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DE93 002142

A REVIEW OF WATER TREATMENT
TECHNOLOGY AS APPLIED IN THE 100 AREAS

HANFORD WORKS

January 23, 1951

COPY 1 OF 1

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This document consists of

8 pages, No.

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INTRODUCTION

Higher operating levels in the 100 Area piles have caused alarming increases in pile effluent activity and pressure drop through the process tubes. Projected additional increases in power level may not be possible unless the problems of film formation and pile effluent activity are overcome. Although a solution to these problems is not the responsibility of the Power Division, we do have an interest in seeing that any proposed solution meets the test of operational practicability. Consequently, the following review was written in order that pertinent water treatment information may be readily available.

SUMMARY

During the 100-B Area start-up in 1944, the Technical Division delivered to the Power Division, a set of water specifications of the utmost rigidity. This set of specifications, with one exception, has not been changed to date. The specifications were stable because corrosion rates were low, film formation was low and pile effluent water activity was low. In short, the specifications were accomplishing their purpose.

At the higher power levels of recent date, film formation and pile effluent activity have greatly increased. It is desirable then, to review the old specifications in the light of new operating conditions.

Water specifications concerning natural turbidity, iron, aluminum, dichromate, pH, chlorine and chlorides would be helpful to the Power Division personnel in fulfilling their job of selecting the proper method of meeting these specifications.

A re-evaluation of the purge operation is a problem closely related to a study of the water specifications. Again, a study of permissible quantities and kinds of purge materials would be of value to the operating division. A solution of the purge problem might offer the simplest approach to the water problem.

A thorough study of coagulation, chlorination, and filtration was begun in 1946 by using parts of the 183-B Filter Plant as a semi-works when that area was on a standby basis. Out of these studies, enough information was obtained to allow full scale tests in the operating areas. The plant tests have been on a more or less continuous basis since that time with the result that unit water treatment costs have decreased more than fifty percent, while water quality has improved.

DISCUSSION

I. Water Quality Specifications

The early water quality specifications were established on the basis of experimental work : the CMX Project. The specifications worked so well that there was little incentive to change them from the standpoint of technical adequacy. However, from an operating standpoint, the meeting of these specifications was an undertaking without precedent in the water treatment field both as to cost and difficulty. Consequently, the Power Division was forced from the very early days to adopt a test program to improve quality and to reduce water treatment costs. (Reference 1).

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DISCUSSION - Water Quality Specifications (Continued)

From time to time, as a result of the Power Division test program, questions concerning the necessity of certain water specifications arose. In such cases, consultations were held with the 'P' and Technical Divisions, as responsibility for water quality specifications did not fall within the scope of Power Division activities. Cooperative efforts of the three divisions led to the elimination of sodium silicate from the treatment process, (See Reference 2). A similar problem, the elimination of sodium dichromate from the treatment process, being much more involved and potentially dangerous, was discussed but not undertaken pending flow lab tests by the Technical Division in the summer of 1949. Flow lab tests were started but discontinued because of Technical manpower limitations. The use of filter alum as a coagulant in place of ferric sulfate was also discussed at some length, but the high aluminum content (0.8 ppm) of the water being treated with alum in the 200 Areas along with the CIX studies indicating the undesirability of aluminum as a constituent of water, led to general agreement that filter alum should not be used for plant tests until a tolerance level for aluminum was established.

The Power Division is of the opinion that the only safe way to evaluate water quality specifications is a series of flow lab and in pile experiments. Even here, however, it is important to form conclusions carefully, because of the impossibility of duplicating on a small scale, the water treatment equipment involved.

II. Reasons for Plant Experiments

In the fall of 1944, the Power Division was handicapped by the lack of good operating information as to the optimum conditions for coagulation and filtration of Columbia River Water. Literature references generally proved to be worthless except as a source of ideas to be proved or disproved on a plant scale. Information was extremely difficult and costly to obtain. For example, one plant test lasting a few days might cost several thousand dollars, without any tangible results. Consequently, progress was slow until parts of 183-B were made available for experimentation while the area was on a standby basis in 1946 and 1947. Data was obtained during this period which has been extremely fruitful in lowering costs and improving quality. (See Reference 3). In addition, enough information was obtained to roughly define the scope of activity where results of full scale plant tests would be most likely of success.

