OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

ORNL-TM- 1710

COPY NO. -

DATE - December 14, 1966

CALIBRATION OF IODINE MONITOR, ORNL MODEL Q-2725

F. E. Gillespie

1. ABSTRACT

All stacks for radioactive off-gas disposal at ORNL are equipped with Iodine Monitors, ORNL model Q-2725, to sound an alarm when an excessive quantity of ^{131}I is released from the stack and to provide count-rate data for calculation of the quantity of ^{131}I being discharged from the stack. The sensitivity of one such monitor was determined by releasing microcurie amounts of ^{131}I directly to the charcoal trap and counting the radioactivity of the trapped iodine. With Barneby-Cheney No. 727 charcoal in the trap, the sensitivity was 425 counts min^{-1} μc^{-1} of ^{131}I.

2. INTRODUCTION

All stacks at ORNL for disposal of radioactive gases are equipped with an Iodine Monitor, ORNL model Q-2725, for the continuous surveillance of ^{131}I which if present in an excessive concentration would indicate a malfunction in one of the facilities connected to the stack. A monitor at the central radioactive gas disposal facility at ORNL was tested to determine its sensitivity to ^{131}I in the range of 20 to 100 µc. Radioactive iodine was injected directly into a charcoal trap, and two G-M tubes and a count-rate meter indicated the quantity of ^{131}I retained by the trap. Although radioactive inert gases are also detected by the monitor, the charcoal trap will hold the inert gases for only a few minutes while permanently retaining the iodine.

Based on the count rate information, a monitor can be preset to sound an alarm when the amount of ^{131}I being released from the stack exceeds the tolerance value, and the approximate quantity of ^{131}I being released at any time can be calculated.

Fourteen calibration tests were performed from April 1965 to September 1966.

3. DESCRIPTION OF EQUIPMENT AND PROCEDURES

3.1 Monitor

The ORNL model Q-2725 Iodine Monitor[1] (Fig. 1) has two Lionel type 106C thin-wall G-M tubes 180° apart outside the charcoal trap. A modified 8-oz Nalgene bottle holds the charcoal. The Nalgene bottle and plastic centrifuge tube form a cheap container that is easily fabricated. The two parts are sealed with Dow Corning Silastic RTV 731 adhesive.

When the instrument is connected for stack monitoring, 2 cfm of gas pumped from the stack passes through the monitor and then returns to the stack. However, in these tests the iodine was released directly into the inlet tube to the monitor and then to the stack.

The electronics equipment, inside a building at the bottom of the stack, consists of an ORNL model Q-2277 count-rate meter (includes a 900-v power supply) and a recorder.

3.2 Iodine-131 Source

Radioactive iodine was generated by allowing $Na^{131}I$ to react with

[1] Designed by R. L. Shipp, ORNL.

