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DATE - January 25, 1968

DESCRIPTION OF PROCESS RADIATION MONITORING INSTRUMENTATION IN THE TRANSURANIUM PROCESSING PLANT, BUILDING 7920

J. H. Holladay D. J. Knowles

1. ABSTRACT

Radiation monitoring instrumentation was installed in the Transuranium Processing Plant, Building 7920, to continuously monitor process areas and equipment for process analysis and control.

Pipes carrying cell ventilation air and vessel off-gas are monitored before the gases enter the HFIR stack. Drain lines carrying process wastes are monitored in the pipe tunnel of Building 7920 and again before they enter the pond area. Radiation detectors are throughout the building at pipes, pumps, etc., for detection of an increase in radiation level in process piping. A radiation detector in each cell measures radioactivity of materials before they are removed from the cell.

The equipment used and the overall operation of the systems are described. Drawing references and a check-out procedure for the vessel off-gas monitoring system are included.

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2. INTRODUCTION

Radiation monitors were installed in the Transuranium Processing Plant, Building 7920, to provide continuous surveillance of process equipment and areas. Four groups of instruments were installed: (1) in the cell ventilation duct and the vessel off-gas line, (2) in the process-waste drain line, (3) at piping, pumps, etc., in various locations throughout the process area, and (4) in each cell. These instruments, indicating at the central radiation monitoring panel (Fig. 1), are for process analysis and control, and are separate from the facility radiation and contamination alarm systems.[1] After radiation levels become established for steady-state operation with intensely radioactive materials, monitoring data showing long-term deviations from the steady-state values are generally useful information for evaluation of process operation, and often indicate impending process upsets. Sudden changes in radiation level usually indicate process upsets or equipment failures. Such instruments complement the process instrumentation system for measurement of process variables such as pressure, temperature, specific gravity, etc.

3. GASEOUS WASTE MONITORING

The High Flux Isotope Reactor (HFIR) stack, 250 ft tall, is the main disposal stack for the Transuranium Processing Plant (TRU), the HFIR, and the Thorium-Uranium Fuel Cycle Development Facility. Cell ventilation air (high flow, low contamination) makes up the bulk of the air flow to the stack; off-gas (low flow, high contamination) is also disposed of through this stack. These two air volumes are first cleaned separately, and then they are mixed before they enter the main exhaust duct to the stack.

Air flowing through the stack at the 50-ft level is monitored by samplers which withdraw small portions of the air stream for counting.[2]

In addition to the stack monitors, each of the three facilities has duct monitors so that, if the stack monitors give warning that the air passing through the stack is radioactive above tolerance, one of the duct monitors will also indicate which facility has released the contaminated effluent.

Two pipes carry effluent from Building 7920 to the stack: cell ventilation air flows through a 48-in.-diameter duct, and vessel off-gas flows through a 10-in.-diameter pipe. The pipe is connected to the duct at the stack area, and both the duct and the pipe are equipped with monitors which are similar except for the sampling nozzle assemblies.

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[1] J. H. Holladay and D. J. Knowles, Description of Facility Radiation and Contamination Alarm Systems Installed in the Transuranium Processing Plant, Building 7920, ORNL-TM-1766 (April 1967). These systems are for protection of personnel working in the building.

[2] These monitoring systems have not been described in a single report. The information collected by these systems is read out at the HFIR and at Bldg. 3105, the Waste Monitoring Control Center.

