OL1000-0020-92-147
C07-54-04

UNCLASSIFIED

DP - 129

Instrumentation

IODINE STACK MONITOR

by

B. M. Carmichael and D. G. Karraker

Instrument Development Division

August 1955

E. I. du Pont de Nemours & Co.
Explosives Department - Atomic Energy Division
Technical Division - Savannah River Laboratory

253281 ✓

UNCLASSIFIED

DP - 129
INSTRUMENTATION

IODINE STACK MONITOR

by

B. M. Carmichael and D. G. Karraker
Instrument Development Division

August 1955

E. I. du Pont de Nemours & Co.
Explosives Department - Atomic Energy Division
Technical Division - Savannah River Laboratory

Printed for
The United States Atomic Energy Commission
Contract AT(07-2)-1

ABSTRACT

An instrument for continuously monitoring radio-iodine in a flowing caustic solution was assembled for use with a stack monitoring system. An absolute counting efficiency of 3.2 per cent was obtained.

External Distribution according to TID-4500 (9th Ed.)

INTERNAL DISTRIBUTION

No. of Copies		
(5)	AEC, SROO	Augusta, Ga.
(1)	R. M. Evans - B. H. Mackey	Wilmington AED
(1)	J. E. Cole - M. H. Smith - J. B. Tinker	"
(1)	H. Worthington	"
(1)	V. R. Thayer	"
(1)	"W" File	"
(1)	S. I. Winde	Engineering Department
(1)	J. D. Ellett	Savannah River Plant
(1)	H. J. Bowman - R. H. Dietz	"
(1)	L. S. Danser	"
(1)	L. C. Peery	"
(1)	W. P. Overbeck - T. C. Evans	"
(1)	C. M. Patterson - E. L. Karlson	"
(1)	W. B. Watkins	"
(1)	J. D. Cist - W. A. Kropp	"
(1)	W. M. Eaton - G. M. Crooks	"
(1)	J. J. Monahon	"
(1)	PRD File	"
(1)	M. H. Wahl - C. W. J. Wende	Savannah River Laboratory
(1)	G. Dessauer	"
(1)	J. W. Morris - W. P. Bebbington	"
(1)	R. I. Martens	"
(1)	J. N. Wilson	"
(1)	L. Cathey	"
(1)	B. S. Johnson	"
(1)	B. M. Carmichael - D. G. Karraker	"
(15)	TIS File	"
(1)	TIS File Record Copy	"

DP-129 - External Distribution Mailed 10/5/55

No. of Copies	Distribution
1	Argonne Cancer Research Hospital
4	Argonne National Laboratory
1	Armed Forces Special Weapons Project, Washington
5	Armed Services Technical Information Agency, Dayton
2	Army Chemical Center
1	Army Medical Research Laboratory
1	Army Medical Service Graduate School (Commandant)
1	Atomic Energy Commission, Patent Branch
3	Atomic Energy Commission, Technical Library
1	Atomic Energy of Canada Limited
2	Australian Atomic Energy Commission
~~1~~ 2	Battelle Memorial Institute
1	Belgium, Centre d'Etudes pour les Applications de l'Energie Nucleaire
3	Belgium, Union Miniere du Haut Katanga
1	Boeing Airplane Company
4	Brookhaven National Laboratory
1	Brush Beryllium Company
1	Bureau of Ships (Code 590)
2	Canadian Joint Staff (Taber)
1	Carbide and Carbon Chemicals Company, C-31 Plant
2	Carbide and Carbon Chemicals Company, K-25 Plant
6	Carbide and Carbon Chemicals Company, ORNL
2	Carnegie Institute of Technology
4	Chalk River Project, Canada
1	Chicago Patent Group
1	Columbia University (Dr. Failla)
1	Columbia University (Dr. Hassialis)
/	Committee on Atomic Casualties
2	Consolidated Vultee Aircraft Corporation
1	Department of Army, Office of Ordnance Research
1	Department of Navy (Code 811)
2	Division of Raw Materials, Denver
1	Division of Raw Materials, Ishpeming
2	Dow Chemical Company, Midland
1	Dow Chemical Company, Rocky Flats
4	duPont Company, Augusta
1	Eldorado Mining and Refining Limited
1	Frankford Arsenal
2	General Electric Company (ANPP)
1	General Electric Company (APS)
3	General Electric Company, Richland
/	Glenn L. Martin Co.
3	Goodyear Atomic Corporation
1	Harshaw Chemical Corporation

