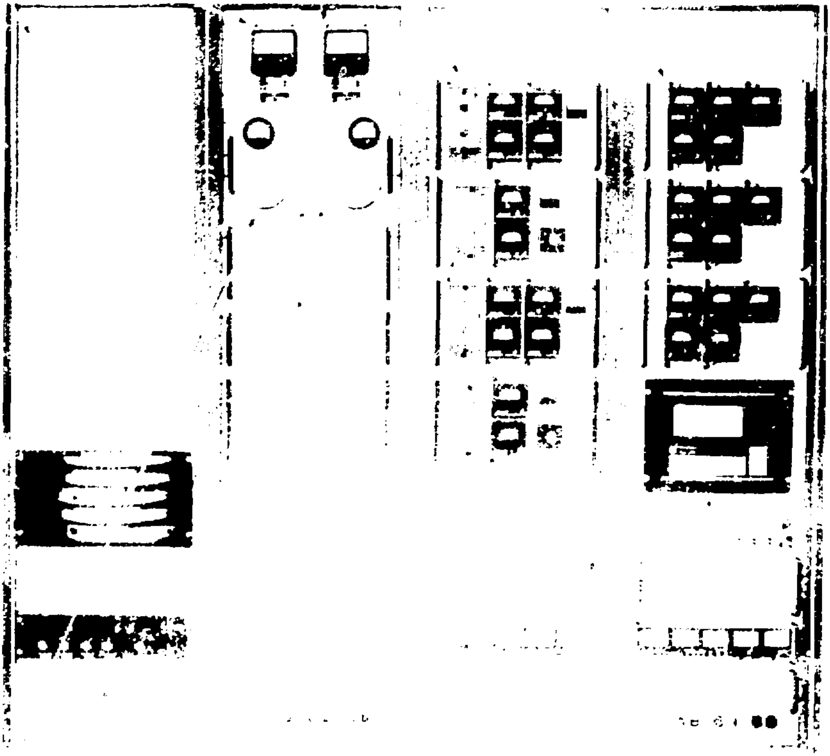
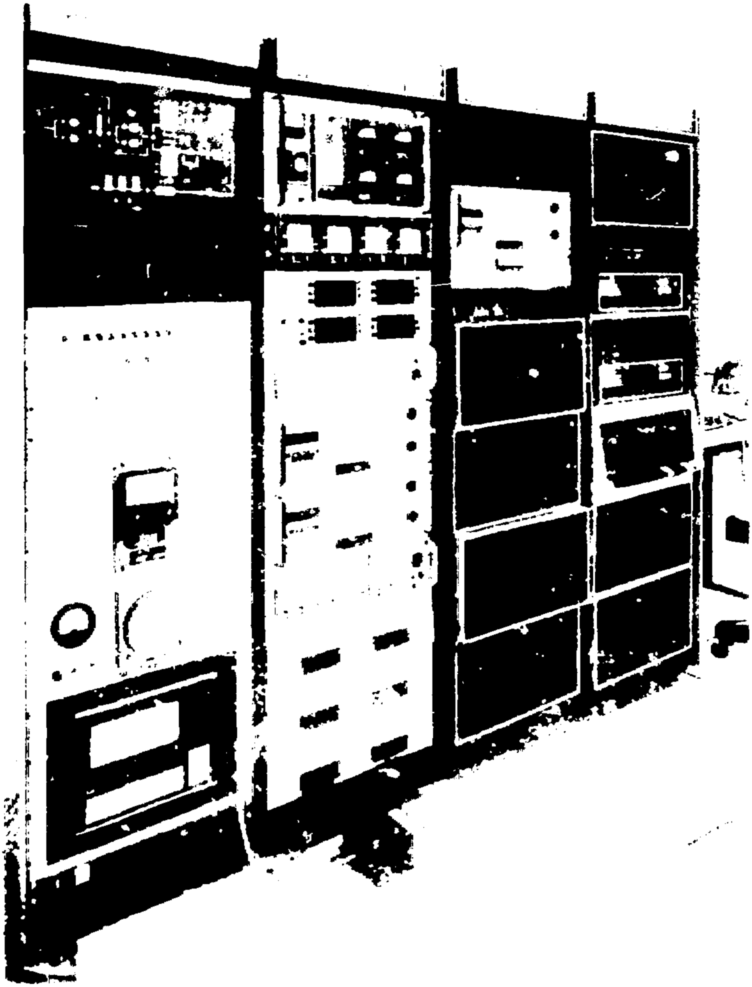