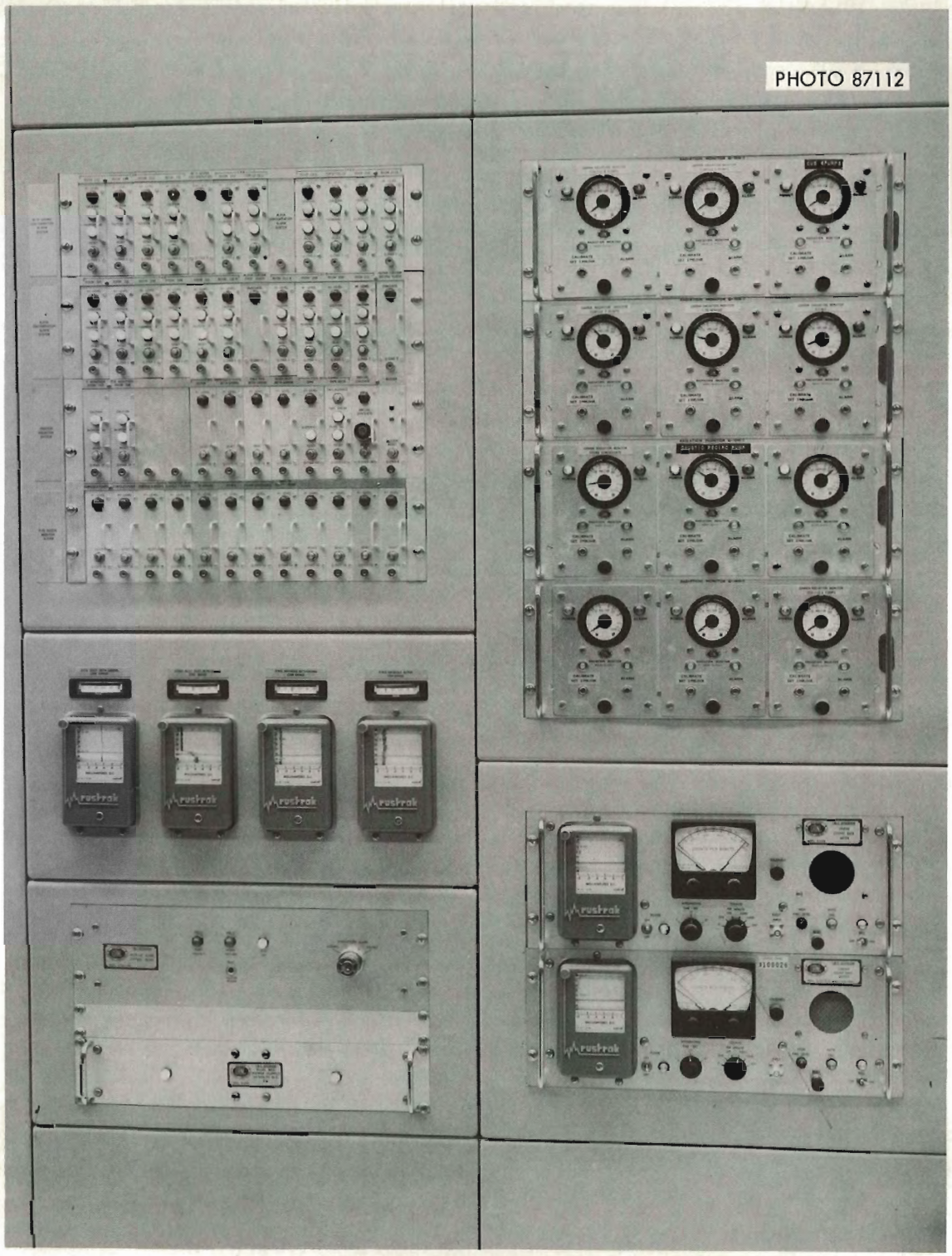

Fig. 1. Central Radiation Monitoring Panel.

When the air (which is combined cell ventilation air and vessel off-gas) sampled by the duct monitor (Fig. 2) is contaminated above tolerance, a "high-level" radiation alarm is annunciated in the Waste Monitoring Control Center, Building 3105, and the TRU plant. High-level radiation alarms from the 10-in.-diameter pipe are annunciated only in the TRU plant.

3.1 Duct Monitor

A sample of air is continuously withdrawn from the duct stream under approximately isokinetic conditions and pumped through the duct monitor[3] at 2.5 cfm by a Roots blower (Fig. 3). Failure of the blower, detected by a vacuum switch, is annunciated by an alarm in the Waste Monitoring Control Center. The air sample is filtered through a section (2.5 x 1 in.) of No. 4 Whatman filter paper which collects more than 90% of the particulates greater than 0.3 μ diameter. Although the air flow rate is not regulated, it remains reasonably constant at 2.5 cfm since the filter is changed every 8 hr (the paper is contained in the monitor as a roll 3 in. wide and 145 ft long). The filter tape can be advanced by a 24-v dc signal from the Waste Monitoring Control Center. The tape entering and leaving the shield passes over wire fingers attached to microswitches, which informs the Waste Monitoring Control Center whenever the tape breaks or runs out.

The filter assembly is contained inside a 2-in. thick steel radiation shield. The material collected on the filter paper is surveyed for beta-gamma radioactivity by a Geiger-Mueller detector (a Lionel Electronic Laboratories, type 210 T tube) which has a mica end-window. The window thickness is 1.4-2 mg/cm^2 nominal, giving a detector sensitivity to beta energies as low as 35 kev.

The Geiger-Mueller tube is connected to a linear duty-cycle count-rate meter (ORNL model Q-2313-9) with a high-voltage supply as an integral part. A range of 0 to 250, 0 to 1000, 0 to 5000, 0 to 10,000, or 0 to 25,000 counts/min can be selected by means of a switch on the front panel. A voltage proportional to the range selected is telemetered from the count-rate meter to meters in Buildings 3105 and 7920 to indicate the range being used. An output signal from 0 to 1 ma full scale from the count-rate meter drives an integrally mounted Rustrak recorder which records the count rate; this signal is telemetered to Buildings 3105 and 7920 where the count rate is also recorded.

A high-level alarm set point on the count-rate meter can be set anywhere between approximately 10 and 100% of full scale by adjustment of the "high" contact on a meter relay. The associated high-level alarm relay is de-energized below the set point. When the high-level set point is reached, the meter contacts and relay are locked in, and an alarm is annunciated in Buildings 3105 and 7920. The contacts and relay are periodically released to allow an automatic reset when the radiation level decreases below the set point. The monitor will also indicate bursts of radioactive gaseous material passing through, but not collected on, the filter.

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[3]The duct monitor is located southwest of Bldg. 7920, adjacent to the exhaust fan pad and east of the 48-in. exhaust duct.