INSTRUMENTATION (Cont'd.)

No. of Copies	Distribution
2	Iowa State College
1	Italy, Centro Informazioni Studi Esperienze
~~1~~	~~Kaiser Engineers~~
1	Kirtland Air Force Base
2	Knolls Atomic Power Laboratory
1	Lockheed Aircraft Corporation
2	Los Alamos Scientific Laboratory
1	Mallinckrodt Chemical Works
1	Mound Laboratory
1	National Advisory Committee for Aeronautics, Cleveland
1	National Bureau of Standards, Atomic Energy Project
1	National Bureau of Standards (Library)
1	National Lead Company of Ohio
1	National Research Corporation
3	National Research Council, Canada
1	Naval Medical Research Institute
3	Naval Research Laboratory
1	New Brunswick Laboratory
1	Newport News Shipbuilding and Dry Dock Company
1	New York Operations Office
2	North American Aviation, Inc.
1	Nuclear Development Associates, Inc.
1	Nuclear Metals, Inc. (Dr. Kaufmann)
1	Oak Ridge Institute of Nuclear Studies
4	Phillips Petroleum Company
1	Princeton University
3	Public Health Service
2	Sandia Corporation
* 135	Technical Information Service, Oak Ridge
1	The Surgeon General
1	Tokyo University
1	United Aircraft Corporation
15	United Kingdom Scientific Mission
3	U. S. Geological Survey (RCS-TEPCO), Denver
2	U. S. Naval Radiological Defense Laboratory
1	UCLA Medical Research Laboratory
2	University of California Radiation Laboratory, Berkeley
3	University of California Radiation Laboratory, Livermore
2	University of Michigan (Dr. Gomberg)
~~2~~ 1	University of Rochester, Atomic Energy Project
3	University of Utah
1	University of Washington (Dr. Donaldson)
1	Vitro Corporation of America
1	Walter Kidde Nuclear Laboratories, Inc.
1	Watertown Arsenal
1	Weil, Dr. George L.
1	Western Reserve University
4	Westinghouse Electric Corporation
1	Yale University (Dr. Wadey)
304	
* 1	Signal Corps Engineering Laboratories
300	Office of Technical Service - Washington

TABLE OF CONTENTS

LIST OF FIGURES

IODINE STACK MONITOR

INTRODUCTION

Small amounts of fission-product iodine may be released to the atmosphere during the dissolving of irradiated uranium. A monitor is necessary to establish that the amount of radioactive iodine discharged from the stack is within an allowable range.

The monitoring system employs a small caustic scrubber that continuously samples the exhaust air from the stack. This report covers the development and calibration of the counting system which is used to monitor the radioactive iodine in the caustic stream.

SUMMARY

A logarithmic count rate system was assembled from commercial components to monitor the radioactive iodine sampled from the discharge of the stack. The sample cell and shield were fabricated in the laboratory. The electronic system responds rapidly to changes in the amount of iodine present in the caustic stream.

The absolute efficiency of the counting arrangement is 3.2 per cent for caustic samples spiked with radio-iodine 131. The logarithmic recorder scale reads from 100 to 10,000 counts/minute, corresponding to 0.88 to 216.5 μc/day of I-131 absorbed by the scrubber.

