DP - 81

Chemistry-General
37

TREATMENT OF DISASSEMBLY BASIN WATER

F. A. Locke
Pile Engineering Division

October 1954

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

253224

UNCLASSIFIED

DP - 81

CHEMISTRY-GENERAL

TREATMENT OF DISASSEMBLY BASIN WATER

by

F. A. Locke
Pile Engineering Division

October 1954

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

Contract AT(07-2)-1 with the
United States Atomic Energy Commission

UNCLASSIFIED

CHEMISTRY-GENERAL
M-3679 (14th Edition)

INTERNAL DISTRIBUTION

Copy No.		
1-5.	AEC, SROO	Augusta, Ga.
6.	R. M. Evans - B. H. Mackey	Wilmington AED
7.	W. C. Kay - M. H. Smith - J. B. Tinker	"
8.	L. Squires - H. Worthington	"
9.	D. F. Babcock	"
10.	J. A. Burns	Engineering Department
11.	J. D. Ellett	Savannah River Plant
12.	W. S. Church	"
13.	W. P. Overbeck	"
14.	A. A. Johnson	"
15.	P. A. Dahlen	"
16.	P. S. Shane	"
17.	PRD File	"
18.	M. H. Wahl - C. W. J. Wende	Savannah River Laboratory
19.	J. W. Croach	"
20.	J. T. Carleton	"
21.	W. M. Heston	"
22-36.	TIS File	"
37.	TIS File Record Copy	"

EXTERNAL DISTRIBUTION

38-45.	Argonne National Laboratory
46.	Armed Forces Special Weapons Project (Sandia)
47.	Army Chemical Center
48.	Arthur D. Little, Inc.
49-53.	Atomic Energy Commission, Washington
54.	Battelle Memorial Institute
55-56.	Brookhaven National Laboratory
57-58.	Carbide and Carbon Chemicals Company (C-31 Plant)
59-61.	Carbide and Carbon Chemicals Company (K-25 Plant)
62-67.	Carbide and Carbon Chemicals Company (ORNL)

CHEMISTRY-GENERAL

EXTERNAL DISTRIBUTION (Continued)

Copy No.	
68.	Chicago Patent Group
69.	Chief of Naval Research
70.	Columbia University (Hassialis)
71.	Division of Raw Materials, Washington
72.	Dow Chemical Company, Pittsburg
73.	Dow Chemical Company (Rocky Flats)
74-76.	General Electric Company (ANPD)
77-82.	General Electric Company, Richland
83-84.	Goodyear Atomic Corporation
85.	Hanford Operations Office
86.	Iowa State College
87-90.	Knolls Atomic Power Laboratory
91-92.	Los Alamos Scientific Laboratory
93.	Mallinckrodt Chemical Works
94.	Materials Laboratory (WADC)
95-97.	Mound Laboratory
98.	National Advisory Committee for Aeronautics, Cleveland
99.	National Bureau of Standards
100.	National Lead Company of Ohio
101.	National Lead Company, Inc. (Winchester)
102.	Naval Medical Research Institute
103.	Naval Research Laboratory
104.	New Brunswick Laboratory
105.	New York Operations Office
106-107.	North American Aviation, Inc.
108.	Nuclear Metals, Inc.
109.	Patent Branch, Washington
110-113.	Phillips Petroleum Company (NRTS)
114.	Pratt & Whitney Aircraft Division (Fox Project)
115.	RAND Corporation
116.	Rohm and Haas Company
117.	Sandia Corporation
118.	Sylvania Electric Products, Inc.
119.	Tennessee Valley Authority (Walthall)
120.	U.S. Naval Radiological Defense Laboratory
121.	UCLA Medical Research Laboratory
122-123.	University of California Radiation Laboratory, Berkeley
124-125.	University of California Radiation Laboratory, Livermore
126-127.	University of Rochester
128.	Virginia-Carolina Chemical Corporation
129.	Vitro Engineering Division
130.	Vitro Laboratories
131.	Western Reserve University (Friedell)
132-133.	Westinghouse Electric Corporation
134-148.	Technical Information Service, Oak Ridge

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

ABSTRACT

Corrosion of steel piping and basin equipment was found to be the main cause of the deposition of a brown flocculent material on the floor and walls of the disassembly basin at R Pile.

A combination of sodium dichromate and chloramine, the best of seven water treatments tested, reduced steel corrosion 50 per cent, zinc corrosion 80 per cent, and met the standards for control of turbidity and bacteria in the water of the basin.

