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**DETECTION OF RADIONUCLIDE CONTAMINATION
ON FACE MASKS**

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ON FACE MASKS

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DETECTION OF RADIONUCLIDE CONTAMINATION ON FACE MASKS

INTRODUCTION

This report describes a monitor which was developed to assure successful decontamination of face masks.

Protective clothing, such as laboratory coats, coveralls, and face masks, is used at Hanford in radiation zones to provide control for the possible spread of contamination and to prevent inhalation and ingestion of radionuclides. A prior report ⁽¹⁾ described a monitoring system developed for radiation surveying of laboratory coats and coveralls.

The face masks (termed "assault masks" at Hanford) are employed in certain plant locations to prevent inhalation and ingestion of beta-gamma emitting fission products. In the course of use, the outer surfaces, and occasionally the inner surfaces, of the masks became contaminated. During decontamination, it is necessary to monitor the surfaces of the masks to assure that the decontamination procedures have been successful.

SUMMARY

An experimental monitoring instrument was developed to detect and measure fission product contamination on the inner and outer surfaces of protective face masks. The instrument includes two large scintillation detector assemblies employing light pipes to conform to mask surfaces and one smaller scintillation detector to monitor the nose piece of the mask. All circuitry employed is solid state. The instrument can detect 10 nanocuries (10 nCi) of Pm^{147} , a low energy beta emitter.

DISCUSSION

Surfaces of the masks are monitored simultaneously, by the instrument system shown in Figure 1, for beta emitters by three separate scintillation detector assemblies and counter channels. The employed scintillator chosen is a thin coating of anthracene (with binder), which is sprayed onto

(1) W. G. Spear and M. O. Rankin. Protective Clothing Monitoring System, HW-76351 REV. August 1, 1963.

polished Lucite light pipes shaped to fit the mask contours. The scintillating material is covered with two layers of aluminized Mylar (0.9 mg/cm^2 mass thickness).

Neg. 0652088

FIGURE 1
Complete Instrumentation System

The mechanical arrangements of the major detectors are shown in Figures 2 and 3. The mask to be monitored is placed over the lower (inner surface) probe, then the counterbalanced upper probe, which employs three detectors, is lowered gently over the outside of the mask. This action automatically starts the electronic counting and initiates a 15 sec time cycle.

Neg. 38400-7

FIGURE 2

Assembled Probe for Monitoring Inside Surface of Mask

Neg. 0651687-2

FIGURE 3

Probe Configuration (with Lucite Light Pipe)
Used for Monitoring Outer Surface of Mask

Beta particles losing energy in the anthracene cause visible light scintillations and the photons from these events impinge on the photocathodes of the multiplier phototubes * causing emission of photoelectrons. These are amplified in a multiplication fashion to provide output signal pulses from the phototubes. Pulses from the two large (upper and lower) detector assemblies and from the smaller nosepiece detector are counted in separate counting channels during the 15 sec timing period. Suitable alarms are provided, and these energize if the count exceeds the alarm set points.

Table I describes the counting sensitivity for various radionuclides.

TABLE I
SYSTEM SENSITIVITY

	(Source Strengths Shown in disintegrations/min)		
	Pm ¹⁴⁷ <u>2.67 x 10⁴</u>	Ra D-E-F <u>2.72 x 10⁴</u>	Cs ¹³⁷ , <u>2.41 x 10⁴</u>
<u>BACKGROUND PLUS SOURCE</u>			
Outer Surface Counts, 15 sec	600	640	640
Inner Surface Counts, 15 sec	630	680	650
Nosepiece Counting Rate, counts/min	1500	4000	3000
<u>NET SOURCE</u>			
Outer Surface Counts, 15 sec	220	340	260
Inner Surface Counts, 15 sec	330	380	350
Nosepiece Counting Rate, counts/min	1200	3700	2700

The solid state electronics circuit diagram is shown in Figure 4. A pulse preamplifier is located in each of the probes and pulses from each are amplified, noise discriminated, and counted for each channel by circuits in

* The nosepiece phototube is an EMI-9536B (3 in.). The other phototubes are EMI-9530B (5 in.).

- NOTES
1. INNER PROBE PHOTOTUBE EMI 9530B
 2. OUTER PROBE PHOTOTUBES (3) EMI 9530B ANODE COUPLING CAPACITORS CONNECTED IN PARALLEL
 3. FOR END PROBE, PHOTOTUBE: EMI 9536B
 4. UNLESS OTHERWISE NOTED, RESISTORS FOR ALL PROBES ARE 1.5M Ω , $\frac{1}{2}$ W
 5. OPERATIONAL AMPL. ARE PHILBRICK SOLID STATE TYPE 65A.

FIGURE 4
Radiation Detection Instrument Mask Monitor

the main instrument. The two main channels provide an indication of total count in the 15 sec period. The nosepiece channel provides continuous indication of the counting rate. Voltages, corresponding to the count or counting rate, operate voltage sensitive trip circuits to provide alarm activation.

