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AUTOMATIC ALUM FEED DEVICE TO PRODUCE WATER
OF ANY GIVEN CLARITY

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AUTOMATIC ALUM FEED DEVICE TO PRODUCE WATER OF ANY GIVEN CLARITY

INTRODUCTION

Hanford has water filter plants which are similar to conventional water filter plants. The Hanford plants produce filtered water which is used to cool fuel elements in nuclear reactors.

As advances in plutonium production, ever increasing amounts of exceptionally clear water are required. Consequently, water filtration is under continuous study. Among the studies on water treatment, a device was fabricated to feed automatically the minimum amount of alum required to produce water of any pre-selected clarity for any given raw water with any given filter. This paper presents some of the results of such automation.

SUMMARY

Alum feed in a small water treatment plant on the Columbia River at Hanford can be controlled automatically (when desired) to produce water of any desired clarity.

A pilot filter tube containing filter media similar to the plant media monitors the alum demand. Hanford generally uses two-inch diameter pilot filter tubes with back washing systems and with valves to give the desired filter rates. Alum treated raw water from a model filter plant influent flume is filtered through one of the pilot filter tubes. A polyelectrolyte is added ahead of filtration to strengthen the floc particles. The pilot tube effluent flows through a cell on a light scattering nephelometer. The turbidity in the flowing water scatters light. This produces a signal which is typ

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Conley, S.R. and R. W. Pitman. Microphotometric Turbidity Analysis, Journal AWWA, Vol. 49, No. 1, January, 1957.

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actuates a controller. The controller adjusts the stroke of an alum feed pump. In the Hanford apparatus, the amount of turbidity in the filtrate from the pilot filter tube is dependent on the amount of alum being fed. Consequently, the controller may be set on automatic to produce filtered water from the pilot filter of any desired turbidity. The water from the model filter plant filters contains essentially the same amount of turbidity as the water from the pilot filter. That is, the pilot filter with a short time lag (2-3 minutes) is used as a sensing element in an apparatus which regulates the alum feed automatically to produce a plant filtered water of any pre-selected turbidity.

Hanford does not use the device on the large production plants because the actual settling time across the basins is a very few minutes (because of short circuits) in some of our water treatment plants. Only a small time gain in the signal would be made by the automatic system. Other Hanford plants with more settling time operate very similar to those with short settling time, and therefore can rely on the latter plants for information. Water treatment is so important, flow demands are so erratic, and changes in conditions so frequent that our crews of highly trained operators are required anyhow. Many water plants would not have our difficult conditions, and the automatic device might be of considerable value.

DISCUSSION

Hanford settling basins are not required for the production of good quality filtered water. Basins do have a decided beneficial effect on the length of filter runs and a slight beneficial effect on alum consumption. Some water treatment plants at Hanford have a very few minutes actual settling time. These plants generally require one to two additional ppm alum feed more than a plant having a settling time of an hour, to produce like quality water. The relative effects of settling time and alum feed on filter effluent turbidity can be demonstrated in the laboratory by filtering raw water through a two-inch diameter tube containing six inches of the plant sand and four inches of the plant filter coal. Results from such a filter are shown in Table I. This laboratory filter was backwashed before each test.

TABLE I

Time Allowed for Mixing and Settling	Alum Fed	Filter Con- ditions Feed	Raw Water Turbidity (3/27/57)	Filtered Water Turbidity by Hanford Microphotometer
3 minutes	16 ppm	0.5 run	308 ppm	0.095
1 hour	16	0.5	308	0.017
3 minutes	20	0.5	308	0.023
1 hour	20	0.7	308	0.12

It will be noted from Table I that the effect of settling time on filtered water turbidity was minor when the alum feed was 20 ppm. The 20 ppm feed is a reasonable dose for the raw water used during the test (308 ppm turbidity). When alum feed was 16 ppm there was a decided difference in the filtered water caused

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by difference in settling time. However, the 16 ppm dose was insufficient to give a good filtered water regardless of length of settling time. The results obtained in Table 1 have been confirmed repeatedly in the eight large Hanford filter plants.