TREATMENT OF DISASSEMBLY BASIN WATER

INTRODUCTION

A few weeks after water was charged to the disassembly basin of the R Pile, deposits of material containing silica, iron, aluminum, and manganese began to accumulate on the walls and floor of the basin.

The objectives of this study were to determine the cause of the deposition and to evaluate possible corrective measures. This work led to a laboratory investigation of the effect of various water treatments on water turbidity, bacteria control, and corrosion.

SUMMARY

Corrosion of the supply pipe line and the basin equipment is an important cause of deposition in the disassembly basin of the R Pile. None of the water treatments tested will completely eliminate this deposition, but a combination of sodium dichromate and chloramine, the best of the water treatments tested, reduced steel corrosion 50 per cent, zinc corrosion 80 per cent, and afforded complete protection from bacteria.

In low concentrations, only chloramine and a combination of sodium dichromate with chloramine met the turbidity and bacteria control standards for basin water. As a result of these tests, chlorine will be replaced by chloramine on a trial basis as a bactericide for basin water treatment.

Water additives tested were chlorine, chloramine, Calgon, Arquad T-2C, Santobrite, and sodium dichromate. Deionized water was also investigated.

DISCUSSION

BACKGROUND

The storage, disassembly, and transfer of irradiated material discharged from a Savannah River reactor are conducted under water in a concrete basin. The necessity of viewing underwater operations requires that the turbidity of this water be not greater than 0.5 ppm (as SiO_2). Therefore, coagulated and filtered water is used. This water is pumped from the water purification station through steel pipe at a maximum rate of 2000 gpm. A bactericide is added to the water to assure that bacteria which could increase turbidity do not grow in the basin.

A few weeks after water was charged to the disassembly basin of the R Pile, deposits of material containing silica, iron, aluminum, and manganese began to accumulate on the walls and floor of the basin. This condition reduced visibility by reducing the amount of reflected light. Also, manganese is a scavanger of fission product activity and its presence greatly increases the difficulty of decontamination in the event the basin must be drained for repairs.

EQUIPMENT

The experiments consisted of feeding filtered water treated by various methods into Amercoated 55-gallon drums at a rate (66 cc per minute) such that the turnover in the drums was comparable to the maximum turnover in the basin. A small section of carbon steel pipe was included in each of the feed lines to simulate basin supply pipe (see Figure 1).

PROCEDURES AND RESULTS

Three drums were charged with filtered water, filtered water and chlorine, and filtered water and chloramine(1) to determine if the addition of chlorine were causing the deposition. Within a week, a brown precipitate, similar in appearance to that deposited in the disassembly basin at R Pile, was noticed on the bottoms of the drums. The greatest deposition occurred in the drum fed with chlorinated water and the least occurred in the drum fed with filtered water.

Turbidity measurements were made with a Hellige turbidimeter on samples taken immediately before and after the water passed through the steel supply pipes to the drums. For each line it was found that the turbidity of the water increased while passing through this section of pipe. This strongly suggested that the precipitation in the drums and in the disassembly basin was caused by deposition of the products resulting from the corrosion of the pipeline and basin equipment.

To prove or disprove this theory, filtered water was charged to a drum without being passed through a carbon steel pipe. There was no deposition in the drum and the turbidity remained constant at a value of less than 0.1 ppm (as SiO_2) during the two weeks of the test. This is in contrast to the first three experiments in which the water in the drums leveled off at an average turbidity of 0.2 ppm. Data typical of these initial experiments are given in Table I. All chlorine and chloramine residuals were measured using a comparator and the ortho-tolidine-arsenite method[2].

The preceding experiments indicated that the deposition is caused by corrosion and not by inefficient filtration, after-precipitation, or bacterial action.

Chlorine was not completely efficient as a bactericide for basin water because chlorine is absorbed by organic material present in the water. In addition, an effective chlorine residual can not be maintained in the basin because of the slow rate of water turnover.

Therefore, further experiments were set up to find a water treatment that would inhibit the corrosion and at the same time meet the turbidity and bacteria control standards for basin water. Water additives tested were chlorine, chloramine, Calgon, Arquad T-2C, Santobrite, and sodium dichromate. Tests were also made with deionized water.

WATER TREATMENTS

The results obtained with each of the water treatments are discussed in the following paragraphs.