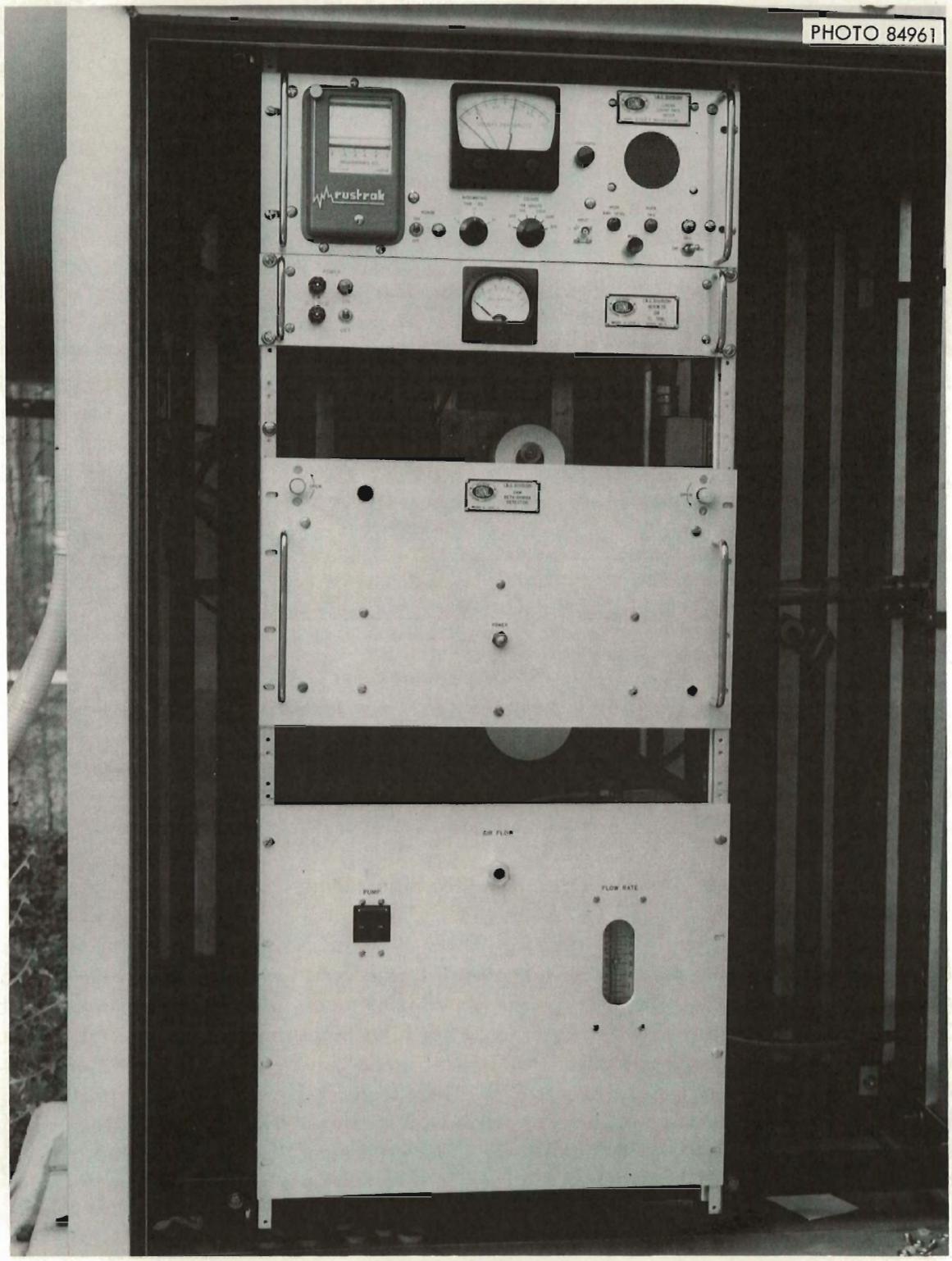

Fig. 2. Vessel Off-Gas and Cell Ventilation Duct Monitor.

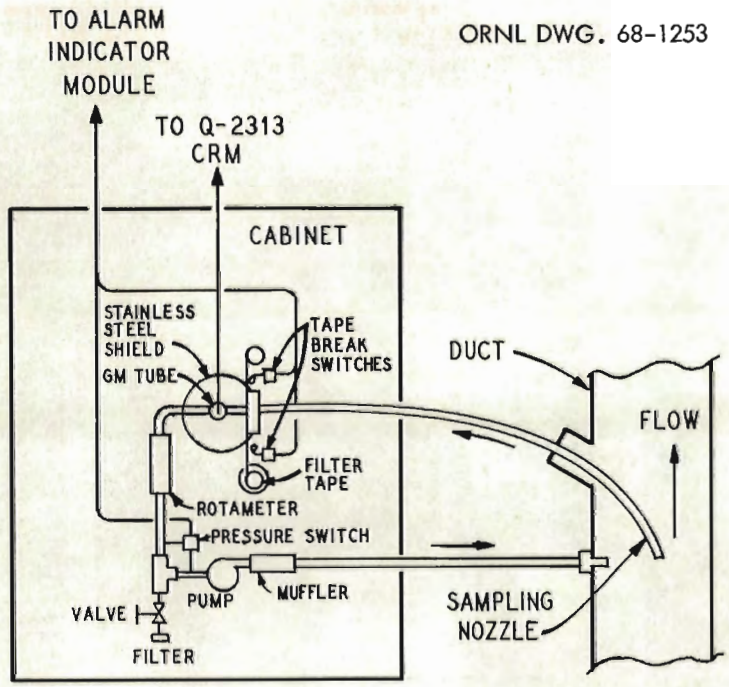

Fig. 3. Diagram of Duct Monitor.

The high-voltage supply is nominally 900 v with ±150 v adjustment.

If some malfunction of the count-rate meter should make it inoperative, an alarm will be annunciated in Building 3105.

3.2 Vessel Off-Gas Pipe Monitor

The vessel off-gas pipe monitor,[4] which is similar to the duct monitor except for the sampling nozzle assemblies, samples only the vessel off-gas. The beta-gamma detector is a thin-wall, type 106-C Geiger-Mueller tube with a window thickness of 30 mg/cm^2. The output of the Geiger-Mueller tube is transmitted by coaxial cable to a linear duty-cycle count-rate meter (ORNL model Q-2313-14) installed on the central monitoring panel in Building 7920. The Q-2313-14 model has a transistor impedance matching stage in the input stage which allows several hundred feet of coaxial cable to be used without the necessity of a preamplifier at the detector. In other respects the Q-2313-14 model is identical to the Q-2313-9 model in the duct monitor.