Figure 15. GPS Control Panel



[illegible]

Automated Tritium Monitoring

The TRL control computer is a Digital Equipment Corporation PDP 11/40 computer (Fig. 17). The tritium concentration is automatically read and recorded for each tritium monitor location. It scans containment and decontamination equipment control systems for any malfunctions. The scan rate is on the order of one scan every ten seconds. It also generates control functions. For example, when a high glove box tritium level exists, the computer selects the proper operating parameters for the GPS and connects the box to the GPS until the tritium level has been sufficiently reduced.

As previously discussed, all TRL tritium monitors are equipped with nonquenchable low- and high-level audible alarms with selectable set points. Should a tritium level exceed a specified threshold for a monitor, in addition to local alarms, an alarm function is generated by the computer. This computer-generated alarm is independent of meter module alarm and is typically set some 10 to 20% lower in order to alert control room personnel to the impending alarm condition.

Whenever the computer detects an alarm condition, it activates the guard alarm interface. A large number of alarm functions are multiplexed into the interface unit. An alarm may be generated by the computer or any of several TRL systems such as the GPS, VERS, any tritium monitor, ventilation system, compressed air, chilled water, or the electrical power distribution system. The interface unit generates one of four alarm functions based on the severity of the malfunction. In order of increasing importance, these are: operational, hazard, danger, and emergency. An audible alarm is activated and the appropriate area of malfunction visually indicated. During non-operational hours, the alarm is relayed to Security Headquarters indicating which of the four alarm functions has been activated so that the appropriate personnel can be notified. The emergency alarm is relayed to Security Headquarters at all times.

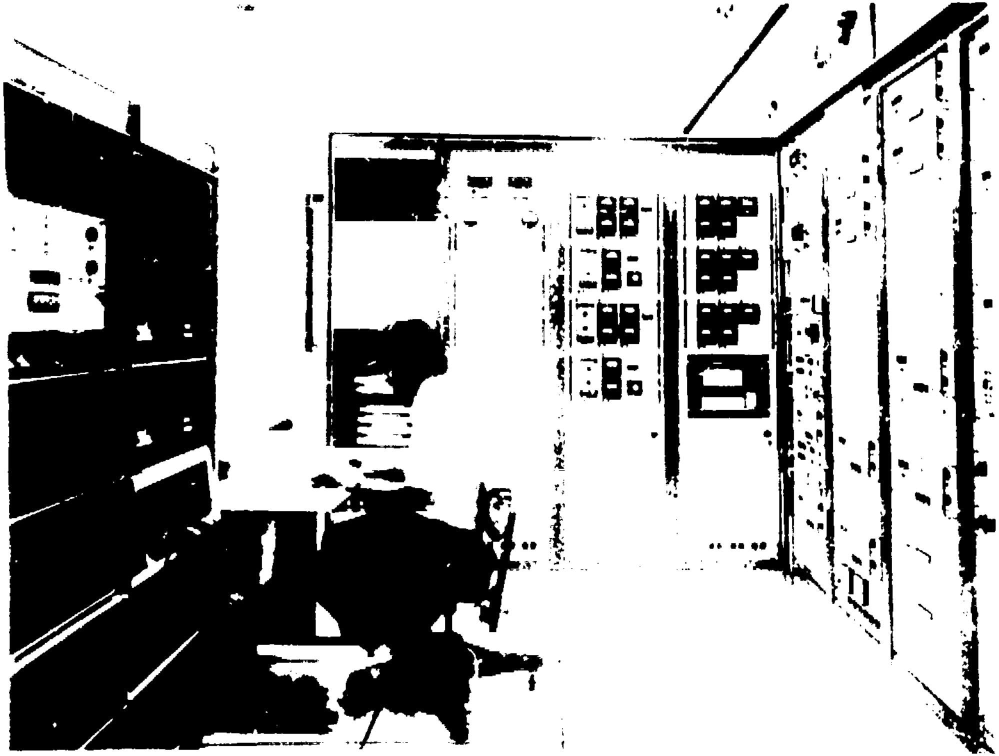


Figure 17. The TRL Control Computer

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