Chlorine

In the existing water treatment, 0.5 ppm of chlorine was added to the filtered water to inhibit the growth of bacteria in the basin. However, during the tests the Cl_2 residual of process water decreased from an average value of 0.5 ppm to 0.35 ppm while passing through the supply pipe to the test drum. Upon reaching the drum the chlorine residual decreased further to less than 0.1 ppm throughout the drum through absorption of chlorine by the organic matter present in the water and escape of chlorine from the water. Bacteria counts showed a steady increase in the number of bacteria present in the drum, indicating that chlorine is not an effective bactericide for basin water treatment unless larger amounts of chlorine which increase corrosion, are used. Actual conditions in the disassembly basin paralleled these test results.

Chloramine

When 0.5 ppm of NH_4OH was added to process water containing 0.5 ppm of chlorine to form a chloramine, the Cl_2 residual of the water did not decrease while passing through the supply pipe as it did with chlorine alone. The chlorine residual throughout the drum remained steady at a value of 0.35 ppm and bacteria counts showed that there were no bacteria growing in this drum.

Taylor(3), supports these observations as he states, "Chloramines are less active oxidizing and germicidal agents than chlorine but they are more stable, and hence an active residuum remains for a longer period (several days) in the treated water. This is an advantage where the water is retained for long periods in reservoirs and mains before delivery to the consumers, since a high standard of bacterial purity can be preserved and after-growth of bacteria prevented".

Corrosion of steel, aluminum coupled with stainless steel, and zinc coupled with stainless steel, was reduced slightly. Relative corrosion rates are listed in Table II.

Chlorine and Calgon

Two ppm of Calgon added to the process water reduced steel corrosion 20 per cent but increased aluminum corrosion twenty-fold. This accelerated corrosion of aluminum eliminated Calgon from further consideration.

Arquad T-2C

Five ppm of Arquad T-2C, the required concentration for effective protection against bacteria, had a turbidity of 0.4 ppm (as SiO_2). After corrosion samples were placed in the drum, a high turbidity, ranging up to 1.25 ppm, developed. This is much higher than the maximum allowable turbidity of 0.5 ppm.

Santobrite

Thirty ppm of Santobrite, the concentration necessary for control of bacteria, had an unacceptably high turbidity of 2.5 ppm.

Chloramine and Sodium Dichromate

The use of 2.0 ppm sodium dichromate and 0.5 ppm chloramine reduced steel corrosion by 50 per cent and the corrosion of zinc coupled with stainless steel by 80 per cent, and at the same time afforded complete protection against bacteria. The turbidity of filtered water treated in this manner was less than 0.1 ppm.

Deionized Water

The corrosion of steel in deionized water was approximately four per cent as great as that observed in chlorinated filtered water. The corrosion of zinc coupled with stainless steel was reduced by 70 per cent while the corrosion of aluminum was very low. However, tests showed that no protection is offered against bacteria by deionized water exposed to the atmosphere.

RELATIVE CORROSION RATES

Comparative results of the corrosion tests after one month are reported in Table II. These results were obtained by measuring the weight loss of metal coupons after exposure to the treated water for one month.

None of the water treatments reduced the corrosion of steel enough to eliminate deposition of the products resulting from corrosion of the pipe line. However, sodium dichromate coupled with chloramine reduced steel corrosion by 50 per cent and at the same time afforded excellent protection from bacteria. Chloramine was the only bactericide tested that met the turbidity and bacteria control standards for basin water. As a result of these tests, chlorine will be replaced by chloramine on a trial basis at R Pile.

F. A. Locke per WMH
F. A. Locke
Pile Engineering Division

BIBLIOGRAPHY

1. Lauter, J., "Aqua Ammonia for Chloramination" Water Works and Sewage, 87, 306-308, (1940).

2. American Public Health Association, Standard Methods for the Examination of Water and Sewage. New York, American Public Health Association, 9th Edition, (1946).