Since this monitor is not a part of the Waste Monitoring Control Center operations, alarm signals from the monitor (pump failure and filter tape breakage alarms) are transmitted only to Building 7920. Since the count-rate meter is in Building 7920 rather than at the monitor, the range is indicated and the count rate is recorded at

[4]This monitor is located southwest of Bldg. 7920 where the vessel off-gas line enters the exhaust fan pad.

panel 7 in Building 7920. The high-level radiation alarm signal and inoperative count-rate-meter alarm signal originate and are annunciated in Building 7920. The filter tape can be remotely advanced only from Building 7920.

3.3 Duct Flow Measurement

An anemometer was installed in the duct to continuously measure the flow rate of the air stream in the duct. The flow rate is recorded in Building 3105. Unusual changes in flow rate can be observed, and the average concentration of particulates in the duct stream can be calculated.

The anemometer, a Belfort Instrument Co. model 14208, type C, produces an ac signal whose amplitude and frequency are proportional to the flow rate. The ac generator is connected to a telemetering transmitter (ORNL model Q-2714-1) located in the duct monitor cabinet. The transmitter determines the air velocity by measuring the frequency of the ac signal, and is calibrated to produce a dc output signal of 1 ma at 20,000 cfm.

4. PROCESS WASTE DRAIN MONITOR

The process waste drain monitor[5] (Fig. 4) indicates total water flow and alpha and beta-gamma radioactivity levels, and automatically operates the TRU diversion valves when the alpha or beta-gamma activity in the water exceeds tolerance.

The flow rate is telemetered from the monitor to a multipoint recorder in Building 3105. The radiation levels are telemetered to a multipoint recorder in Building 3105 and to two Rustrak recorders on panel 6 in Building 7920. In addition, a "high level" radiation alarm signal is telemetered to Building 7920. Representative and proportional samples of water are collected daily for laboratory analysis.

Since routine check out and maintenance is provided by the ORNL Operations Division, coordinated by the Waste Monitoring Control Center, it is not described in this report. Briefly, it consists of checking each detector assembly with a radioactive source, observing water flow through the detector assembly, and checking telemetering and automatic diversion systems.

4.1 Sample Station

Process waste water from Building 7920 flows through a 60° V-notch weir (sized for maximum flow of 5000 gal/hr) in a covered rectangular box upstream from a diversion valve box (Fig. 5). The flow rate of the water is measured by a bubbler

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[5]This monitor is located on a pad north of the Melton Valley waste disposal ponds and adjacent to the TRU process waste drain diversion valves.

tube behind the weir; the back pressure of the water against air bubbled through the small tube is converted to a flow rate in gallons per hour by a pressure transducer and cam in a Bristol recorder. An air compressor in the monitor cabinet supplies the air for the bubbler tube.

A submerged pump (with a strainer in the pump inlet) in the reservoir behind the weir plate pumps approximately 1 gpm of water to the monitor cabinet where it flows past an alpha detector and a beta-gamma detector.

4.2 Alpha Detector

The alpha scintillation detector assembly (ORNL model Q-2590-1) is connected to a linear duty-cycle count-rate meter (ORNL model Q-2313-10) that has a high-voltage supply as an integral part. By means of a switch on the front panel, a range of 0 to 250, 0 to 1000, 0 to 5000, 0 to 10,000, or 0 to 25,000 counts/min can be selected. A voltage proportional to the range selected is transmitted from the count-rate meter to a meter in Building 7920 to indicate the range being used. The input sensitivity of the count-rate meter is 200 mv, and its overall accuracy, including the effect of long-term drift, is within 5% of the scale reading. The corona-regulated high-voltage supply is nominally 900 v with ±150 v adjustment. The maximum load current is 20 μa.

The high-level radiation alarm set point on the count-rate meter can be set between approximately 10% and 100% full scale by adjusting the "high" contact on a meter relay. The associated high-level relay is de-energized below the set point. When the alpha contamination in the water exceeds tolerance, the meter contacts and relay are locked in and transmitted to the back-flush module (Sect. 4.4) which also operates the diversion valves.

A 1-ma full-scale output signal from the count-rate meter drives an integrally mounted Rustrak recorder and is telemetered to a Rustrak recorder in Building 7920 and a multipoint recorder in Building 3105.

4.3 Beta-Gamma Detector Assembly

After passing through the alpha detector assembly, the process water flows by gravity through a beta-gamma detector assembly (ORNL model Q-1907-13) and returns to the weir box. The detector is a type 106-C Geiger-Mueller tube in a waterproof centrifuge tube which is immersed in the water stream within a plastic bottle. The entire assembly is in a lead shield (ORNL model Q-1907-15) to reduce external beta-gamma radiation. The G-M tube is connected to a linear count-rate meter (ORNL model Q-2313-10) which operates the same as the count-rate meter described in Sect. 4.2.

