TABLE 3 RECORD OF TEST RUNS—DEMINERALIZING UNIT NO. 1 GREAT NORTHERN PAPER COMPANY

Run no.	Date	Anions, gr/gal	Net output between regeneration, M gal — Guarantee — Unit No. 1	Net output between regeneration, M gal — Actual — Unit No. 1	Per cent under guarantee—Unit No. 1
80......	3/31/55	3.56	253	184	27.3
81......	4/1/55	3.18	283	205	27.5
82......	4/4/55	3.72	242	231	4.5
83 to 88, inc.			Not included as test runs		
89......	4/27/55	3.65	247	235	4.9
90......	4/30/55	3.90	231	214	7.4

basic anion resins, silica residuals in the demineralized water average about 0.05 ppm with maximum concentration of 0.1 ppm; thus, with 20 to 30 per cent demineralized make-up boiler water, silica concentrations have been consistently maintained within the control limits of 3 ppm without excessive blowdown.

About 2 to 4 ppm color and 5 ppm chemical-oxygen demand persist with demineralized water as shown by the analysis in Table 1, although no adverse effect on boiler operation has been noted in the 6 months of high-pressure operation. Traces of organic acids, which are not completely removed by anion exchange, resulted in lowering pH of finished water to 5.5 during a normal run. This was particularly noticeable with reduction of sodium leakage from the cation unit.

Steam and Condensate System Clean-Up

Years of mill operation with Corliss reciprocating-engine drives for the paper machines utilizing 10 to 12-psi exhaust steam for heating paper-machine drier cylinders had resulted in fouling the steam and condensate systems as well as the driers, with oil and oily sludges.

During the mill-expansion program, existing paper-machine drives were replaced with modern steam-turbine drives, thus removing the source of oil contamination of condensate returns to be used in the high-pressure boilers. A problem of some magnitude concerned clean-up of the steam and condensate systems, and the drier cylinders of the four existing paper machines to remove accumulations of oil, sludges, scale, iron oxide, and dirt.

In April, 1954, before replacement of the Corliss engines, a cleaning program was initiated to test the effectiveness of cleaning chemicals. Solutions of Oakite No. 19, alkaline phosphate, and Oakite No. 8, a detergent, in concentrations of 1 lb and 0.25 lb per gal, respectively, were injected at rates of 18 gal per hr into the 10-psi exhaust header delivering steam to the paper machines. Two periods of application, one of 72 hr and one of 56 hr, were used initially during which condensate was discharged to waste.

Sampling points in the system were selected at the steam-header oil trap, paper-machine drier rolls, sectional condensate headers under the paper machines, and the main condensate header. Oil determinations were made on 800-cc samples of condensate using an extraction method with purified ether to remove oil.

The results of tests showed average oil concentration of samples taken at the various points before chemical addition was 9.2 ppm. The daily average for one week after termination of chemical addition was 3.3 ppm and later increased to about 5 ppm. A sample taken from the oil trap at the end of the exhaust-steam header prior to introduction of cleaning solution contained 488 ppm of oil; after treatment average oil concentrations were about 15 ppm. All sampling points showed large increases of oil concentration during chemical addition with a general increase for about five days.

As the Corliss engines for each of the four paper machines were replaced with steam turbines the cleaning program was continued, reducing concentrations of oil in the condensate to approximately 2 to 3 ppm. To clean the systems more efficiently, it was necessary to mix several hundred gallons of hot cleaning solution and circulate it through the drier cylinders of each paper machine and the condensate system during week-end shutdowns of the machine. Also, where convenient, condensate lines and traps were dismantled and cleaned mechanically to remove oily sludges. Cleaning was continued until late October, 1954, when analyses of condensate samples showed less than 1 ppm of oil. Except for short periods after week-end shutdown, condensate returns remained clear and free from oil contamination and were accepted for use in the high-pressure boiler.

With the elimination of oily exhaust steam and the removal of oily deposits from the piping and equipment, it became necessary to provide other protection against corrosion and iron pickup. In accordance with current practice a neutralizing amine is introduced to the high-pressure boiler drum to raise pH of condensed steam to 8.5.