DISCUSSION

In the iodine stack-monitor system a portion of the air exhausted up the stack is run through a scrubber which removes the iodine with 0.1N NaOH. The NaOH solution is passed through a counting chamber and the iodine is counted by a scintillation counter. The count obtained by the scintillation counter is proportional to the iodine activity flowing up the stack, and gives an indication of the instantaneous level of iodine activity exhausted by the stack. The NaOH solution of radioactive iodine leaves the counting chamber and flows to a catch tank where the solution is sampled and analyzed every 24 hours to allow calculation of the total amount of iodine exhausted in that day.

To establish the proper size of the caustic scrubber, the counting efficiency in the proposed sample cell had to be measured, since this efficiency determined the magnitude of the sample air stream.

MEASUREMENT OF COUNTING EFFICIENCY

Isotopically pure I^{131} in solution with Na_2SO_3 was obtained from Oak Ridge, diluted in a solution of NaOH by a factor of 10^4, and counted in a counting chamber. A scintillation crystal NaI(Tl), a G.E. scintillation probe unit, and a Tracerlab CC-10 scaler comprised the counting equipment.

The experimental counting chamber was a right cylinder made of brass, 4 cm in diameter and 2 cm high (internal dimensions), which held about 25 cc of solution. One face of the cylinder was a brass "window," 0.12 mm thick, through which the iodine radiation passed. The counter was shielded with two inches of lead bricks.

After the solution was counted in the experimental chamber, the activity level was determined by plating a sample and counting it in a windowless proportional counter (Nuclear Measurements PCC-10).* The counting efficiency calculated from these measurements was 3.2 per cent. Corrections for dead-time losses in the counting rates were included.

OPERATING RANGE OF THE MONITOR

A fraction of the exhaust air in the stack is drawn by vacuum from sample points in the stack into a caustic scrubber. This gas sample is fed into a 3-foot column packed with 1/4-inch x 1/4-inch Raschig rings to a depth of 12 inches and is contacted with 0.1N(0.4 per cent) NaOH at a flow rate of 20 ml/min. Under these conditions of flow rate, it is calculated that a uniform rate of 2.5 μc/day of iodine into the scrubber will yield 145 dis/min/ml in the caustic effluent, provided that the scrubber efficiency is 75 per cent.

Since the volume of the iodine counting chamber is 25 cc and the absolute counting efficiency is 3.2 per cent, the average counting rate will be 115 c/m for an average rate of 2.5 μc/day of iodine into the scrubber.

DESIGN OF COUNTING CHAMBER AND SHIELD

The detecting unit is composed of a counting chamber through which the NaOH flows for monitoring, and a G.E. scintillation probe, all housed in a lead shield as shown in Figure 1. The minimum level of detection is considered to be 50 per cent of the background count. Since the background for a normal unit is about 60 c/m in the lead shield, this background restricts the detectable limit to 30 c/m, which amounts to a rate of 0.65 μc/day of iodine entering the scrubber.

The counting chamber is dimensionally identical (4 cm I.D. and 2 cm high) with the chamber that was used to determine the counting efficiency. However, the

* Prohaska, C. A. The SRP Standard Windowless Flow Counter. E. I. du Pont de Nemours & Co., DP-45, April 1954.

material used in its construction is #347 stainless steel to eliminate corrosion. The steel window has almost the same density as the experimental brass window.

The lead shield is 2 inches thick; it is composed of five lead "doughnuts" which are 4 inches high, 6-1/2 inches in diameter, with 2-inch walls. The tops and bottoms of the doughnuts are inclined at an angle of 30° to avoid cracks at the joints. Each doughnut weighs about fifty pounds. Top and bottom plates for the assembly fit on the angled sides of the doughnuts. The counting chamber is placed at the bottom of the shield, with the pipes for the flowing NaOH entering at the bottom of the shield and leaving through the side. Cables for the scintillation probe leave the shield through a groove at the junction of the top plate and its supporting doughnut. A set screw through the bottom lead doughnut permits vertical adjustment of the position of the scintillation probe.

