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UCRL - 73295, Rev. 1
PREPRINT

Conf-710809--16

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A TRITIUM STACK MONITOR WITH A WIDE DIGITAL RANGE

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April 3, 1972

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The paper was prepared for the Proceedings of the Tritium Symposium conducted by the Southwestern Radiological Health Laboratory of the Environmental Protection Agency at Las Vegas, Nevada, August 30 to September 2, 1971.

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A TRITIUM STACK MONITOR WITH A WIDE DIGITAL RANGE*

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Stack effluent from LLL Livermore's main tritium-handling facility, Building 331, has been continuously monitored for possible tritium discharge since its construction 12 yr ago.¹ The monitoring system (Fig. 1) consisted of an air mover, a 1-liter ionization chamber, a logarithmic picoammeter, a continuous dual-pen recorder, and an alarm set to trigger at some preset current or release rate. With this system it was possible to measure and record the stack release concentration over a six-decade range from 10^{-4} $\mu\text{Ci/cc}$ to 10^3 $\mu\text{Ci/cc}$. The system has reliably indicated the total tritium effluent. There were, however, two major inherent limitations.

With respect to the first, in order to determine the total tritium released during a given period, it was necessary to hand-integrate the logarithmic curves and convert ampere-seconds to curies. Although this could be done fairly accurately, there were occasional problems when one tried to quickly estimate the total activity released following an accidental discharge.

The second limitation was related to the problem of alarm setting. The alarm point could be chosen on the basis of concentration only, because the system had no accumulating capability. This presented no great problem in

*Work performed under the auspices of the U.S. Atomic Energy Commission.

triggering the alarm, so long as the release occurred in a short time with a high tritium concentration. However, there was the possibility that the inverse would occur, that is, a low tritium concentration coupled with a long release time.

To correct these two deficiencies, it was decided to convert an ionization chamber output current proportionately to pulses and feed the pulses to a counting system (Fig. 2). We used a more sensitive version of an improved recycling integrator that was developed for current-to-frequency conversion of the photomultiplier tube output in the LLL automatic personnel dosimeter reader.² The seven-decade input current range (10^{-13} to 10^{-6} A) of this device lent itself well to the analog-to-digital conversion of the ionization chamber output current, thus allowing integration of varying ionization chamber currents on a scaler. In the CTF (Current-to-Frequency) conversion technique, a MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor) input converter is used (Figs. 3,4). The MOSFET is a low-input-current solid-state device that functions as the input electrometer of the conductor. The converter yields a frequency (or pulse-rate) output directly proportional to input current at the rate of 10^{-11} A/Hz.³ The CTF converter has good temperature-stability characteristics, drifting approximately 10^{-15} A/ $^{\circ}$ C at 25° C, and its 10^{-11} A/Hz transfer function is stable to better than 200 ppm/ $^{\circ}$ C above 10^{-11} A.

As finally designed (Fig. 5), stack effluent from each of the two stacks is drawn through individual 1-liter ionization chambers at approximately 20 liters/min (Fig. 6). A potential of 1,000 V is maintained on each ionization chamber, to minimize nonlinearity due to recombination.⁴ Each chamber output current is fed directly into a CTF MOSFET converter. Output pulses from each converter are counted by two parallel, seven-decade scalars

located at the control console in the main office area (Fig. 7). The converters are currently set to yield 10 counts/Ci.

One scaler, called the accumulator, is used for long-term recording of activity released from both stacks, and it may be reset manually only. Two buttons must be depressed simultaneously to reset this accumulator. One button is protected by a knurled knob that must be unscrewed before activating. These precautions were taken to eliminate the possibility of accidentally resetting the accumulator between monthly readouts. A special low-power scaler with COS/MOS (Complimentary-Symmetry/Metal-Oxide-Semiconductor)⁵ integrated circuits was developed to permit use of low-power battery backup. This scaler normally operates on ac power and automatically switches to the battery without loss of accumulated counts in case of power loss, and requires only 12 Vdc at 100 mA (1.2 W) to operate.

The second scaler (one for each monitor) is a commercially available unit that also accumulates pulses from the CTF converter but is reset automatically every 15 min by an external timer. A 10-column printer prints the total count from the scaler before it resets on command from the timer. If the total count during any 15-min period exceeds certain preset limits, a high- or low-level alarm is activated. The reset period and alarm points may be adjusted manually to allow for special circumstances.

The low-level alarm activates a bell within the building to warn occupants that a small release has occurred. If the high-level alarm is activated, the building klaxon sounds and a signal is sent to the LLL Emergency Control Center, which is manned 24 hr a day.

The stack integrator has been operational for about 6 mo and has performed as accurately and reliably as originally planned. Total cost for

the electronics, including installation, was under \$5,000. The total system in its installed configuration has been calibrated at the lower end by comparing indicated release values obtained during known low-level releases. Upper-range response was checked by introducing known quantities of tritium to the ionization chamber and by exposing the chamber to a large radiation source. The original logarithmic picoammeter detection system will be kept in operation, since it provides valuable information about the release profile.

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FIGURE CAPTIONS

- Fig. 1. Original stack monitoring system block diagram.
- Fig. 2. Block diagram of digital tritium stack monitoring system.
- Fig. 3. MOSFET current-to-frequency converter.
- Fig. 4. Block diagram of current-to-frequency converter.
- Fig. 5. Block diagram of present stack monitoring system.
- Fig. 6a. Front panel view of ionization chamber, current-to-frequency converter, and sampling apparatus rack.
- Fig. 6b. Rear view of ionization chambers, current-to-frequency converter, and sampling-apparatus rack.
- Fig. 7. Control console and digital readout panel.

Silver - Fig. 1

Silver - Fig. 2

Silver - Fig. 3

Silver - Fig. 4

Silver - Fig. 5

Silver - Fig. 6a

Silver - Fig. 6b.