III. Coagulation and Filtration

The standard coagulant for water treatment in 1944 was filter alum. Although ferric sulfate had been used in a few plants, data concerning it was conflicting. Laboratory and plant tests at Hanford have disclosed the following facts about its use:

- (a) The iron content of filtered water is an indicator of the efficiency of removal of turbidity particles from raw water.

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DISCUSSION - Coagulation and Filtration (Continued)

- (b) The iron content in the effluent of a freshly washed filter is dependent on the rate of coagulant feed. The lower the coagulant feed, the higher is the iron content of the effluent of a freshly washed filter. The time required for return to normal (0.01 ppm iron) after backwash is called "recovery time". "Recovery time" is normally from two to five hours.
- (c) Filters that have been on the line for some time (15-60 hours), may "break through" allowing high concentrations of iron to appear in the effluent.
- (d) Filter runs must be shortened during periods of high turbidity to prevent filter "break through".
- (e) Filter runs must be shortened during periods of cold water to prevent filter "break through".
- (f) Filter runs must be shortened during periods of high rates of filtration to prevent filter "break through".
- (g) Coag feed must be held to the absolute minimum consistent with good "recovery time", to minimize filter "break through". This effect is most striking at feed rates below 10 ppm ferric sulfate. At times, a reduction of one or two ppm may lengthen filter runs as much as five to ten hours.
- (h) Sludge of ferric sulfate and turbidity will decay with production of sulfides and ferrous compounds if protected from oxygen or chlorine. Decay has been shown to exist in the settling basins and distribution flumes at depths anywhere below 3" from the surface. At times, an accumulation of too much sludge has been shown to hinder "filter recovery".
- (i) The manganese content of Columbia River Water is reduced markedly by the coagulation-filtration process. For example, the maximum manganese content yet reported in river water (0.100 ppm) was reduced to less than 0.01 ppm by the process.
- (j) The use of activated silica as a coagulant and is beneficial with alum but not with ferric sulfate (See Reference 4).
- (k) Microscopic examination of river water for a one year period disclosed that the rate of head loss increase on the filters was affected by the diatom count of the raw water. (See Reference 5).
- (l) Laboratory tests at 100-11 Area indicate that #42 filter paper is roughly equivalent to the plant filters in removing turbidity and iron particles from coagulated water.

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DISCUSSION - Coagulation and Filtration (Continued)

- (m) Filtration in the plant filters occurs in depth, the floc progressively working downward through the anthracite and sand as the filtration continues. Eventually, iron works through into the filter effluent.
- (n) There is a coating of manganese and iron oxide throughout the pre-treatment plant but not on the effluent side of the filters.
- (o) This coating of iron and manganese oxides amounting to about one ton was removed from #3 filter at 100-B Area with oxalic acid without any noticeable effect on the quality of the water or the head loss across the filter.
- (p) The optimum proportions of anthracite of effective size 0.8 mm and of sand of effective size 0.4 mm for filter construction at this plant are 10" and 20" respectively. Other sizes and other materials have not been investigated.

IV. Chlorination

Prechlorination has been used throughout this country as an aid to coagulation process. Its action is to break up iron and manganese organic complexes and to oxidize other organic material such as leachings from swamps, etc., which have a tendency to retard coagulation. When used with ferrous sulfate, of course, the function is to oxidize the ferrous iron to ferric iron. The so called "chlorinated copperas" process employs ferrous sulfate and chlorine in definite proportions to manufacture ferric compounds right in the water. As the current ferrous sulfate content of Ferriclear, our present coagulant, is sometimes as high as 15% it is imperative that free chlorine be present in the water at all times. The oxidation of ferrous compounds by dissolved oxygen in the water does not proceed at pH 7.6 although it is rapid at pH 9.0 and above. Laboratory and plant experiments have indicated that the lowest overall treatment cost can consistently be obtained by feeding the maximum permissible amounts of chlorine. The slight additional cost of chlorine is more than compensated for by the reduction of coagulant feeds. In addition to its function in reducing treatment costs and improving quality, chlorination also serves to keep the filters in good operating condition and prevents growths in the filtered water system. In the summer of 1945, slimes as much as 1/4" thick were removed from the rubber lined process water tanks in 100-D Area. These slimes were caused by microscopic organisms. After the chlorine residual was increased there has been no further evidence of these slimes. Such cases are quite common in unchlorinated water supply systems. A great deal of positive evidence of harmfulness to the pile would be necessary before a decision to abandon chlorination could be considered (See Reference 6).