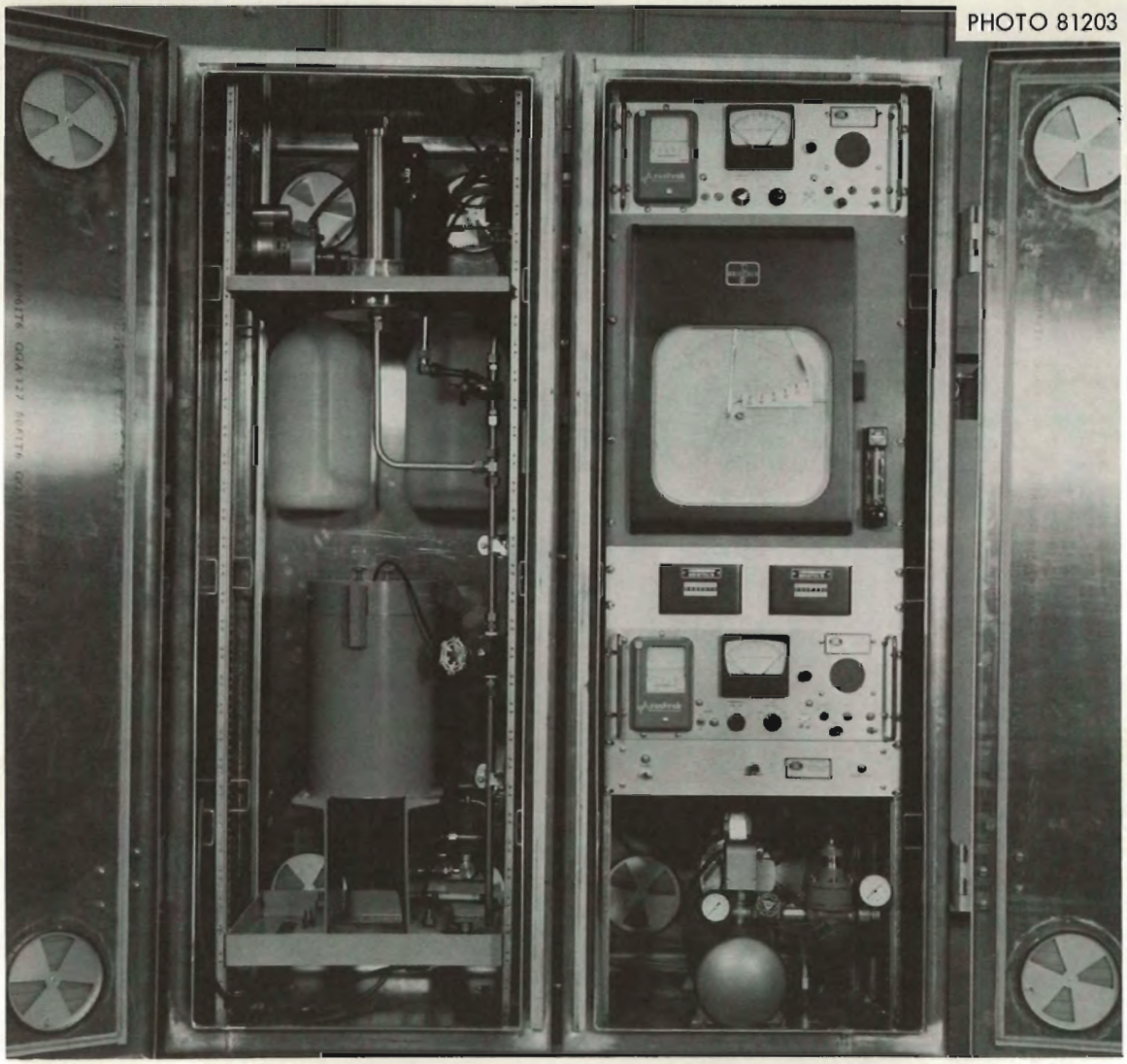


Fig. 4. Process Waste Drain Monitor.

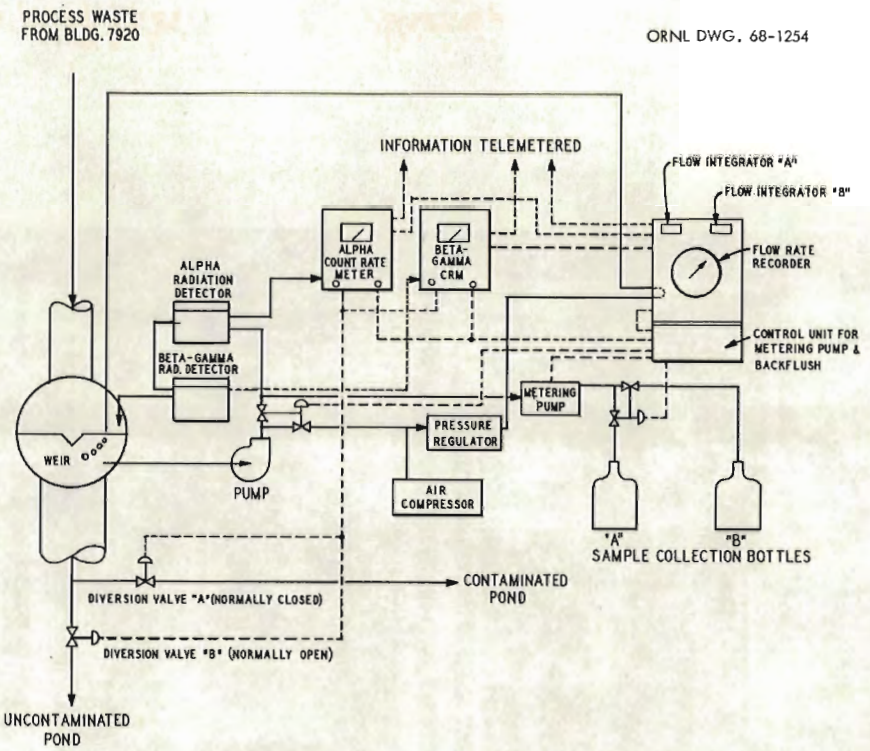


Fig. 5. Diagram of Process Waste Monitor.