COUNTING EQUIPMENT

A block diagram of the counting system is shown in Figure 2. The equipment consists of a standard G.E. scintillation probe, an Atomic Model 316 high-voltage supply for the G.E. probe, an Atomic Model 204B linear amplifier, an RCL log count rate meter, and a Brown recorder. Filament current and plate voltage for the probe preamplifier are obtained from the linear amplifier. The output of the preamplifier is fed into the linear amplifier which in turn drives the log count rate meter. The output of the log count rate meter is monitored remotely by the Brown recorder.

The location of the log count rate meter, linear amplifier, and the high-voltage source is not critical, but should be within twenty feet of the pre-amplifier. Coaxial cables should be used for the high-voltage and signal cables, since an objectionable amount of "noise" may appear otherwise. A "Sola" constant voltage transformer is used to reduce fluctuations in the line voltage.

In laboratory tests the discriminator on the linear amplifier was adjusted to provide the maximum counting rate consistent with a reasonable background. The log count rate meter and Brown recorder were calibrated by feeding pulses from a pulse generator into the log count rate meter. The pulse repetition rates indicated by the meter and recorder were then adjusted to obtain agreement with the rates measured by a scaler.

Long-time drifts in the instrument system were studied over a two-week interval with a fixed test source. Drifts of the order of five per cent per day were observed. The calibration of the circuit needs to be checked once in each 24-hour period by means of the 60-cycle calibration point provided on the log count rate meter.

The monitor recorder has a three-decade logarithmic scale to match the log count rate meter. Since the background is about 60 c/m and since 2.5 μc/day of iodine into the NaOH scrubber is expected to give 115 c/m, the recorder scale calibration is approximately as follows:

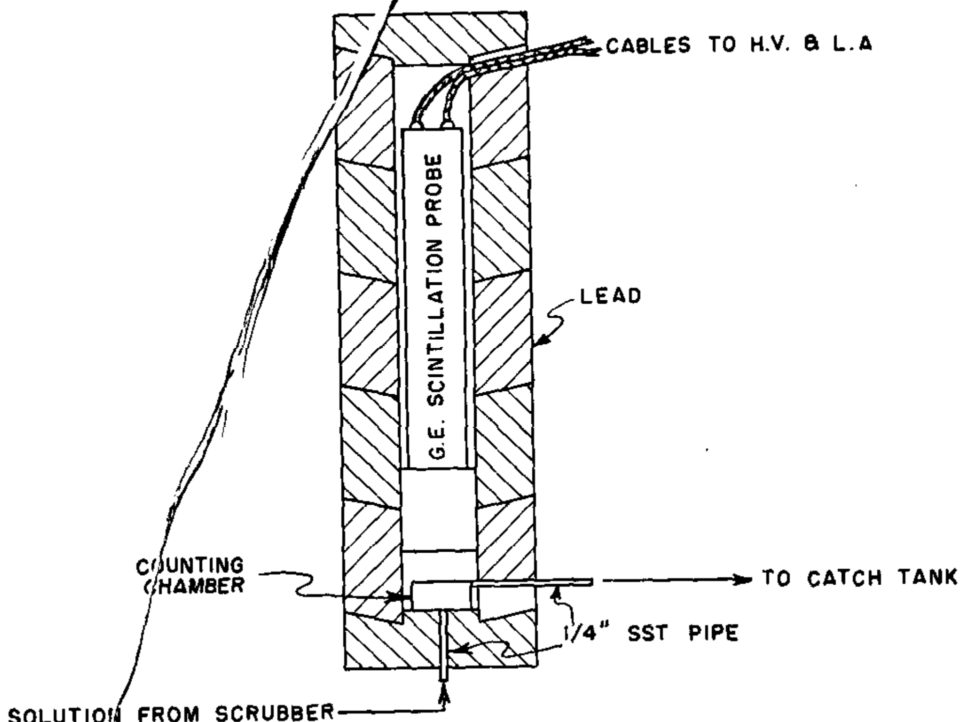
100 c/m	0.88 μc/day into scrubber
1,000	20.3
10,000	216.5

The exact calibration depends on field conditions.