ORNL DWG. 66-12994

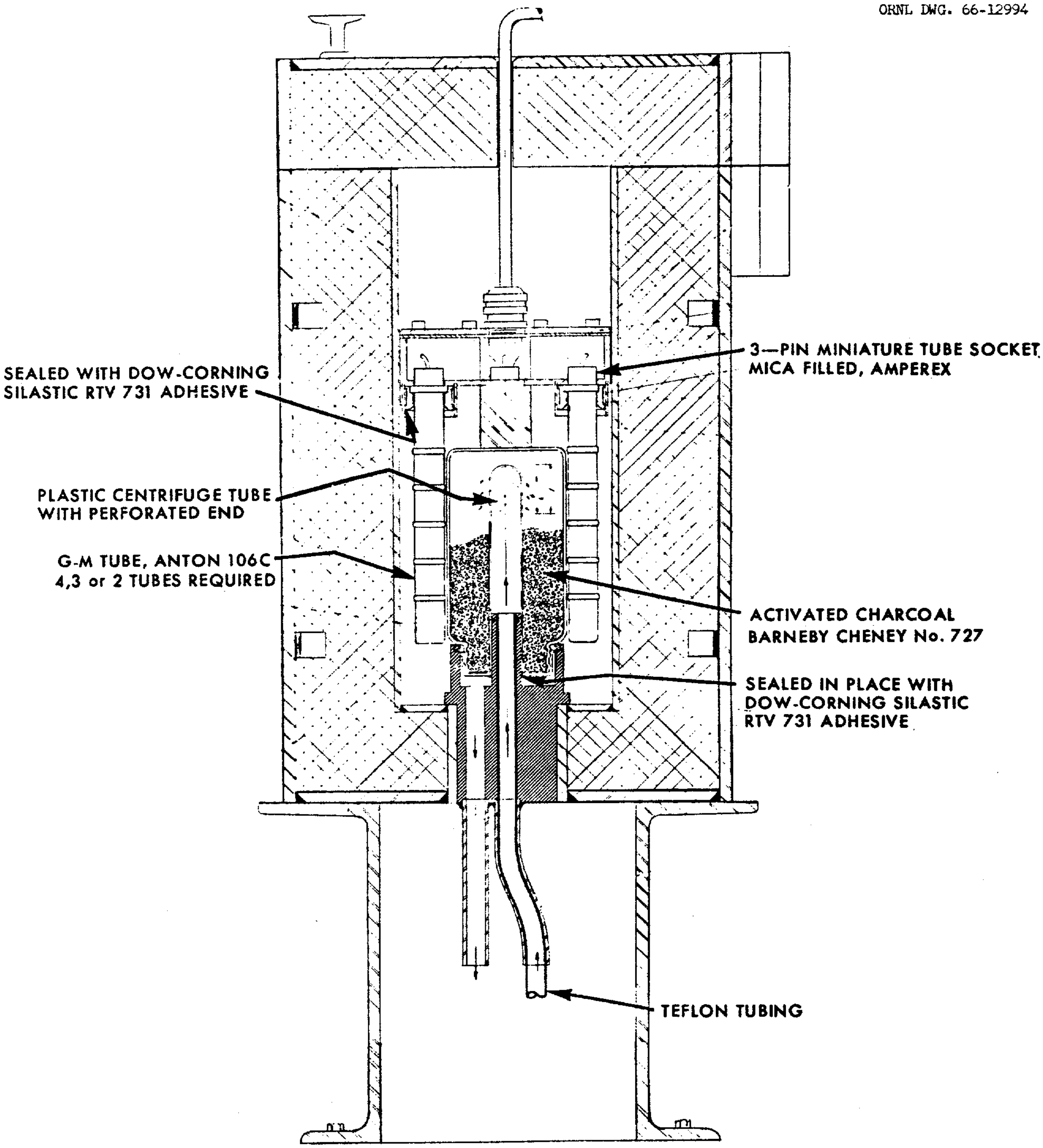

Fig. 1. Iodine Monitor, ORNL Model Q-2725.

concentrated nitric acid.[2] A carrier-free solution of $Na^{131}I$ was placed in one side of a double-sided 1-ml glass shipping ampoule (Fig. 2), and the fill opening to the $Na^{131}I$ was sealed with epoxy resin. The other side of the ampoule contained concentrated HNO_3 which was separated from the $Na^{131}I$ by a glass wall. The fill opening to the HNO_3 was sealed with a plastic stopper.

The ampoule was placed inside a 1/2 in. OD thin-walled (0.008 in. thick) stainless steel tube about 12 in. long and lined with Teflon. The tube was crimped at each end to prevent the ampoule from falling out.

To release the ^{131}I, the ampoule and tube were crushed with pliers. The iodine was released and detected within 1 min (Fig. 3). The release of iodine was immediate and complete when the ampoule was crushed. Heating the tube with a propane torch did not change the count rate.

No attempt was made to produce pure elemental iodine under dry air conditions, because the tests were designed to use outside air with high humidity, as might be found inside the stack.

---

[2]Other methods of releasing iodine are described by H. J. Ettinger, "Iodine Sampling with Silver Nitrate-Impregnated Filter Paper," pp. 305-311 in Health Phys. 12, 1966; and by Sevald Forberg and Torbjörn Westermark, "Sorption of Fission Product Iodine from Air on Different Materials with Application to Nuclear Reactor Accidents," pp. 31-41 in Nukleonik 3(1), 1961.