The minimum alum feed for good quality water at Hanford can be determined very easily. Fortunately this happens to be the point where maximum filter runs can be achieved. When raw water is treated with various amounts of alum and filtered through a laboratory filter the effluent contains variable amounts of turbidity. Figure No. 1 shows results obtained on one series of experiments. A plant filter having the same sand layer performs similarly. It will be noted that there is a definite relationship between the amount of alum added and filtered water turbidity. This relationship is quantitative for a given sample of water and given filter media. Time and degree of agitation have such a small effect on this relationship that both can be ignored for most purposes. The size of the filter media is critical. Coarse media requires more alum than fine media to produce the same quality filtered water. From the foregoing discussion it follows that a small laboratory pilot filter can be used to control the alum feeds for a large water treatment plant according to the scheme in Figure No. 2. The media in the pilot filter must be of the same size as the media in the plant filters. The Atomic Energy Commission has applied for a patent.

An inexperienced operator will have some difficulty in determining the proper organic polyelectrolyte feed for both the plant filters and the pilot filters. In general, the following principles will guide him:

1. Higher filter rates demand higher organic polyelectrolyte feeds to overcome the increased rupturing of the floc. Higher filter rates do not materially increase alum demand.
2. Longer periods between alum and polyelectrolyte addition requires less polyelectrolyte. If on a given day a one-hour period requires 0.005 ppm polyelectrolyte at a given filter rate, then a ten-minute period would require approximately 0.01 ppm and a three-minute period would require 0.2 ppm.
3. The proper polyelectrolyte feed is that which gives maximum runs at high filter rates without breakthrough.
4. Alum feed demands change rapidly during some days in some periods of the year, while polyelectrolyte feed demands remain rather constant.

The light scattering microphotometer scale is arbitrary. It is used at Hanford due to historical reasons. The Baylis Turbidimeter becomes blind around 0.02 ppm as measured by the microphotometer; the Baylis Turbidimeter would record zero for any number less than 0.02 ppm. On the other hand, turbidities at 0.02 ppm and higher as indicated by the microphotometer are probably 10 to 100 less than the turbidity measured by customary methods. The microphotometer cannot directly be correlated to other methods. In any event, the determination of the optimum alum feed to treat raw water properly by measuring the turbidity of the filter effluent cannot be accomplished unless the sensitivity of measurement is in the range of 0.00 to 0.02 ppm on the Hanford arbitrary scale.

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instrument other than the microphotometer has been found to have this required sensitivity.

Hanford generally operates around 0.007 ppm as recorded by its microphotometer. We believe that in a general manner water filtration is as follows:

- b. The positive complicated hydrate of aluminum oxide particles will accept inclusions of negative large molecules and suspended materials, and the mass will grow into a floc. The particles grow to a size within one to three minutes than can be retained on 30-40 mesh sand.
- 20 Upon the start of a filter run a few of these particles can be wedged between the grain junctions of the filter media.
- 30 Upon these wedged particles other floc particles can be bonded provided the colloidal makeup is not too negative to allow intimacy among the particles. The size of the voids between the media grain controls the intimacy thrust.
- 40 The floc particles are structurally weak and can be ruptured easily. They will bleed into lower depths in the filter.
- 50 If the floc particles are too fragile and bleeding is excessive, they can be firmed by a filter conditioner. Many organic polyelectrolytes will strengthen and bridge the particles.

Although Hanford does not use the automatic alum feed device on the large plants the principles of the device are used to control plant operation. These principles have allowed the Hanford plants to achieve new records for water production rates and low operating costs. Some of the plants are being operated at 250 per cent of the original design capacity. This represents a capital cost saving of over 10 million dollars.

Most of the plants are operating above 6 gpm per square foot filtration rate with settling times which would by the usual standards be considered unacceptable even at low filtration rates.

There has been some speculation that the Hanford results are possible because the Columbia River is unusually clear. However, the cold clear water can be extremely difficult to treat. When the river is very turbid (over 500 ppm) treatment is not difficult. Control of treatment by the conventional jar test procedure is very difficult and leads to low filtration rates and poor results. For this reason the special Hanford control methods were developed. These methods should be generally useful at other locations but this should be established by careful laboratory investigation before any wide application is attempted.

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