B. M. Carmichael
B. M. Carmichael

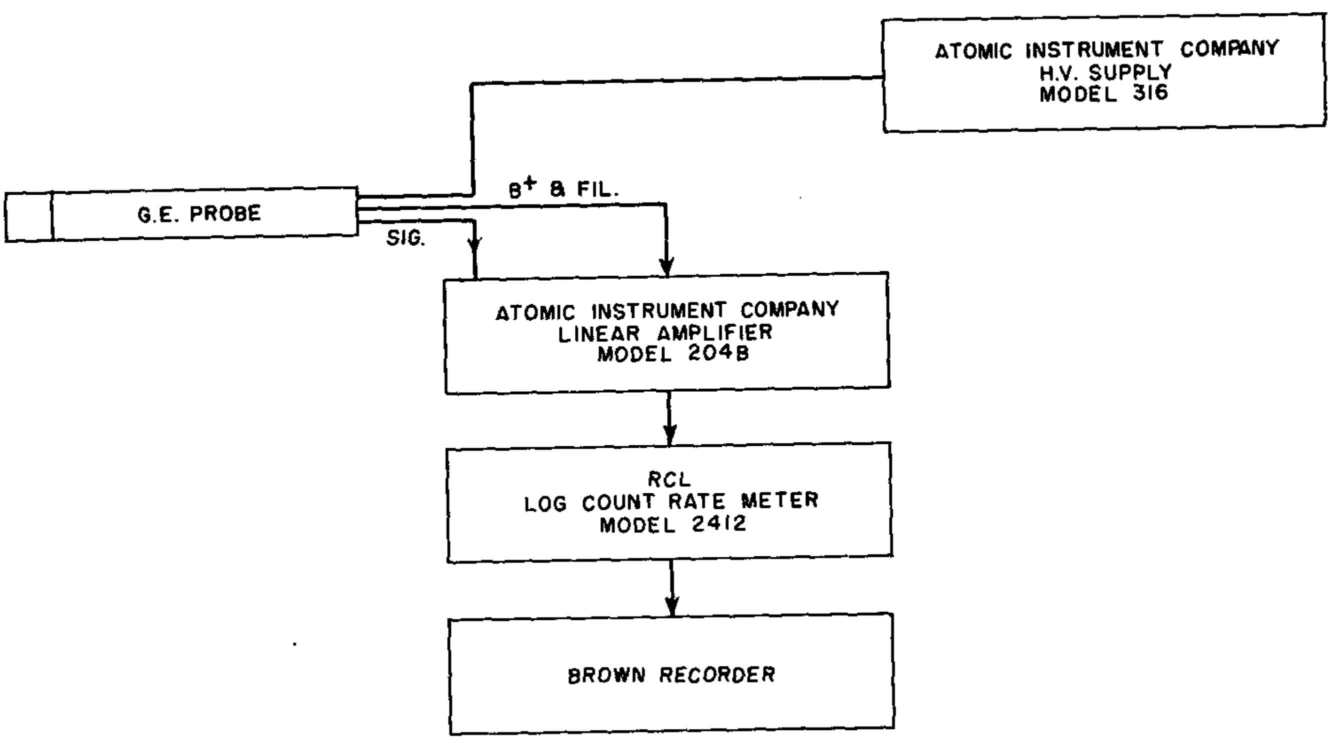
D. G. Karraker
D. G. Karraker
Instrument Development Division

FIGURE 1



ACTIVITY CHAMBER, PROBE, AND SHIELD

FIGURE 2



BLOCK DIAGRAM OF COUNTING EQUIPMENT