ORNL DWG. 66-12995

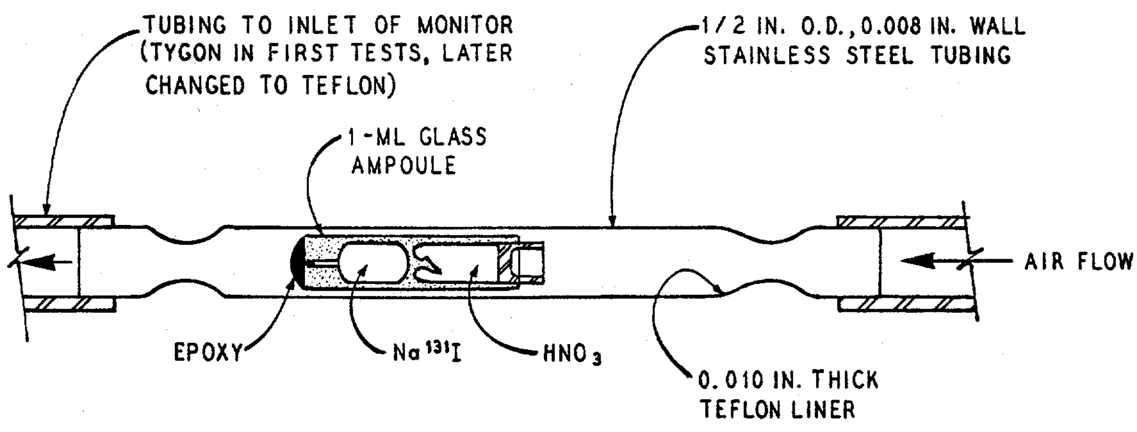

Fig. 2. Iodine Source.

ORNL DWG. 66-12996

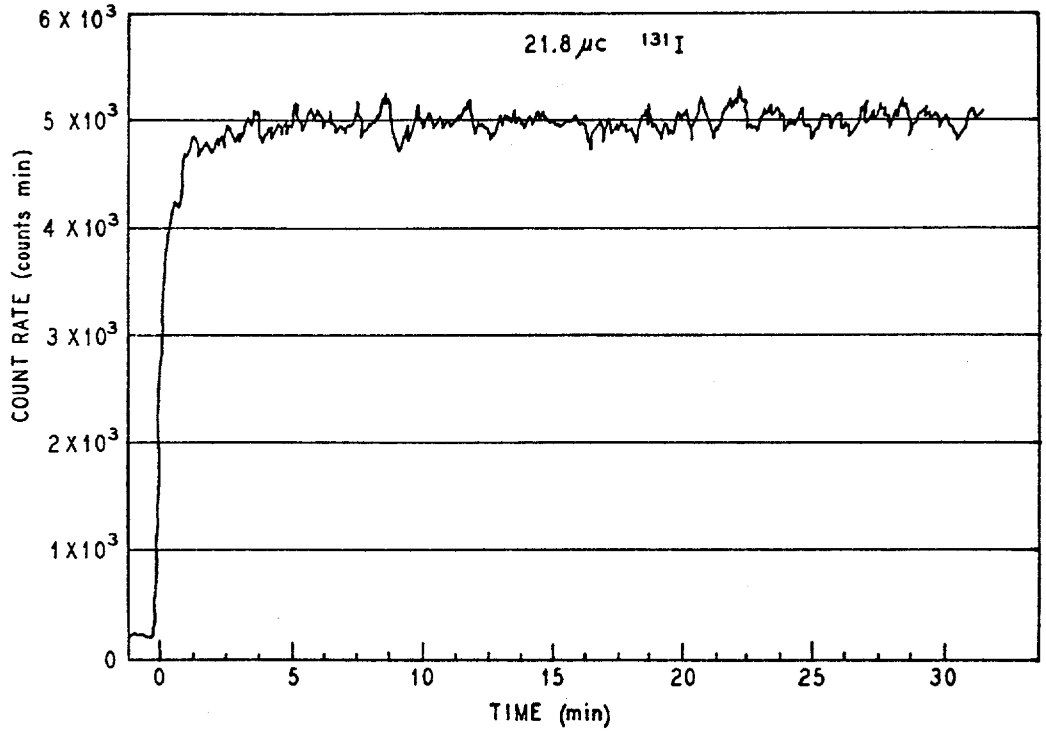

Fig. 3. Release of Iodine as a Function of Time.

4. TEST RESULTS

The tests can be divided into three groups. In the first group, five tests were made with No. 5-685 activated cocoanut charcoal (6-14 mesh) from Fisher Scientific Company in the trap and with Tygon tubing and stainless steel piping to the monitor. The sensitivity results were very erratic, ranging from only 65 to 380 counts min^{-1} μc^{-1}. We believed that the iodine had reacted with the tubing and pipe.

To obtain better results, Teflon tubing (1/4 in. ID by 3/8 in. OD) was installed inside the stainless steel piping on the inlet side of the monitor. The next six tests were made with this Teflon tubing and the same type of activated charcoal used in the first five tests. The results were much more consistent: all except one gave close to 300 counts min^{-1} μc^{-1}. One result was low by 50%. This might have been due to high humidity, or possibly the iodine could have changed to methyl iodide and not be retained by the trap.