4.4 Backflush Module

The strainer in the inlet to the submerged pump at the weir box is cleaned once each hour, as follows: the pump is stopped, a three-way solenoid is electrically operated, and compressed air is blown for 20 sec through the sample inlet pipe to expel materials collected in the valve or inlet line or on the strainer. A 1/8 rev/hr timer motor starts this operation, and a 20-sec Amperite timer limits the backflush to 20 sec.

Two dc relays, connected to the high-level alarm contacts of the alpha and beta-gamma count-rate meters, were installed in the backflush panel. These relays operate the diversion valves when a high-level radiation alarm is sounded. A circuit in the backflush unit also supplies power for operation of a proportional sample pump described in Sect. 4.5.

4.5 Sample Pump and Bottles

A water sample, proportional to the flow rate, is collected in either of two bottles: in one during normal operation, in the other during operation when the stream is diverted in response to a high-level radiation alarm. The sample is pumped by a finger pump which is controlled by a proportional signal from a Bristol recorder. Contacts in the recorder operate on a 15-sec time interval cycle; during a part of the

15-sec interval proportional to the stream flow rate, the contacts are closed and a 110-v ac signal is transmitted from the backflush unit to the finger pump. A dc voltage is supplied from the backflush unit to brake the pump and prevent overrun. A second set of contacts in the recorder supplies 110-v ac to operate an integrator that records the number of gallons of water passed through the process waste line. Two integrators are provided, and their inputs are switched by contacts in the radiation count-rate meters such that one integrator records during normal operation and the other integrator records during diverted water flow. The proportional sample flow to the collection bottles is also switched so that the samples collected are representative of either the normal operation or the diverted operation. A third set of contacts from the recorder telemeters a time proportional signal to a converter and multipoint flow recorder at Building 3105.

5. PIPE TUNNEL, PROCESS WASTE DRAIN RADIATION MONITOR

A beta-gamma monitor[6] (Fig. 6) in the pipe tunnel of Building 7920 continuously monitors the beta-gamma radioactivity of the process waste water before it flows from the building, and if the radioactivity exceeds tolerance, the TRU plant operators are warned before the radioactivity reaches the diversion valves at the Melton Valley ponds.

[6] See ORNL Drawing I-10001-Q340 for pump assembly details.

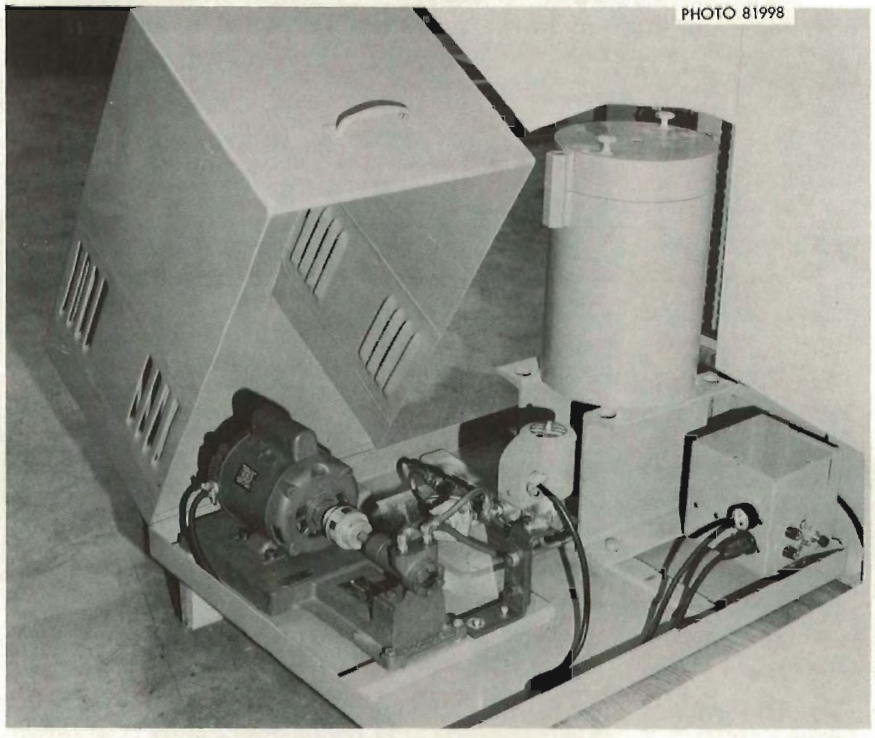


Fig. 6. Pipe Tunnel, Process Waste Drain Radiation Monitor.

A sample of the waste water is pumped continuously from a U-trap in the process waste line through a beta-gamma detector assembly (ORNL model 2319B-5), and flows by gravity back into the U-trap. The entire assembly is in a lead shield (ORNL model Q-1907-15) to reduce external background radiation. A Geiger-Mueller tube in the detector assembly transmits a signal through coaxial cable to a count-rate meter located on panel 7D in Building 7920. In addition to the recorder and alarm on the count-rate meter, a "high level" radiation alarm is also indicated on panel 6C, Bldg. 7920.