Each preamplifier is a charge sensitive, two transistor stage followed by a current feedback, cable driving stage with a voltage gain of approximately 22. Voltage gain can be reduced by reducing the value of R25, the current feedback resistor. Resistor R17 (in series with the amplifier output impedance) terminates the cable to permit use of long coaxial cables, if desired. Each stage of the preamplifier provides voltage inversion so the overall gain is noninverting; this results in a negative-output pulse. In the main instrument, additional voltage gain and frequency bandwidth limiting is provided by two feedback-pair stages with an attenuator to control channel gain. Both stages are noninverting, and the attenuation is provided by potentiometers P1, P5, and P9 for the outer, inner, and nosepiece channels respectively. Low frequency noise is attenuated by the differentiating network formed by Capacitor C16 and the parallel combination of bias resistors R33 and R34 for the outer channel (similar for the other channels). This time constant is approximately $1 \mu\text{sec}$, corresponding to a lower cutoff frequency of approximately 150 kHz.

Amplifier output pulses are gated "on" and "off" by the threshold detector with the gating action controlled by the timer circuit. Point X from the timer provides bias current to transistors Q9 and Q10 (outer channel) during the timing interval and reverse-biases both transistor emitter base junctions to stop pulse transmission. Negative pulses from the threshold detector drive a binary circuit that divides the pulse rate by two and provides 0 to 15 V transitions to the input of the diode pump network.

For the outer and inner channels, the diode pumps operate into solid state operational amplifier* integrators to integrate the count. The nose-piece channel diode pumps operate a count-rate circuit that features a bootstrap voltage reference point for the recharging diode (D16) in the pump. This provides a 0 to 10 V output without the loss of linearity normally associated with a diode pump. For the count integrator circuits, the diodes operate into ground and virtual ground potential such that the output voltage rises linearly with a constant charge transferred to the integrating capacitor during each positive voltage transition at the input. Silicon diode temperature coefficient is about 2 mV/°C giving an overall coefficient for the two diodes of +4 mV/°C or 0.04% of full scale per degree.

Transistor voltage trip circuits observe the 0 to -10 V output of the two integrators and the 0 to +10 V of the count-rate circuit output. For the outer channel, the trip level voltage is set (at the base of Q18) with a 10 turn potentiometer that reverse-biases the emitter-base junction of Q16 for integrator outputs below the trip level. When the output voltage exceeds the trip setting by a small amount, Q17 conducts and turns "on" Q19 and the display lamp.

During the pulse counting interval following actuation of the start switch, the timer circuit energizes a "counting" lamp on the front panel and activates electronic gates to pass pulses in the inner and outer channels. After the preset time has elapsed, the timer energizes the "reset" lamp on the front panel and turns off the gates. A stable electronic RC timing circuit was developed to provide an accurate 15 sec time base. The timer capacitor output voltage with respect to the -15 V bus is (in volts) $V_c = 30 \left(1 - e^{-\frac{t}{T}} \right)$, where $T = RC$. A voltage comparator tests this voltage and trips at $V_c = 15$ V (or $t = 0.692 T$ sec). The time constant, (T), is adjustable from 9 to 28 sec and is usually set for a 15 sec time base.

* Model P65A amplifier, Philbrick Co.

A paper dielectric capacitor was used to insure negligible leakage current compared to the minimum charging current of $15 \mu\text{A}$. The voltage comparator current and discharge path current combined are less than 20 nA during the time interval; this is negligible compared to the charging current.

A portion of Figure 4 details the timer circuit. Assume the circuit was reset, started, and the timing interval was initiated. Time base capacitor, C94, is connected between Pins H (-15 V) and E. Pin E is the output for the charging current from the +15 V bus (Pin A) through P19 and R210. The voltage drop from Pin E to ground starts at -15 V and charges toward +15 V and forward-biases Q67 at slightly above ground potential. During this period, transistor Q66 is nonconducting. At the end of the time interval, Q67 turns on and sets binary Q68-Q69 such that Q69 is on. Then sequentially, Q70 turns off; and Q71, Q72, and the reset lamp turn on. The collector of Q68 in going from on to off provides a -15 V transition (+15 to 0 V) at Pin V. This transition is differentiated to provide a -15 V pulse at Pin S thereby turning Q64 off, Q65 on, and Q66 on (which discharges the timing capacitor through Q66 and R209). In addition, the Q65 transition turns on Q61, providing -15 V at Point X which turns off the electronic gates. Transistor Q64, which initiates the stated action, forms a binary with transistor Q63. This binary also controls the count lamp through the lamp driver transistors (Q59, Q60, and Q62). A "start" pulse turns Q64 on again to initiate a new time cycle.

CONCLUSIONS

The described instrument is now being used to monitor standard Hanford face masks for beta-gamma contamination. To date, the only difficulties have been minor pinholes (easily repaired) occurring in the aluminized Mylar covering over the scintillators. General operation appears to be successful and three masks can be monitored per minute.

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