Before the final three tests were made, the charcoal in the trap was replaced with Barneby-Cheney No. 727 charcoal.[3] This is an improved charcoal, impregnated with iodine or triethylene diamine, that gives significantly better results for trapping methyl iodide (formed from

---

[3]A similar charcoal is No. 85851 by Mine Safety and Appliances.

ORNL DWG. 66-12997

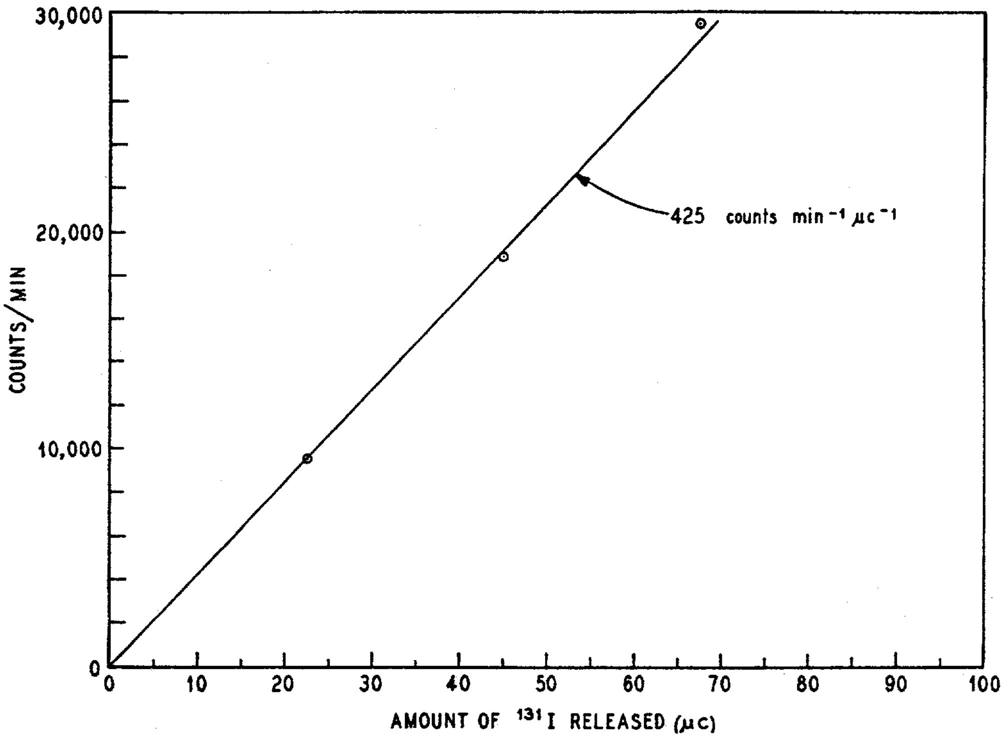

Fig. 4. Count Rate as a Function of Amount of Iodine Released.

reaction of iodine and greases and oils usually present in such a system) under high humidity conditions.[4,5] (The No. 5-685 charcoal would not trap methyl iodide.) In each test 22.5 μc of ^{131}I was released to the monitor; the interval between tests was 5 min. The results (Fig. 4) show that the sensitivity was 425 counts min^{-1} μc^{-1}, a sensitivity about 40% greater than that obtained with the No. 5-685 charcoal.

5. APPENDIX

The following example, which applies only to the central radioactive gas disposal stack, shows how microcurie amounts of ^{131}I relate to stack activity.

A sample rate of 2 cfm, a flow velocity in the stack of about 165,000 cfm, and 5 μc trapped in the monitor corresponds to

$$\frac{(5 \times 10^{-6})\ \ (1.65 \times 10^{5})}{2} = 0.41 \text{ curie}$$

---

[4] R. D. Collins in "Letters," p. 7 in Nucleonics 23(9), Sept. 1965.

[5] C. M. Murphy, Nucl. Safety 7(2), 252 (Winter 1965-1966).

passing through the stack. This is approximately the average amount released per week (5 work days) at this stack. (The charcoal trap is changed weekly.) Corrected for the decay of ^{131}I (half life of 8.05 days) with the assumption that the ^{131}I was released at a constant rate during the 5-day interval, the indicated activity is increased to 0.50 curie.

The relationship between the count rate and ^{131}I activity is linear to at least 70 μc (Fig. 4). This quantity in the trap is approximately 14 times the average weekly amount released from this stack.