5.1 Water Sampler

A positive displacement, Viking model CT2G rotary pump supplies 2/3 gpm of water to the detector assembly (Fig. 7). Water to the pump inlet passes through a stainless steel in-line strainer to reduce clogging. A backflush control unit operates a solenoid valve every hour to blow air through the strainer to clean out material collected in the filter or sample lines. The detector assembly is housed in a lead shield to reduce the background radiation.[7]

5.2 Radiation Detector and Count-Rate Meter

A type 106-C Geiger-Mueller tube, mounted in a plastic centrifuge tube, monitors the beta-gamma radiation in the liquid flowing around the centrifuge tube. The signal from the G-M tube is transmitted through RG-59/U coaxial cable to a

[7]The sampler is located in the southeast corner of room 118, Bldg. 7920.

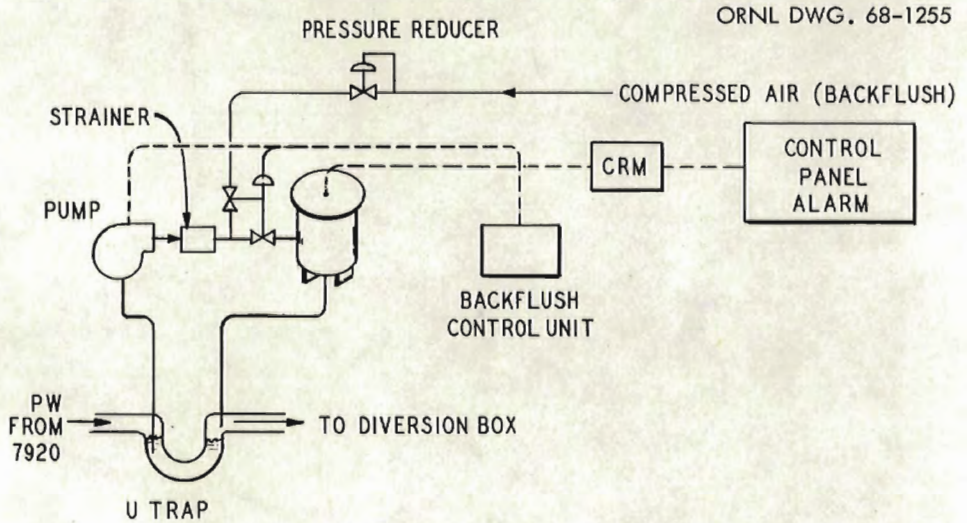
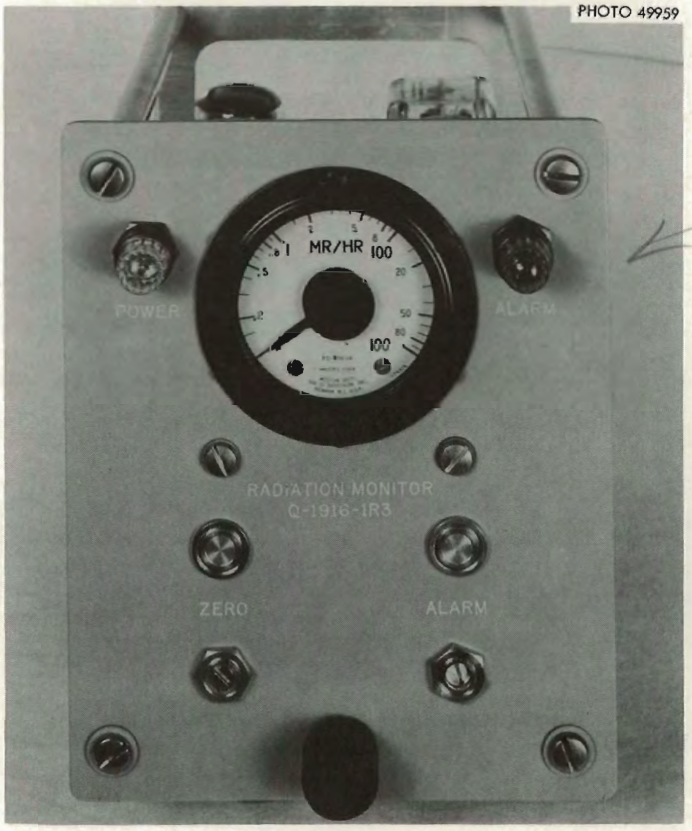


Fig. 7. Diagram of Pipe Tunnel, Process Waste Drain Radiation Monitoring Station.

count-rate meter (ORNL model Q-2313-11) in Building 7920. The count-rate meter has a transistor impedance-matching stage at the input that permits several hundred feet of coaxial cable to be used without a preamplifier at the detector. The count-rate meter is a linear, duty-cycle type with ranges of 0 to 250, 0 to 1000, 0 to 2500, 0 to 10,000, and 0 to 25,000 counts/min full scale, and has a high-voltage supply as an integral unit. A "high" contact on a meter relay operates a load relay for a "high-level" radiation alarm. The load relay contacts are connected to operate a red light on the count-rate meter and a red light on an indicator module on panel 6C. When the radiation level drops below the high set point, the red light on the count-rate meter will be automatically reset, but the red light on panel 6C must be reset by operating the reset button on the module. If the radiation level drops to zero, a clear neon lamp on the count-rate meter will indicate an inoperative instrument. The reset button on the count-rate meter must be operated to reset the "low level" alarm. A Rustrak strip-chart recorder, as well as a meter on the count-rate meter, gives an indication of the radiation level.

6. PROCESS AREA MONITORS

Gamma radiation detectors at various points throughout the building for monitoring process transfer pipes, pumps, etc., are connected by coaxial cable to ORNL model Q-1916 radiation monitors in the operating area at panel 7 (Fig. 8). Alarms from these



Q-3006 now used for these

Fig. 8. Process Area Radiation Monitor.

monitors are connected to the central monitoring panel (panel 6), operating visible and audible alarms.