V. Nessler Tube Iron Determination

Perhaps the most useful single method yet discovered or adopted by the Power Division was a rapid method for determining iron in water. This method was worked out by Power Division personnel in January, 1947, and has been invaluable to operations since that time. The method was a simple adaptation of GNY Procedure to Nessler tubes, giving a sensitivity roughly equal to the standard method, and taking two minutes rather than two hours to complete. The accuracy of the Nessler Method is not nearly as good as the standard method, but this has not proved to be a serious obstacle for operation.

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DISCUSSION (Continued)

VI. Cotton Plug Filter

Baylis, at the Chicago Filter Plant, developed a cotton plug filter for determining water quality as measured by suspended solids. This method has been in use at this plant since November, 1948. The Baylis Method of determining total suspended solids was extended to include suspended iron and manganese at this plant. The tests are now run routinely for the Power Division by the Analytical Section of the Technical Division in all of the 100 Areas. The results show that when suspended solids increase there is a corresponding increase in pressure drop and pile effluent activity. As pressure drop and pile effluent activity are influenced by other variables, such as power level, purge frequency, and rate of water flow, the data must be taken over several months time to notice the strong correlation. Note that this may offer a strong hint that raw water will cause high rates of film formation and pile effluent activity. (See References 7, 8 and 9.)

VII. Iron Pick-Up - 100-B Area

When 100-B Area was on a standby basis, there was an inverse relationship between rate of flow and iron pick up from the pipes and tanks as would be expected. Pick up of as much as 0.05 ppm iron was common at flow rates of 2,000 GPM through the system. Normal average pick up at 30,000 GPM and above is about 0.005 ppm or only one tenth of that at low flows.

VIII. Iron and Steel Corrosion Rates

Periodic inspection of tanks and steel lines carrying filtered water have generally confirmed the CMX prediction of 0.00085 inches penetration per month. (See Reference 10).

IX. High Quality Test at 100-H Area

During the spring of 1950, the rate of pressure drop increase and pile effluent activity increased alarmingly as power level was raised. At the request of the 'P' Division, an attempt was made to reduce the iron content of the filtered water to less than 0.01 PPM. This was done. There was a slight improvement in pressure drop and pile effluent activity but it could not be concluded that the water treatment was responsible because of other variables. Consequently, conditions were returned to normal without any noticeable effect on either pressure drop or pile effluent activity. The purge frequency was very low during this period as was the frequency of shutdown. These variables may have interfered seriously with the test. (See References 11, 12 and 13).

X. Purge Data

An analysis of the available purge records show that effective purges reduce the pile effluent activity and increase water flows, (sometimes as much as 1000 GPM). There is no apparent relationship between the effectiveness of the purge and the rate of film formation.

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DISCUSSION (Continued)

XI. Seasonal Changes

Both pressure drop and activity show a well defined seasonal change as do other water treatment variables. A few of the variables which reach a maximum in the spring and a minimum in the fall are: pressure drop, pile effluent activity, river turbidity, river manganese, river iron, and filtered water turbidity. There are many other variables that can be listed also, so that it becomes impossible to say that any two are related until it is possible to obtain better data under more controlled conditions.

XII. Settling Tests - 182 Reservoirs

Tests concerning settling rates of natural turbidity in the 182 Buildings at 100-D and 100-H, disclose that an average of about 10% of the turbidity is removed during a theoretical settling time of from 3½ to 12 hours. The tests also indicate that most of the settling takes place during the first hour (large particles) while very little additional settling takes place even on very prolonged settling (colloidal particles).

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