Recent analysis of condensate samples shows average iron content is 0.26 ppm.

Conclusion

From discussion of the water-plant design, operation, and performance covered in this paper, it is apparent that there are challenging problems to be met and solved by both the plant designer and operator in treating successfully certain classes of natural surface-water supplies prior to demineralization.

Preliminary investigations at East Millinocket as well as eight months of plant-scale operation during which approximately 35,000,000 gal of Penobscot River water have been processed satisfactorily by demineralization for high-pressure boiler operation have demonstrated the nature of these problems and revealed some of the answers.

The exacting specifications required for waters applied to the highly basic anion resins used in demineralizers have made the problem of chemical pretreatment particularly critical and one demanding extreme vigilance on the operator's part to assure success of plant operation.

Acknowledgment

The author wishes to express appreciation to Mr. Roy V. Weldon, Executive Vice-President, Great Northern Paper Company, for his advice in preparing this paper and thank his associates in the Engineering Department and the Research and Control Department, Messrs. W. F. Daniell, Manager of Engineering, J. H. Heuer, Manager of Research and Control, D. F. Pollard, Technical Director, Roy Illingworth, Chief Chemist, and Carl Reed, Chemist, for their co-operation in conducting laboratory and field investigations and supplying data and material used.

Discussion

S. B. Applebaum.[2] We are indebted to Mr. Davidson of Stone and Webster and his associates at the Great Northern Paper Company for this interesting preliminary account of their experiences with the Cochrane demineralizer.

When it was reported that the capacity was below normal it was at first felt that addition of more anion resin would be a solution of the problem. However, when Mr. Crits, of Cochrane's Research Department, visited the plant and returned with representative core samples of the resin for work in the laboratory, the real cause of the shortage of capacity was determined. It was

[2] Director, Water Treatment Division, Cochrane Corporation, Philadelphia, Pa. Mem. ASME.

apparent that the difficulty was due to fouling of the anion resin by color and organic matter. The problem was how best to remove this fouling impurity from the resin. Painstaking tests with various cleaning reagents in varying strengths and amounts and for varying contact periods were made until the successful method described by Mr. Davidson was determined in the Cochrane laboratory. The use of salt first followed by acid and then by caustic succeeded in dislodging the organic matter from the pores of the anion resin. Salt causes the resin particles to contract and caustic causes them to swell. This alternate contraction and swelling of the resin was successful. Capacity tests in column resin tubes were made to prove that the cleansing method finally developed would restore the capacity. We are glad that it was equally successful on a large scale with the actual plant.

The next question is what can be done to reduce this organic fouling in the future. Even though the pretreatment plant is reducing the color and organic matter to a substantial degree it is apparent that the anion resin is still continuing to absorb some of the residual color and organic matter even if only by 2 or 3 ppm. When this is multiplied by millions of gallons passing through the resin beds an accumulation of color takes place which blocks the active reacting sites in the resin particles, reducing their capacity for acid and silica adsorption.

Mr. Davidson states that the preliminary laboratory study of the necessary pretreatment before designing the plant showed that alum coagulation was sufficient and that superchlorination followed by activated carbon accomplished negligible additional reduction of color and organic matter. However, in the writer's opinion, it is precisely this small additional improvement in the pretreatment that is now necessary.

Additional tests are now being made in that direction and it is hoped the final report on this interesting installation at some future technical meeting will round out this initial progress report by Mr. Davidson by revealing a successful solution of the pretreatment problem so that the frequency of cleansing of the anion resin will be reduced to a minimum.

Author's Closure

The comments and suggestions made by Mr. Applebaum are greatly appreciated. We wish also to express appreciation for the co-operation and interest shown by the Cochrane Corporation in making Mr. G. Crits, research engineer, available to take an active part in connection with the resin-fouling problem which occurred following preliminary operation of the demineralizing-plant equipment. The salt and acid treatment for cleaning the fouled resin developed by Mr. Crits proved to be a satisfactory method for restoring the exchange capacity of the anion units. In consideration of Mr. Applebaum's faith in the value of activated carbon for removing the final traces of organic contaminants in the clarified and filtered river water, this medium will be evaluated on small-scale laboratory-column tests.