The radiation monitor will indicate up to 1 r/hr full scale with a logarithmic, three-decade span. An upscale electronic alarm can be adjusted to any point over the scale range, and the alarm point can be read on the meter while the setting is being made without tripping the alarm circuit. The gamma radiation detector is a 700-v halogen-quenched, type 303 Geiger-Mueller tube. The radiation level is determined from the average current through the tube rather than from the pulse rate. Since the tube is used as a dc device, no preamplifier is needed for long cable runs. The tube quantitizes the current for each radiation event. Such a low impedance voltage source does not require electrometer techniques. The G-M tube is independent of gamma energy, and a true dose rate is not read out except for a particular gamma energy. This instrument will respond within 25% accuracy of the scale reading and is useful in installations where the accuracy and reliability of an ion chamber electrometer is not required. The locations of these process monitors are shown in Table 1.

Table 1. Process Area Radiation Monitors Located in Building 7920

Monitor No.	Location[a]
RSS-4	cubicle 4 pumps
RSS-5	cubicle 5 pumps
RSS-6	cubicle 6 pumps
RSS-7	cubicle 7 pumps
RSS-70	T-70 service area
RSS-F113	recirculating cooling water return lines
RSS-M19	steam condensate tank
RSS-L131	caustic recirculating pump

[a]The exact locations are shown on ORNL drawing I-10001-Q301.

7. IN-CELL MONITOR

An ORNL model Q-2501 radiation monitor was installed on each cell face wall with a detector inside the cell. By means of a manipulator, the detector can be moved to all areas of the cell for monitoring material before removal from the cell.

The monitor is an electrometer-type radiation meter with an RCP-2720, 432-cc, air-equivalent ionization chamber. The instrument dial reads from 0 to 10 r/hr with ranges of X0.1, X1.0, X10, X100, and X1000. The electrometer is a balanced bridge circuit with a zero balance adjustment control which should be adjusted each time the instrument is used for a radiation measurement. With the range switch on the "zero" position and the "calibrate" button depressed, the meter should read full scale. This instrument has no alarm, and the radiation level is indicated only on the electrometer mounted on the cell face.

8. DRAWINGS

The TRU process radiation monitoring instruments are described in the following ORNL Instrumentation and Control Division drawings:

1.	I-10001-Q301 through Q341	Instrument Location and Wiring Diagrams
2.	Q-2563-1, -4, -15	Plug-In Modules
3.	Q-1916-1, -22	Radiation Monitor
4.	Q-2501-1	In-Cell Radiation Monitor
5.	Q-2313-9	Count-Rate Meter
6.	Q-2313-10	Count-Rate Meter.

9. VESSEL OFF-GAS DUCT MONITORING SYSTEMS CHECK-OUT PROCEDURE, BUILDING 7920

TEST	PURPOSE AND PROCEDURE	CORRECT OPERATION
1. Preliminary	Prepare to test system: 1. Notify building supervisor and HP of test. Stand by to silence buzzer.	
2. Check panel lamps	Examine all panel lamps.	All lamps are dim.
3. Sample collection efficiency	Test for proper sample collection.	
a. Air flow	1. Read rotameter.	Should indicate 2.5 to 2.8 cfm. Record.
	2. Compress input hose on sample line.	Rotameter should indicate 0.5 cfm or less.
b. Pump failure alarm	1. Turn the pump off with circuit breaker.	Pressure switch causes white "pump inop" lamp at Bldg. 7920 panel to glow brightly. Buzzer sounds. Buzzer can be reset.
	2. Restore power to pump.	"Pump inop" alarm clears.
c. Tape break alarm	1. Pull enough slack in filter tape to allow microswitch arm on supply side to drop.	When switch arm drops, the white "tape break" lamp should glow brightly. Buzzer sounds. Buzzer can be reset.
	2. Pull tape through so that supply side switch clears.	"Tape break" lamp glows dim.
	3. Drop switch arm on take-up side.	Same as step 1.
	4. Restore tape to normal tight condition.	"Tape break" lamp glows dim.
4. Tape advance	Test filter advance mechanism.	
	1. Push "tape advance" button at VOG cabinet.	Filter advances.
	2. Push "tape advance" button at panel 6C, Bldg. 7920.	Filter advances.
5. Detector system check	Test for proper operation of detector and radiation alarm.	
	1. Stop pump. Remove G-M tube from shield and insert it in a standard source. Set CRM range switch to 25,000 counts/min.	CRM indication increases; record final count-rate indication. Read recorder; record count-rate.
	2. Adjust meter relay set point down to actuate high-level alarm.	Buzzer sounds and red lamp glows brightly. Buzzer can be reset.
	3. Reset high alarm by removing source temporarily.	Count rate decreases and red lamp resets to dim.
	4. Remove source and reinstall G-M tube. Start pump.	Count rate decreases to former reading. Record. Recorder tracks count-rate meter indication.
	5. Reset meter set points to normal position. Turn count rate meter power off to actuate inoperative alarm.	White "inoperative" lamp glows brightly. Buzzer sounds. Buzzer can be reset.
	6. Turn power back on, push alarm reset on CRM.	White "inoperative" lamp glows dim.
	7. Turn up volume control on panel if necessary.	Loudspeaker chirps.
6. Conclude Test	Return system to normal condition. Notify building supervisor of conclusion of test.	Check that the pump is running, panel 6C lamps are cleared, and the count rate is normal for a clean filter.

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