3. Taylor, E. W., The Examination of Waters and Water Supplies, Philadelphia, Blakiston, (1949). (p. 622)

Figure 1

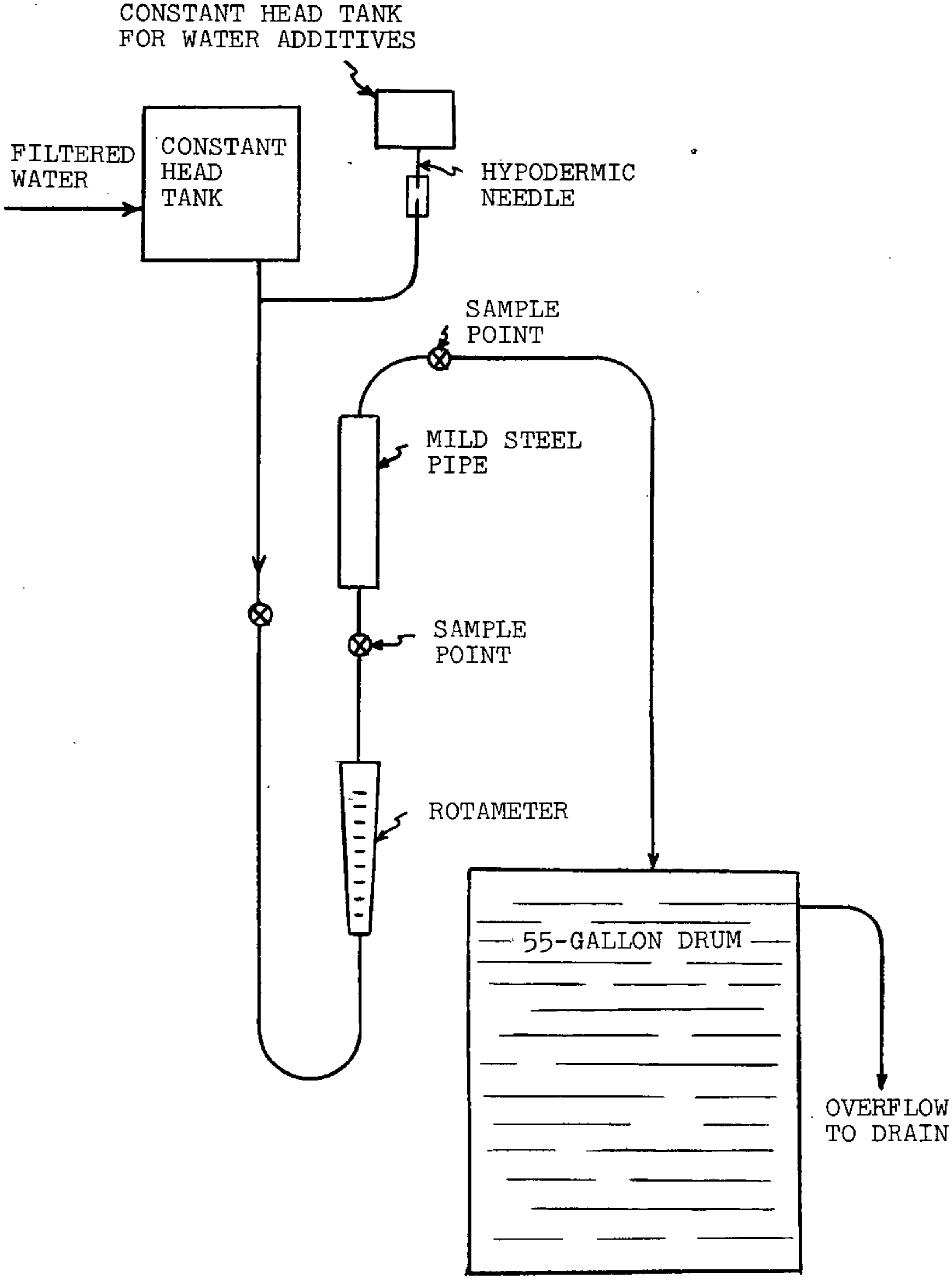

DIAGRAM OF EQUIPMENT

TABLE I

RESULTS OF INITIAL EXPERIMENTS

	Filtered H_2O	Chlorinated H_2O	Chlorinated $H_2O + NH_4OH$ Chloramine	Filtered H_2O (No Pipe)
Turbidity, ppm as (SiO_2)				
Before pipe	<0.1	<0.1	<0.1	--
After pipe	0.4	0.5	0.4	--
In drum	0.2	0.2	0.2	<0.1
Chlorine residual, ppm				
Before pipe	--	0.5	0.5	--
After pipe	--	0.35	0.5	--
In drum	--	<0.1	0.35	--
Deposition	Occurred in one week, grew heavier	Occurred in one week, grew heavier	Occurred in one week, grew heavier	None
Bacteria	Present	Present	None	Present

TABLE II

RELATIVE CORROSION RATES

(Relative to corrosion rate in chlorinated water)

Water Treatment	Al (Coupled with Stainless Steel)	Zn (Coupled with Stainless Steel)	Steel	Al
Chlorine	1.0	1.0	1.0	1.0
Chloramine	0.8	0.5	0.8	1.0
Calgon & Chlorine	1.2	0.8	0.8	20.0
Arquad T-2C	1.2	0.3	1.0	1.0
Chloramine & Sodium Dichromate	1.0	0.2	0.5	~0
Deionized H_2O	--	0.3	0.04	~0